

Journal of Oilseeds Research

Samir
27/10/09

27/10/09

DOR-375

Volume 26
Number 1
June, 2009
ISSN 0970-2776

Indian Society of Oilseeds Research

Indian Society of Oilseeds Research

THE INDIAN SOCIETY OF OILSEEDS RESEARCH

(Founded in 1983, Registration Number ISSN 0970-2776)

EXECUTIVE COUNCIL FOR 2008-09

President	:	Dr. M.V. Rao	
Vice-President	:	Dr. D.M. Hegde	
General Secretary	:	Dr. H. Basappa	
Joint Secretary	:	Dr. M.A. Shankar	
Treasurer	:	Dr. R.D. Prasad	
Councillors	:	Dr. Yashpal Yadav	(Northern Zone)
		Dr. M.M. Ansari	(Central Zone)
		Dr. H.V. Nanjappa	(Southern Zone)
		Dr. M.P. Deshmukh	(Western Zone)
		Dr. U.C. Kar	(Eastern Zone)

Editorial Board

Chief Editor	:	Dr. Harvir Singh
Editors	:	Dr. I.Y.L.N. Murthy
Members	:	Dr. S.S. Banga Dr. C.V. Reddy Dr. O.P. Joshi Dr. M.L. Lodha Dr. A. Bandopadhyay Dr. S.D. Kulkarni Dr. Arvind Kumar Dr. S.P. Tiwari Dr. S.J. Kolte Dr. D.R.C. Bakhetia Dr. H. Basappa

MEMBERSHIP TARIFF

(w.e.f. 01.01.2007)

Life Membership	Annual Subscription	India	Abroad
Individual : Rs.2500/- + Admn. Fee Rs.50/-	Individual : Rs. 300/- + Admn. Fee Rs.50/- Institutions : Rs. 1500/- Students : Rs. 200/- + Admn. Fee Rs.50/-		US\$ 100 Ordinary US\$ 150 Institutions

For subscription, please contact The General Secretary, Indian Society of Oilseeds Research, Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, A.P., India

ADVERTISEMENT TARIFF

Location	Two issues (Rs)	One issue (Rs)
Back cover (in side)	8000/-	5000/-
Page facing back cover	3000/-	1500/-
Inside full page	2500/-	1500/-
Inside half page	1500/-	750/-
Overall size	23 cm height (max.) x 17 cm width (max.)	
	1. Back cover & Full page	23 x 17 cm
	2. Half page	11 x 17 cm

Indian Society of Oilseeds Research
thankfully acknowledges the financial
assistance received from **INDIAN**
COUNCIL OF AGRICULTURAL RESEARCH,
New Delhi for printing this Journal

Journal of Oilseeds Research is published biannually by the Indian Society of Oilseeds Research

Contents

Research Papers

Diacylglycerol oil as an edible oil : A review <i>Aparna Kuna, A. Poshadri and Sumit Pandey</i>	... 1
Inheritance of fatty acid content and related quality traits in groundnut, <i>Arachis hypogaea</i> L. <i>R. Aruna and S.N. Nigam</i>	... 10
RAPD markers linked to self-compatible and self-incompatible genotypes of sunflower, <i>Helianthus annuus</i> L. <i>Deepa Mehta, K.S. Boora and R.K. Sheoran</i>	... 18
Heterosis and combining ability for seed yield and other yield contributing characters in sunflower, <i>Helianthus annuus</i> L. <i>M. Sujatha and A. Vishnuvardhan Reddy</i>	... 21
Management of defoliators and capitulum borer in sunflower, <i>Helianthus annuus</i> L. through newer insecticides <i>B.V. Patil and H. Basappa</i>	... 32
Studies on host resistance to <i>Botrytis</i> grey rot in castor <i>P. Janila, A. Ashok Kumar, N. Rajashekar Reddy, R. Sudhakar and S.K. Ahammed</i>	... 35
Performance of castor, <i>Ricinus communis</i> L. genotypes at different integrated nutrient management practices under irrigated conditions <i>Narayan S. Mavarkar, T.K. Prabhakara Setty and S. Sridhara</i>	... 41
Suitability of containers and moisture content for proper storage of safflower, <i>Carthamus tinctorius</i> L. seeds <i>Pratibha Parihar, S. Nema and S. Kumar</i>	... 44
Effect of supplementation of red palmolein, iron and vitamin C on vitamin A and iron status of adolescent girls <i>K. Aparna and K. Manorama</i>	... 47

Short communications

Attempts to transfer <i>Ogura</i> cytoplasm based CMS-FR system in <i>Brassica rapa</i> <i>Gurpreet Kaur, Shashi K. Banga, Navjyot Kaur and S.S. Banga</i>	... 50
NPJ-93 (Pusa Vijay) : A juvenile stage high temperature tolerant variety of Indian mustard <i>D.K. Yadava, V. Sujata, B. Dass, S.C. Giri and T. Mohapatra</i>	... 52
Efficacy of herbicides against weeds in groundnut, <i>Arachis hypogaea</i> L. <i>Virender Sardana and Parvender Sheoran</i>	... 55
Integrated nutrient management in summer groundnut, <i>Arachis hypogaea</i> L. under north Gujarat agro-climatic conditions <i>D.C. Chudhari, D.M. Patel, G.N. Patel and S.K. Patel</i>	... 57
Productivity of groundnut, <i>Arachis hypogaea</i> L. varieties under different sowing dates <i>Virender Sardana and S.S. Kandhola</i>	... 60
Performance of promising Indian mustard entries at different fertility levels under late sown condition <i>R.S. Baghel, Lallu, Anjani Singh and S.B.L. Srivastava</i>	... 62
Evaluation of bioefficacy of biopesticides against larvae of mustard saw fly, <i>Athalia lugens proxima</i> Klug. under laboratory condition <i>Wajit Hasan and C.P. Singh</i>	... 63
Eco-friendly management of <i>Alternaria</i> blight of Indian mustard, <i>Brassica juncea</i> L. <i>Rajendra Prasad, K.K. Maurya and S.B.L. Srivastava</i>	... 65
Effect of salinity on Indian mustard, <i>Brassica juncea</i> at seedling stage <i>Lallu, R.S. Baghel and S.B.L. Srivastava</i>	... 66
Suitability of soybean, <i>Glycine max</i> L. varieties for kharif/rainfed conditions in northern telangana zone <i>S. Narendra Reddy</i>	... 69

Breeding of sunflower for high seed yield and oil content <i>S.L. Sawargaonkar, M.K. Ghodke and I.A. Madrap</i>	... 73
Productivity of spring planted sunflower, <i>Helianthus annuus</i> L. as influenced by critical inputs and management factors <i>Virender Sardana</i>	... 74
Effect of weed competition on yield and economics of <i>rabi</i> sunflower <i>A. Malliswara Reddy, G. Prabhakara Reddy and D. Srinivasulu Reddy</i>	... 76
Evaluation of sunflower genotypes for stem borer, <i>Nupserha</i> sp. near <i>vexator</i> (Pascoe) resistance <i>B.V. Patil and K.S. Shinde</i>	... 78
Management of wilt, <i>Fusarium oxysporum</i> f.sp. <i>ricini</i> disease in castor through seed treatment in Rajasthan <i>T.S. Rajpurohit and S.S. Solanki</i>	... 80
Assessment of improved technology in castor, <i>Ricinus communis</i> L. on farmer's fields <i>P.M. Vaghasia and R.H. Kavani</i>	... 82
Impact of frontline demonstrations of improved safflower technologies in northern dry zone of Karnataka <i>M.M. Nekar, V.S. Kubsad and V. Rudranayak</i>	... 84
Induction of chlorophyll, plant types, floral and leaf mutations using gamma rays and EMS in niger, <i>Guzotia abyssinica</i> Cass. <i>Premjyoti C. Patil, S. Gangaprasad and R.L. Ravikumar and P.M. Salimath</i>	... 87

Review Article

Diacylglycerol oil as an edible oil : A review

Aparna Kuna, A. Poshadri¹ and Sumit Pandey¹

Post-Graduate Research Centre, ANG Ranga Agricultural University, Rajendranagar, Hyderabad-500 030, AP

(Received: March, 2008; Revised: March, 2008; Accepted: March, 2009)

Abstract

Diacylglycerol (DAG) oil has beneficial effects on obesity and weight-related disorders in both animals and humans. The physiological effect of DAG is believed to be attributed to its metabolic pathway, which is different from triacylglycerol (TAG) metabolism. Physicochemical properties, such as melting and smoke points and polymorphic forms of DAG are also distinct from TAG. The new DAG oil is derived from a combination of oils and has a different chemical structure from TAG oils. While both types of oil are digested the same way, the body metabolizes DAG oil differently, promoting greater breakdown by the liver. The result is that the body stores less of the oil as fat. Clinical studies of DAG oil demonstrated that consumers can lower body weight, abdominal fat, and triglyceride levels when it is used as part of a healthy eating plan.

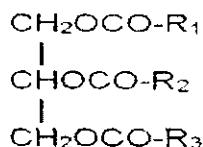
Key words: Diacylglycerol, edible oil

Introduction

Commonly consumed vegetable fats and oils are known to contain triacylglycerols and small amounts of diacylglycerols and monoacylglycerols (D'alonzo *et al.*,

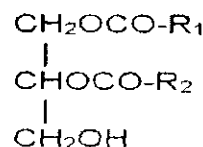
1982). Triacylglycerol consists of 3 fatty acids esters, whereas diacylglycerol oil has 2 fatty acids esters-linked to a glycerol backbone. 1, 2 or 2, 3 Diacylglycerols (Fig. 1) are formed as a result of hydrolysis of triacylglycerols by enzymes in animal tissues, and they are also generated in seed oils by the action of plant lipases. Another structural stereo chemical form 1, 3-diacylglycerol can be formed as a result of hydrolysis. Recently, Watanabe *et al.* (2003) developed a process by which the ratio of glycerides found in plant oils such as soybean, canola (rapeseed), or corn can be shifted from triacylglycerols to diacylglycerols leading to the formation of oil composed largely of randomized diacylglycerols. Commercially, diacylglycerol oil is produced by esterification of fatty acids derived from natural edible plant oils in the presence of lipase enzyme. Commercially produced vegetable diacylglycerol oil contains >80% diacylglycerols, <20% triacylglycerols, <5% monoacylglycerols, and small amounts of emulsifiers and antioxidants to maintain quality. The main constituent fatty acids of this oil are oleic (C18: 1), linoleic (C18: 2), and linolenic (C18: 3) acids, present as 1, 3 and 1, 2 (or 2, 3) diacylglycerols in a ratio of 7:3 respectively. At equilibrium, diacylglycerol oil is composed of 1, 2 (or 2, 3) diacylglycerol and 1, 3 diacylglycerol (Matsuo and Tokimitsu, 2001).

A. Triacylglycerol (TAG)

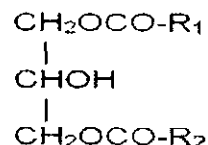


B. Diacylglycerol (DAG)

a) 1,2-DAG



b) 1,3-DAG



$$1,2\text{-DAG}:1,3\text{-DAG}=3:7$$

Fig. 1. Structure of triacylglycerol and diacylglycerol R1, R2 and R3 indicate fatty acids

¹ Department of Food Science and Technology, College of Food Technology, Marathwada Agricultural University, Parbhani, MS.

In recent years, because of potential health benefits and comparable taste/usability characteristics to commonly consumed oils, diacylglycerol oil is gaining popularity around the world as a replacement for conventional cooking oils. The constituents of diacylglycerol oil are commonly found in diets as components of conventional dietary oils, as approved food additives, i.e., mono and diacylglycerols, and as metabolites of normal lipid metabolism following the consumption of dietary fat. Following the ingestion of triacylglycerol, diacylglycerol is produced in the gastrointestinal tract as a metabolic intermediate, either as sn-1, 2-diacylglycerol or as sn-2, 3-diacylglycerol (Matsuo and Tokimitsu, 2001). Using a 1, 3 specific lipase, one can produce diacylglycerol oil, mainly sn-1, 3-diacylglycerol, by migration of the acyl group. All cooking oils naturally contain small quantities of diacylglycerol (1, 2 or 2, 3 and 1, 3), ranging from 0.8% in rapeseed oil to 9.5% in cottonseed oil (Flickinger and Matsuo, 2003). Corn oil and olive oil are reported to contain about 2.8 and 5.5% diacylglycerol oil, respectively. As diacylglycerol oil is similar to other commonly used oils including rapeseed, soybean, and safflower oil (Takase *et al.*, 2005) in characteristics such as taste, appearance, and fatty acid composition, it can be readily incorporated into food products.

The position of the fatty acid on the glycerol backbone has been claimed to be responsible for the metabolic differences of diacylglycerol oil relative to triacylglycerol oil. Watanabe and Tokimitsu (2004) hypothesized that the 1, 3 diacylglycerol (primary component of diacylglycerol oil) is less readily resynthesized as chylomicrons and is directly transported to the portal vein for β -oxidation. This increase in fat oxidation may influence satiety (Rudkowska *et al.*, 2005). Foods containing diacylglycerol oils have been shown to promote weight loss and body fat reduction and may be useful as an adjunct to diet therapy in the management of obesity (Maki *et al.*, 2002; Kamphuis *et al.*, 2003). The structural and metabolic characteristics of diacylglycerol compared with triacylglycerol appear to be responsible for suppression of body fat accumulation, body weight loss, and lower serum triacylglycerols levels postprandially. Thus, inclusion of diacylglycerol oil in diet may help prevent weight gain and fat deposition.

Diacylglycerol oil is "generally recognized as safe" (GRAS) as a food ingredient in the United States (FDA, 2000; 2003) and has been approved by the Japanese Ministry of Health, Labor and Welfare (MHLW) as a "food for specified health use" (MHLW, 1998). During the 1970s, Joint FAO/WHO Expert Committee on Food Additives (JECFA, 1974) and Federation of American Societies for Experimental Biology (FASEB, 1975) reviewed the safety data of partial mono and diacylglycerol and concluded that these ingredients present no safety concerns at the intended use levels. In view of this and the potential increase in use, an attempt has been made to

systematically review the existing information related to Diacylglycerol oils.

Physicochemical properties

DAG oils are esters of the trihydric alcohol glycerol in which two of the hydroxyl groups are esterified with fatty acids. They can exist in two structural isomers namely, 1,2-DAG and 1,3-DAG (Fig. 1). These isomers will undergo acyl migration to form equilibrium at a ratio of 3-4:7-6 between 1,2 and 1,3-DAG (Takano and Itabashi 2002) often in the presence of an acid, alkali, or heat (Sedarevich, 1967). 1,3- DAG is more thermodynamically stable because of the steric effect of the molecule. In general, the melting point of 1,3-DAG is approximately 10°C higher than TAG, and 1,2-DAG is approximately 10°C lower than 1,3-DAG, of the same fatty composition (Benson 1967; Formo 1979; Bockish 1998). The causes of these melting point differences are the strength of hydrogen bonding of the hydroxyl group and fatty acid chain arrangement of the DAG isomers. 1,3-DAG has a V-shaped fatty acid chain arrangement, while 1,2- DAG has a hairpin-shaped conformation. The type of molecular arrangement of the DAG isomer relates to its polymorphic form. Unlike TAG polymorphism, DAG exhibits two types of polymorphic forms. 1,2-DAG exhibits the α and β forms but has no β form, while 1,3-DAG has no β form but exhibits two types of β form, β 1 and the more unstable β 2 (Nakajima *et al.*, 2004).

Biochemical properties of DAG

DAG is a natural component of various edible oils (Table 1) DAG can be synthesized enzymatically with the reverse reaction of 1, 3 specific lipase, and consists mainly of the 1, 3 species due to the migration of the acyl group in an equilibrium reaction.

Table 1 Contents (weight %) of triacylglycerol and diacylglycerol in various edible oils

Edible oils	Triacylglycerol	Diacylglycerol
Soybean oil	97.9	1.0
Cottonseed oil	87.0	9.5
Palm oil	93.1	5.8
Corn oil	95.8	2.8
Safflower oil	96.0	2.1
Olive oil	93.3	5.8
Rapeseed oil	96.8	0.8
Lard	97.9	1.3

Source: Abdel-Nabey *et al.*, 1992

Digestion, Absorption, and Metabolism

Dietary TAG oil is hydrolyzed by lipase to free fatty acids (FFA) and 2 monoacylglycerol in the small intestinal lumen, and these are absorbed by intestinal cells (Fig. 2). In intestinal cells, TG is re-synthesized from 2-monoacylglycerol and two FFA via the 2-monoacylglycerol pathway (Yang and Kuksis, 1991). Monoacylglycerol acyltransferase (MGAT) and diacylglycerol acyltransferase (DGAT) work in the

2-monoacylglycerol pathway (Cao *et al.*, 2003; Cheng *et al.*, 2003). TG is incorporated into chylomicrons (CM) by microsomal triglyceride transfer protein (MTP), which are released into the intestinal lymph and poured into the bloodstream (White *et al.*, 1998). In the case of DAG oil, the metabolic pathway in the intestinal cells is different from that of TAG oil (Fig. 3). Dietary DAG oil is mainly in the form of 1, 3-DAG. 1, 3-DAG would be hydrolyzed initially to 1-monoacylglycerol and then to glycerol and FFA, which are absorbed into the intestinal cells (Watanabe *et al.*, 1997). TG cannot be synthesized from 1-monoacylglycerol via the 2-monoacylglycerol pathway in the intestinal cells, because 1-monoacylglycerol cannot be the substrate for both DGAT and MGAT (Cao *et al.*, 2003;

Cheng *et al.*, 2003). TG could be synthesized via the glycerol-3-phosphate pathway, which is less active than the 2-monoacylglycerol pathway (Friedman and Nylund, 1980). 1, 2-DAG would be hydrolyzed to 2-monoacylglycerol, and TG is synthesized via the 2-monoacylglycerol pathway. Recently it was reported by Yasunaga *et al.*, (2007) that DAG oil reduced plasma TG levels, resulting from more efficient clearance of DAG by both LPL-mediated lipolysis and apolipoprotein E-mediated hepatic endocytosis. A lowered plasma TG levels accompanied by an increase in adipocyte LPL activity was found in Sprague Dawley rats (Kim *et al.*, 2007).

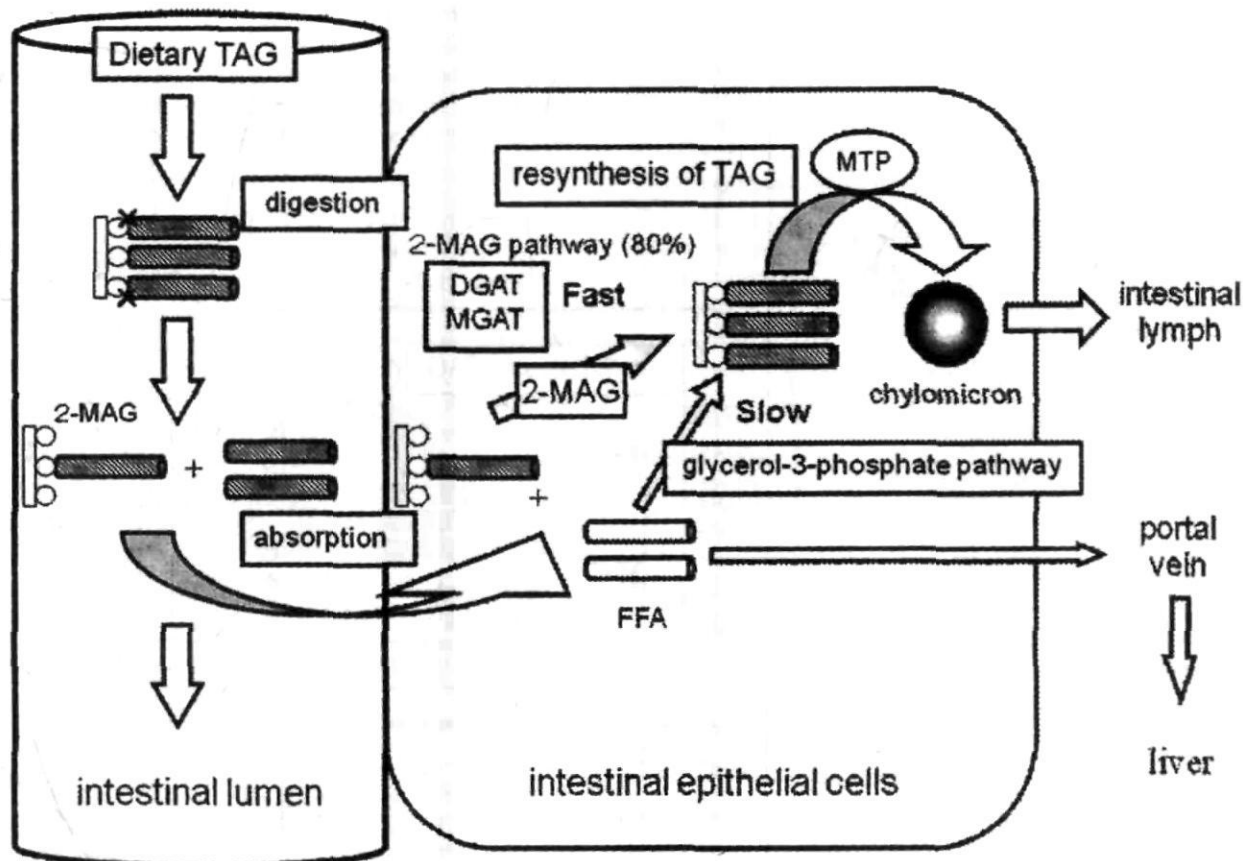


Fig. 2. Digestion and absorption of triacylglycerol. DGAT, diacylglycerol acyltransferase; FFA, free fatty acids; 2-MAG, 2-monoacylglycerol; MGAT, monoacylglycerol acyltransferase; MTP, microsomal triglyceride transfer protein; TAG, triacylglycerol

Nutritional implications and application of DAG to dietary treatment for disease

The metabolism of DAG-oil is comparable to that of partial glycerides (mono- and diglycerides) and triglycerides. Furthermore, diglyceride-rich oils have energy values and digestibility coefficients equivalent to those of triglyceride oils of similar fatty acid composition. The most important difference with the digestion of triacylglycerols and DAG-oil is that, following the intake of diacylglycerols; the formation of 2-monoacylglycerols is limited. As a result, more fatty acids are broken down to release energy. Therefore, they are not available for re-synthesis in triacylglycerols and hence do not contribute to fat deposition. Consumption of DAG-oil, as compared to triglyceride oil, has the effect of producing lower level of serum triglycerides, as well as decreasing body weight and fat mass thereby contributing to reduced incidence of degenerative disorders like obesity, coronary vascular diseases, metabolic syndrome and diabetes. The application of DAG to dietary treatment in diabetes has been studied by few scientists. Maki *et al.*(2002) performed human efficacy studies among subjects comprising obese or overweight volunteers with BMI 30 or greater who underwent 6 months ingestion of DAG oil or TAG oil, and changes in body fat were studied comparatively. The results showed a statistically significant

difference between the DAG and TAG oil ingestion groups with regard to body weight and body fat reduction. Tada *et al.* (2001) reported that RLP-C and RLP-TG (remnant-like lipoprotein particle fraction cholesterol and triglycerides) values were significantly lower in DAG oil ingestion versus TAG oil ingestion, indicating that postprandial elevation of remnants was suppressed.

Tada *et al.* (2005) administered DAG at 30g/m² body surface area to 6 diabetic patients and reported that postprandial serum triacylglycerol levels were suppressed to significantly lower levels compared to administration of TAG oil with a virtually identical composition. Yamamoto *et al.* (2001) performed a 3-month single-blind controlled ingestion study on subjects comprising diabetic patients with hypertriglyceridemia and reported a distinct reduction in serum triacylglycerol and glycosylated hemoglobin (HbA1c). Teramoto *et al.* (2004) reported usefulness of DAG oil among patients on hemodialysis.

DAG oil consumption has been reported to ameliorate the constituents of the metabolic syndrome such as excess adiposity, impaired glucose metabolism, and dyslipidemia, suggesting the usefulness of DAG oil for the management and prevention of the metabolic syndrome (Hidekatsu *et al.*, 2007).

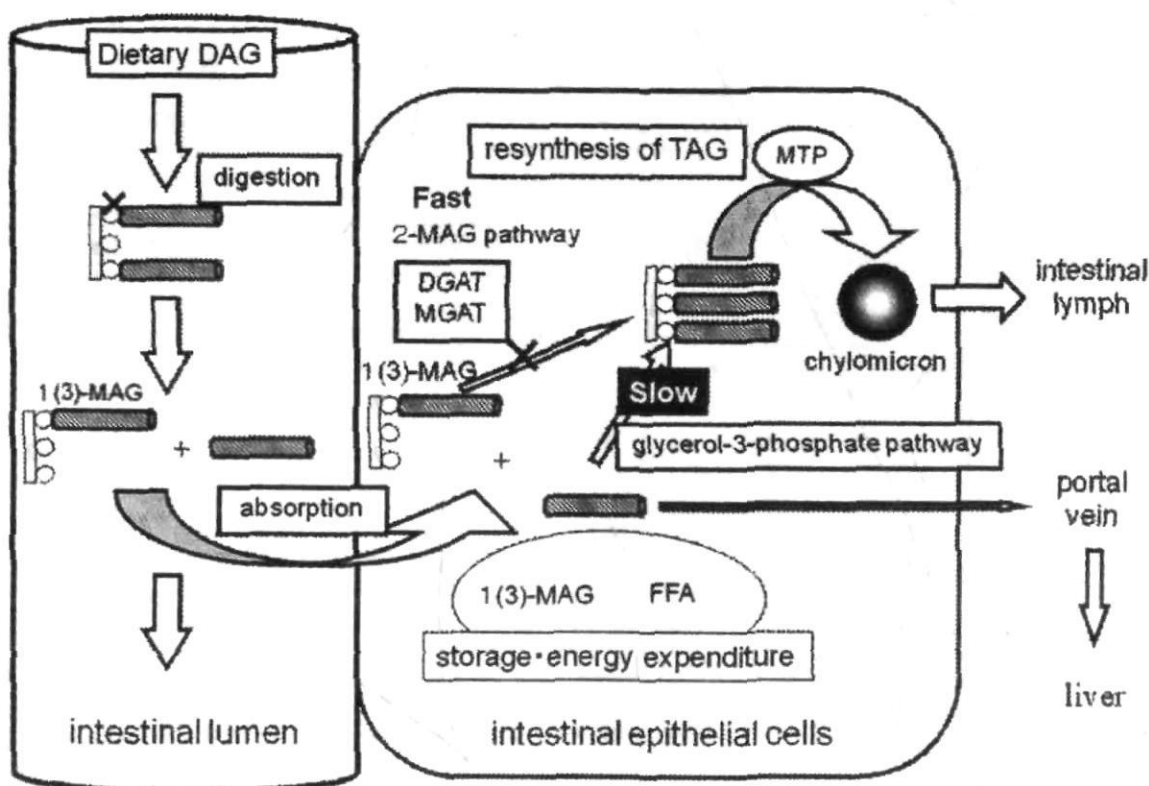


Fig. 3. Digestion and absorption of diacylglycerol. DGAT, diacylglycerol acyltransferase; FFA, free fatty acids; 1(3)-MAG, 1-monoacylglycerol or 3-monoacylglycerol; MGAT, monoacylglycerol acyltransferase; MTP, microsomal triglyceride transfer protein; TAG, triacylglycerol

Significance of diacylglycerols in food applications:

Confectionery fats

DAG oils have been shown to have significant effects on the physical properties of oils and fats. These vary from melting point and polymorphism changes, rate of crystallization, crystal size and habits. Substantial research work has been carried out on palm oil, sal fat, hydrogenated oils and coconut oil. Confectionery fats are made from both lauric and non-lauric oils. Cocoa butter is the ideal fat used in chocolate and related confectionery industries but, being expensive, it is partially replaced by cheaper fats in some products. The properties of cocoa butter are essentially affected by the main TAG component, SOS triacylglycerol. The DAG level in cocoa butter is around 2%, and, at this proportion, it does not affect the properties to a significant extent. The influence of DAG oils on the rate of transformation of α to β crystals was investigated by Wahnelt *et al.* (1991) who showed that 1, 2-(2, 3) DAGs cause more significant changes compared to 1, 3 DAG. Sal (*Shorea robusta*) fat comprises mainly the symmetrical monounsaturated, di-saturated type of TAGs, mostly 2-oleodistearin. Its application in cocoa butter as extenders and confectionery fat formulations has been increasing steadily.

Oil-in-water type emulsion foods

Oil-in-water type emulsion (O/W) food products are commonly represented by mayonnaise and salad dressings. In general, mayonnaise and salad dressings contain oil, egg yolk, vinegar, and seasonings (salt, sugar, spices, flavors, etc.). The major difference between mayonnaise and salad dressings is in the oil content. Mayonnaise has an oil content of 65-85% (w/w), while salad dressing has less than 60% (w/w) oil. The application of DAG oil in O/W products was first patented by Nomura *et al.* (1992). According to the invention, the O/W product has an oil phase comprising of 30-100% (w/w) DAG with a melting point of 20°C or less. The O/W composition is claimed to exhibit a rich fatty savor even at a low fat content. Several years later, Kawai and Konishi (2000) describe an O/W composition that has excellent storage stability, good appearance, taste, and physical properties.

Water-in-oil type emulsion foods

The other form of emulsified food product has a water-in-oil type emulsion (W/O). Examples of such products are margarine, spreads, butter cream fillings, and icings used in baking and the confectionery industry. Mori *et al.* (1999a) invented a W/O-emulsified fat composition that has good stability and spreadability and is suitable for use as margarine. The W/O composition is made up of 40 to less than 95% (w/w) of DAG and 5 to less than 60% (w/w) of TAG, wherein the DAG comprises of 0.5 to less than 20% (w/w) DAG containing two saturated C14-C22 fatty

acid groups, 20 to less than 55% (w/w) DAG containing one saturated C14-C22 fatty acid group and one unsaturated C14-C22 fatty acid group, and 25 to less than 70% (w/w) DAG containing two unsaturated C14-C22 fatty acid groups, and the weight ratio of total C14 and C16 saturated fatty acid groups in DAG to total C18, C20, and C22 saturated fatty acid groups in DAG is in the range from 1 to 8. Another W/O composition claimed to have excellent flavor release during the time of ingestion was invented by Masui and Konishi (2001).

Shortenings

DAG also finds an application in the formulation of shortenings. Doucet and Olathe (1999); Mori *et al.* (1999b) invented a shortening composition comprising a no hydrogenated vegetable oil and a stearine fraction containing 50-60 mol% of DAG. It is claimed that the shortening formulation has a synergistic amount of solids and crystal matrices that imparts superior organoleptic properties to the food product, without the incorporation of trans-fatty acids commonly found in partially hydrogenated fats. Concomitantly, Doucet *et al.* (1999) claimed that the above effects can also be made possible with the addition of MA

Frying applications

Because DAG has a lower molecular weight than TAG, DAG oil has a significantly lower smoke point (30-40°C) than TAG oil with similar fatty acid compositions. Several DAG compositions suitable for use as frying oil have been reported. Sakai *et al.* (2002a) reported a fat composition containing at least 15% (w/w) of DAG, a fatty acid L-ascorbic ester, and a component such as catechin or a natural plant extract such as rosemary, sage, and turmeric extracts. The authors claimed that the DAG composition has excellent stability toward oxidation, while providing good flavor and appearance. Another DAG composition reported by Sakai *et al.* (2002b) contains 15% (w/w) or more of DAG and 70 ppm or more of one or more types of organic carboxylic acids such as two to eight carbon hydroxycarboxylic or dicarboxylic acids and their derivatives thereof. The composition is claimed to resist thermal oxidation or hydrolysis after prolonged heating or storage, as well as to reduce smoking when the oil composition is used for frying purposes.

Ice cream coating fats

Ice cream coating fats are generally TAG of medium-chain fatty acids, such as lauric acid rich coconut oil. The first use of DAG as an ice cream coating fat was reported by Cain *et al.* (1999). The fat composition is comprised of 50-90% (w/w) DAG and 10-50% (w/w) TAG of vegetable origin. The DAG oil is composed of 75-90% (w/w) di-unsaturated DAG, less than 5% (w/w) disaturated DAG, and 10-25% (w/w) DAG with one unsaturated and one saturated fatty acid. The TAG composition in this fat

composition is such that the sum of tri-unsaturated and di-unsaturated TAG is at least 50% (w/w). According to this report, the ice cream coating fat had resulted in a product that is softer and less brittle but had quicker and smoother meltdown, than cocoa butter-based coating fats.

Production process

Various routes for the production of DAG oil have been reported in patent literature. In general, DAG oil can be produced via glycerolysis between TAG and glycerol, esterification of fatty acids or its derivatives to glycerol, hydrolysis of TAG, or a combination of methods thereof. These processes often involve either a chemical or an enzyme catalyst. Apart from these methods for the production of DAG, other related technologies such as DAG separation and purification methods that complement well with DAG production have also been reported. In this, there are a number of patents for the production of DAG oil via esterification of fatty acids or its derivatives such as fatty acid anhydrides and fatty acid methyl esters. Mazur and Hiler (1992) process involves the esterification of 3-40% of fatty acid anhydride with 3-40% of glycerol in the presence of a water-immiscible hydrocarbon or chlorinated hydrocarbon solvent such as methylene chloride. The reaction is catalysed by a 1,3-position-specific immobilized lipase. DAG yield of 41% (w/w) is reported. This method involves the use of chlorinated solvents, which may pose a problem in waste management. Additionally, the use of such solvents may not be an attractive marketing option for DAG oil.

Lo and Baharin (2001) reported on a solvent-free method for the production of DAG from fatty acid deodorizer distillates obtained from edible oil refineries. In this method, DAG oil is produced by esterification of free fatty acids present in the deodorizer distillates with glycerol, which is added into the reaction. Similarly, the process is catalyzed by a 1,3-position-specific immobilized lipase. A yield of 60% (w/w) of DAG oil can be obtained. The advantage of this process is in its use of a lower-cost raw material compared with refined fatty acids and thus may positively reflect on the production cost of the DAG oil. However, because the process requires the use of an immobilized enzyme as catalyst, the process cost may not be low. To provide a solution to the high cost of enzymes, Lai *et al.* (2007) reported on the use of a strongly acidic cation exchange resin as a chemical catalyst for the synthesis of DAG oil from free fatty acids. The application of the heterogenous catalyst will allow for easy separation of the catalyst from the reaction products. The cost of the ion-exchange resins is also significantly cheaper than that of commercial immobilized lipases. Another advantage of this process involves the use of relatively lower temperatures as compared to other chemically catalysed synthetic processes. However, one major drawback of this process is the use of more expensive free fatty acids compared with TAG as raw materials.

Yoon *et al.* (2004) documented a process for the production of DAG oil containing conjugated linoleic acids, comprising of esterifying MAGs with free fatty acids in the presence of a lipase. A similar process for DAG production involving transesterification between MAG and TAG has been invented by Toshinori *et al.* (2000). These processes utilizing MAG as raw materials for DAG production may not be industrially attractive as the Cost of MAG is relatively high. DAG oil can also be produced from partial hydrolysis of TAG. Lai *et al.* (2006) discloses an enzymatic process for partial hydrolysis of TAG to produce DAG. A commercial immobilized lipase was used to catalyze the hydrolysis of TAG under controlled conditions to produce DAG oil. The advantage of this process lies in the single-step hydrolytic reaction of TAG without further addition of other substrates such as glycerol. However, precise control of water content in the reaction system is required for optimal DAG yield.

Sugiura *et al.* (2002) documented a glycerolysis process to produce DAG from TAG and glycerol, in the presence of small quantities of water and lipase to assist catalysis. The glycerolysis reaction is conducted at relatively lower temperatures (0-25°C). As such, the DAG product is removed by crystallization during the course of reaction. This method of DAG separation may not be cost effective in large-scale production as longer reaction times are required (20-100 h). Jacobs *et al.* (2003) reported on a glycerolysis process for producing DAG oil from TAG and glycerol using potassium acetate as a catalyst. The process is claimed to provide a crude DAG product with good colour. However, the process requires a relatively high reaction temperature of 190-240°C and therefore may translate to a significant energy cost. Nevertheless, the economics of this process is compensated by the use of low-cost raw materials and catalyst.

Another process for the production of DAG oil involves a combination of hydrolysis and esterification reactions (Yamada *et al.*, 1999). The process comprises of hydrolyzing TAG oil to obtain free fatty acids, followed by esterification of these free fatty acids, without further purification, with glycerol to produce DAG. The hydrolysis step may be performed using steam or in the presence of a lipase. For the esterification step, an immobilized lipase is required for catalysis. In comparison with other enzymatic processes for DAG oil production, this process has the potential for industrial feasibility. As a follow-up to this process, Sugiura *et al.* (2002) up-scaled this process into a production plant setting and described that high-purity DAG oil can be produced at high yields and in a short time by carrying out esterification reaction of fatty acids with glycerol in an immobilized enzyme-packed tower. Sugiura *et al.* (2002) also described that the residence time for the reaction substrates in the tower should not be more than 120 seconds to prevent increased concentrations of TAG.

Another method of producing DAG oil was reported by Choo et al. (2007). According to the invention, an edible oil with high DAG content of at least 8% (w/w) can be produced from TAG oil of vegetable origin by subjecting the vegetable oil to short-path distillation under vacuum of not more than 0.01 Torr and at temperature of 300°C and below, wherein the DAG oil is obtained as the distillate. As mentioned earlier, vegetable oils generally do not contain more than 10% (w/w) of DAG. Because of the relatively low DAG content in vegetable oils, the DAG oil yield obtained from this process will be at most 10% (w/w). The low DAG yield will translate to a high production cost of DAG oil, thus making this process industrially unattractive.

Conclusion

Numerous scientific reports have shown the effectiveness of DAG in preventing body fat accumulation and obesity related disorders. The commercial potential of DAG has prompted various patent publications on production technologies and product applications of DAG oil. However, greater emphasis is required to further reduce the overall cost of DAG oil to meet consumer expectations. At the current growth rate of obese population throughout the world, it can be expected that the global market demand for DAG oil will increase in the future. There is no doubt that DAG oil is a new approach to calorie control and fat reduction that holds great promise for long-term weight loss and health management. The use of DAG oil in conjunction with a hypo-caloric diet may soon provide an effective tool against many diseases and its introduction to Indian subcontinent is worth anticipating in the near future.

References

- Abdel-Nabey, A.A., Shehata Y., Ragab, M.H. and Rossell J.B. 1992. Glycerides of cottonseed oils from Egyptian and other varieties. *Reviews of Italian Sostanze Grasse*, **69**: 443-447.
- Benson, F.R. 1967. Polyol surfactants. In M. J. Shick (Ed.), *Nonionic surfactants*, pp. 247-299, New York, NY: Marcel Dekker.
- Bockish, M. 1998. Composition, structure, physical data, and chemical reactions of fats and oils, their derivatives, and their associates. In M. Bockish (Ed.), *Fats and oils handbook*, pp. 53- 120. Illinois, USA: AOCS.
- Cain, F. W., Manson, H. G. A., Quinlan, P. T. and Moore, S. R. 1999. Ice-cream coating fats. US Patent no. US5891495 (in English).
- Cao, J., Lockwood, J., Burn, P. and Shi, Y. 2003. Cloning and functional characterization of a mouse intestinal acyl-CoA: monoacylglycerol acyltransferase, MGAT2. *Journal of Biological Chemistry*, **278**:13860-13866.
- Cheng, D., Nelson, T.C., Chen, J., Walker, S.G., Wardwell-Swanson, J., Meegalla, R., Taub, R., Billheimer, J.T., Ramaker, M. and Feder, J.N. 2003. Identification of acyl coenzyme A: monoacylglycerol acyltransferase 3, an intestinal specific enzyme implicated in dietary fat absorption. *Journal of Biological Chemistry*, **278**:13611-13614.
- Choo, Y. M., Puah, C.W., Ma, A.N. and Basiron, Y. 2007. Production of edible oil. US Patent Application no.US20070021625 (in English).
- D'alonzo, R.P., Kozarek, W.J. and Wade, R.L. 1982. Glyceride composition of processed fats and oils as determined by glass capillary gas chromatography. *Journal of American Oil Chemists Society*, **59**:292-295.
- Doucet, J. and Olathe, K. 1999. Shortening system, products there with and methods for making and using the same. US Patent no. US5908655 (in English).
- Doucet, J., Olathe, K., Rethwill, C. E., McHugh, K. and Wilhelm, C. L. 1999. Shortening system. European Patent Application no. EP1057887 (in English).
- FDA. 2000. GRAS Notice No. GRN 000056, FDA official website <http://www.cfsan.fda.gov/~rdb/opa-g056.html>.
- FDA. 2003. GRAS Notice No. GRN 000115, FDA official website <http://www.cfsan.fda.gov/~rdb/opa-g115.html>
- Flickinger, B.D. and Matsuo, N. 2003. Nutritional characteristics of DAG oil. *Lipids*, **38** : 129-132.
- Formo, M. W. 1979. Physical properties of fats and fatty acids. In D.Swern (Ed.), *Bailey's industrial oil and fat products* (vol. 1, 4th ed., pp. 53-120). Illinois, USA: AOCS.
- Friedman, H.I. and Nylund, B. 1980. Intestinal fat digestion, absorption, and transport. *International Journal of Clinical Nutrition*, **33**:1108-1139.
- Hidekatsu Yanai., Yoshiharu Tomono., Kumie Ito., Nobuyuki Furutani., Hiroshi Yoshida. and Norio Tada. 2007. Diacylglycerol oil for the metabolic syndrome. *Nutrition Journal*, **6**: 43.
- Jacobs, L., Lee, I. and Poppe, G. 2003. Chemical process for the production of 1,3-diglyceride oils. PCT International Patent no. WO03029392 (in English)
- JECFA. 1974. Mono and diglycerides. In: JECFA. *Toxicological Evaluation of Some Food Additives Including Anticaking Agents, Antimicrobials, Antioxidants, Emulsifiers and Thickening Agents*. 17th JECFA Session, June 25-July 4, 1973, Geneva, Switzerland.
- Kamphuis, M. M., Mela, D. J. and Westerterp-Plantenga, M.S. 2003. Diacylglycerol affects substrate oxidation and appetite in humans. *American Journal of Clinical Nutrition*, **77**: 1133-1139.
- Kawai, S. and Konishi, Y. 2000. Acid oil-in-water emulsified composition. PCT International Patent Application no. WO0078162 (in English).
- Kim, H.J., Lee, K.T., Lee, M.K., Jeon, S.M., Jung, U.J., Cho, Y.Y. and Choi, M.S. 2007. Hypolipidemic effect of dietary diacylglycerol oil in Sprague-Dawley rats fed a normal diet. *Journal of Medicinal Food*, **10**: 60-66.
- Lai, O. M., Yusoff, M. S. A., Lo, S. K., Long, K., Tan, C. P. and Lim, J.W. 2006. Process for the production of

- diacylglycerol. PCT International Application no. PCT/MY2006/000034 (in English).
- Lai, O. M., Yusoff, M.S.A., Lo, S.K., Long, K., Tan, C.P. and Tahiruddin, S. 2007. Production of acylglycerol esters. PCT International Application no. PCT/MY2007/000025 (in English).
- Lo, S.K. and Baharin, B.S. 2001. Process for producing phytonutrient-enriched diacylglycerols. Malaysian Patent Application no. PI20014817 (in English).
- Maki, K.C., Davidson, M.H., Tsushima, R., Matsuo, N., Tokimitsu, I. and Umporowicz, D. 2002. Consumption of diacylglycerol oil as part of a reduced-energy diet enhances loss of body weight and fat in comparison with consumption of a triacylglycerol control oil. *American Journal of Clinical Nutrition*, **76**, 1230-1236.
- Masui, K. and Konishi, Y. 2001. Water-in-oil type emulsified fat and/ or oil composition. PCT International Patent Application no. WO0101787 (in English).
- Matsuo, N. and Tokimitsu, I. 2001. Metabolic characteristics of diacylglycerol, *Inform*, **12**:1098-1102.
- Mazur, A. W. and Hiler, G.D. 1992. Regioselective synthesis of 1, 3-disubstituted glycerides. Canadian Patent no. CA2106316 (in English).
- MHLW. 1998. Ministry of Health, Labour and Welfare. Japan official website [http:// www.mhlw.go.jp/index.html](http://www.mhlw.go.jp/index.html).
- Mori, H., Masui, K., Tanaka, Y. and Yasukawa, T. 1999a. Water-in-oil emulsified fat composition. PCT International Patent Application no. WO9959422 (in English).
- Mori, H., Sakai, H., Tanaka, Y. and Yasukawa, T. 1999b. Fried food and shortening. PCT International Patent Application no. WO9959424 (in English).
- Nakajima, K., Furutani, I., Tachimoto, H., Matsubara, H. and Hashimoto, T. 2004. SPIRAL1 encodes a plant-specific microtubule-localized protein required for directional control of rapidly expanding Arabidopsis cells. *Plant Cell*, **16**: 1178-1190.
- Nomura, M., Koike, S., Yamashita, K., Okisaka, K., Sano, Y. and Omura, H. 1992. Edible oil-in-water emulsion. US Patent no. US5160759 (in English).
- Rudkowska, I., Roynette, C.E., Demonty, I., Vanstone, C.A., Jew, S. and Jones, P.J. 2005. Diacylglycerol: efficacy and mechanism of action of an anti-obesity agent. *Obesity Research*, **13** : 1864-1876.
- Sakai, H., Ishibashi, M. and Kohori, J. 2002a. Fat compositions. European Patent Application no. EP1186648 (in English).
- Sakai, H., Katada, M. and Ishibashi, M. 2002b. Oil or fat composition. European Patent Application no. EP1249173 (in English).
- Sedarevich, B. 1967. Glyceride isomerisation in lipid chemistry. *Journal of the American Oil Chemists Society*, **44**: 381-393.
- Sugiura, M., Shimizu, M., Yamada, Y., Mine, K., Maruyama, E. and Yamada, N. 2002. Process for producing partial glyceride. US Patent no. US 6337414 (in English).
- Tada, N., Watanabe, H., Matsuo, N., Tokimitsu, I. and Okazaki, M. 2001. Dynamics of postprandial remnant-like lipoproteins particles in serum after loading of diacylglycerol. *Clinica Chimica Acta*, **311**: 109-117.
- Tada N. Shoji, K., Takeshita, M., Watanabe, H., Yoshida, H., Hase, T., Matsuo, N. and Tokimitsu, I. 2005. Effects of diacylglycerol ingestion on postprandial hyperlipidemia in diabetes. *Clinica Chimica Acta*, **353**(1-2) : 87-94.
- Takano, H. and Itabashi, Y. 2002. Molecular species analysis of 1, 3- diacylglycerols in edible oils by HPLC/ESI-MS. *Bunseki Kagaku*, **51**: 437-442.
- Takase, H., Shoji, K., Hase, T. and Tokimitsu, I. 2005. Effect of diacylglycerol on postprandial lipid metabolism in non-diabetic subjects with and without insulin resistance. *Atherosclerosis*, **180**: 197-204.
- Teramoto T., Watanabe, H., Ito, K., Omata, Y., Furukawa, T., Shimoda, K., Hoshino, M., Nagao, T. and Naito, S. 2004. Significant effects of diacylglycerol on body fat and lipid metabolism in patients on hemodialysis. *Clinical Nutrition*, **23**:55, 1122-1126.
- Toshinori, I., Yasuharu, N., Shinichi, H. and Shoichi, K. 2000. Production of diglyceride-containing fat and oil composition and fat and oil composition using the same. Japanese Patent no. JP2000345189 (in Japanese).
- Wahnelt, S., Meusel, D. and Tulser, M. Der Einfluss, 1991. Isomerer Diglyceride auf Phasenumwandlungen von Kakaobutter-Untersuchungen Mittels Isothermer DSC. *Fat Science and Technology*, **93**: 174-178.
- Watanabe, H., Onizawa, K., Taguchi, H., Kobori, M., Chiba, H.Naito, S., Matsuno, N., Yasukawa, T., Hattori, M. and Shimasaki, H. 1997. Nutritional characterization of diacylglycerols in rats (in Japanese). *Journal of Japanese Oil Chemists Society*, **46**:301-307.
- Watanabe, H. and Tokimitsu, I. 2004. Digestion and absorption of diacylglycerol. In: Katsuragi, Y., Yasukawa, T., Matsuo, N., Flickinger, B.D., Toimitsu, I., Matlok, M.G. (Eds.), *Diacylglycerol Oil*. American Oil Chemists' Society, Champaign, pp. 30-45.
- Watanabe, T., Shimizu, M., Sugiura, M., Sato, M., Kohori, J., Yamada, N. and Nakanishi, K. 2003. Optimisation of reaction conditions for the production of DAG using immobilized 1,3-regiospecific lipase lipozyme RM IM. *Journal of the American Oil Chemists Society*, **80**: 1201-1207.
- White, D.A., Bennett, A.J., Billett, M.A. and Salter, A.M. 1998. The assembly of triacylglycerol-rich lipoproteins: an essential role for the microsomal triacylglycerol transfer protein. *British Journal of Nutrition*, **80**:219-229.

- Yamada, Y., Shimizu, M., Sugiura, M., and Yamada, N. 1999.** Process for producing diglycerides. PCT International Application no. WO9909119 (in English).
- Yamamoto, K., Asakawa, H., Tokunaga, K., Meguro, S., Watanabe, H. and Tokimitsu, I. 2005.** Effects of diacylglycerol administration on serum triacylglycerol in a patient homozygous for complete lipoprotein lipase detection. *Metabolism*, 54, 67-71
- Yamamoto, K., Asakawa, H., Tokunaga, K., Watanabe, H., Matsuo, N. and Tokimitsu, I. 2001.** Long-term ingestion of dietary diacylglycerol lowers serum triacylglycerol in type II diabetic patients with hypertriglyceridemia. *Journal of Nutrition*, 131: 3204-3207.
- Yang, L.Y. and Kuksis, A. 1991.** Apparent convergence (at 2-monoacylglycerol level) of phosphatidic acid and 2-monoacylglycerol pathways of synthesis of chylomicron triacylglycerols. *Journal of Lipid Research*, 32:1173-1186.
- Yasunaga, K., Saito, S., Zhang, Y.L., Hernandez-Ono, A. and Ginsberg, H.N. 2007.** Effects of triacylglycerol and diacylglycerol oils on blood clearance, tissue uptake, and hepatic apolipoprotein B secretion in mice. *Journal of Lipid Research*, 48:1108-1121.
- Yoon, D.H., Han, G.W., Hong, S.G. and Lee, Y.H. 2004.** Preparation method of conjugated linoleic acid diglycerides. PCT International Application no. WO2004096748 (in English).

Inheritance of fatty acid content and related quality traits in groundnut, *Arachis hypogaea* L.

R. Aruna and S.N. Nigam

International Crops Research Institute for the Semi-Arid Tropics, Patancheru-502 324, AP

(Received: March, 2008; Revised: March, 2008; Accepted: March, 2009)

Abstract

Groundnut is a rich source of edible oil. The fatty acid composition of the endogenous fats plays an important role in determining the shelf life, nutrition and flavor of groundnut. Gene action involved in the fatty acid composition (palmitic acid, stearic acid, oleic acid, linoleic acid, arachidic acid, eicosenoic acid, behenic acid and lignoceric acid) and quality parameters (Oleic/linoleic fatty acid ratio (O/L ratio), iodine value (IV), total saturated fatty acids, polyunsaturated / saturated fatty acid ratio (P/S)) and total long chain saturated fatty acids (TLC SFA)) were studied in three crosses in groundnut. Generation means analysis for all the traits indicated that additive and additive \times additive gene actions played predominant role in controlling the fatty acid content and quality parameters. In addition to additive and additive \times additive gene actions, dominance and additive \times dominance gene action were also important in explaining variation for IV and P/S ratio. The choice of a suitable breeding procedure depends upon the relative magnitude of different gene effects and an understanding of the mode of inheritance of some complex quantitative characters. The additive and additive \times additive components of genetic variation are fixable in groundnut. Oleic acid content, O/L ratio and IV are predominantly under the control of additive gene action; hence selection for these traits can be practiced in early generations.

Key words: Iodine value, O/L ratio, P/S fatty acid ratio, generation means analysis, gene action

Introduction

Groundnut (*Arachis hypogaea* L.) is the fourth most important source of edible oil and third most important source of vegetable protein in the world (FAO, 2007). About two-thirds of the produce is crushed for oil and the remaining one-third is used for confectionery purposes. Groundnut makes an important contribution to the human diet and its wide spread acceptability is attributed to its economic value to the industry and nutritional benefits to the consumers. The presence of groundnuts and its products in the diet reduces the risk of heart disease by

21% (O'Bryne *et al.*, 1997). A groundnut seed contains approximately 50% of its weight as oil. Oleic acid, a monounsaturated acid, and linoleic acid, a polyunsaturated fatty acid account for 75-80% of the total fatty acids in the groundnut oil (Mercer *et al.*, 1990; Ahmed and Young, 1982). The fatty acid composition of the endogenous fats plays an important role in determining the shelf life, nutrition and flavor of groundnut. Groundnut oil varies both in quantity and relative proportion of fatty acids. Although up to 12 fatty acids have been reported in groundnut, generally palmitic acid (16:0) constitutes nearly 10%, and the oleic (18:1) and linoleic acid (18:2) proportions together make up 80% of the fatty acid composition in groundnut (Ahmed and Young, 1982). Oleic (O)/linoleic acid (L) acid ratio and iodine value (IV) are both the indicators of stability and shelf life in groundnut products (James *et al.*, 1983; Branch *et al.*, 1990).

Earlier investigations indicated that the fatty acid content of groundnut is quantitatively inherited; predominance of additive gene action was reported by Khan *et al.* (1974); Moore and Knauff (1989); Mercer *et al.* (1990); Knauff *et al.* (1993); while significance of both additive and non-additive gene action was reported by Tai and Young (1975) and Bansal *et al.* (1992 and 1993). In two high oleic and low linoleic natural mutant breeding lines (Norden *et al.*, 1987), the genetic control of high O/L ratio was reported to be under the control of duplicate recessive alleles (Moore and Knauff, 1989) and in addition to these, there are modifiers and epistatic interactions governing the trait (Isleib *et al.*, 2006). The present study aims at providing a better understanding of the inheritance pattern and magnitude of gene action governing different fatty acid composition and quality related traits in three different crosses. This knowledge would further help in targeted breeding for different fatty acid content and in modifying the fatty acid composition suiting to different uses and needs.

Material and methods

The experimental material consisted of parents, F_1 , F_2 and back cross generations of three crosses, Cross 1 : ICGV 88438 \times ICGV 88448 (ICGV 88438 is a large-seeded breeding line derived from two germplasm lines, GP NC 343 and NC 17367, and ICGV 88448 is a large-seeded interspecific derivative from a cross between *A. hypogaea*

and *A. cardenesii*, developed at North Carolina State University); Cross 2 : ICGV 96234 × Hard Kernel Mutant (ICGV 96234 is a chemically (ethyl methyl sulphate) induced mutant from ICGV 88448 developed at ICRISAT (Dwivedi *et al.*, 1998) with O/L ratio of >2.0 and Hard Kernel Mutant was isolated (Chandramouli and Kale, 1990) after 200 Gy treatment of TG 18A; and Cross 3: ICGV 96234 × JL 24 (JL 24, a selection from EC 94943 is a popular cultivar in India and is also known as Phule Pragati).

The experimental material (P_1 , P_2 , F_1 , F_2 , BC_1P_1 and BC_1P_2) in each cross was planted on 60 cm ridges in a Randomized Block Design with two replications during the 1999 rainy season in Alfisols at the International Crops Research Institute for the semi-Arid Tropics (ICRISAT, 17° 30' N; 78° 16' E; altitude 549 m), Patancheru. In each cross, two rows for each of the parents, a single row each for F_1 , BC_1P_1 and BC_1P_2 and 20 rows for F_2 , each of 4 m length, were grown. The distance between plants within a row was maintained at 10 cm with a uniform seed depth of 5 cm. The trial received 375 kg/ha of single super phosphate before sowing and was protected against foliar diseases and insect pests during the cropping period, and kept weed-free through manual weeding. Individual plants were harvested in each plot at the time of maturity. Five gram of sound mature kernels (8% seed moisture) from each plant in each generation was used for estimating the fatty acid content as per the procedure described by Mercer *et al.* (1990). From the fatty acid estimation, five quality parameters, iodine value (IV), oleic (O)/linoleic (L) fatty acid ratio, total saturated fatty acids (TSF), polyunsaturated (P)/saturated (S) fatty acid ratio, and total long chain fatty acids (TLCSF), were determined as described by Mozingo *et al.* (1988). The statistical analyses were performed using Genstat 8th Edition (GenStat, 2005). The means and variances from individual plant data on fatty acids and quality parameters were estimated for every generation and estimates of genetic effects were determined. A joint scaling test (Cavalli, 1952) was conducted to estimate the genetic components and digenic interaction among these components, viz., m (mean), d (pooled additive effects), h (pooled dominance effects), l (the pooled additive × additive epistatic effects), j (the pooled additive × dominance effects) and i (the pooled dominance × dominance effects). Subsequently, the stepwise regression analysis was done to find the best fit model as per Torres *et al.* (1993). In addition to the three-parameter model, epistatic interactions were also studied to explain the variation. For this purpose, a six-parameter model was fitted to the generation means. This model was tested for goodness of fit by the chi-square test to determine if linkage in the higher order interactions was present (Mather and Jinks, 1982). Contribution made by each parameter in explaining the variation for a trait was calculated using the sum of squares.

Results and discussion

The quality of the edible groundnuts is principally due to the chemical composition of the oil, protein, and carbohydrate fractions of the seed. Since fatty acids make up the major portion of the weight of an oil molecule, the physical and chemical properties of the oil tend to be determined by the properties of the fatty acids which predominate in their makeup. Parents in all the three crosses differed significantly from each other for the palmitic, stearic, oleic and linoleic acids but variation between parents for arachidic, eicosenoic, behenic and lignoceric acid contents was non-significant. Significant differences were also observed between the parents in all the three crosses for O/L ratio, IV and TSF but the differences for P/S fatty acid ratio and TLCSF were non-significant (Table 1). The F_1 mean for all the traits except for behenic acid in ICGV 88438 × ICGV 88448 and ICGV 96234 × Hard Kernel Mutant fell between the two parents. The F_2 population in all the three crosses showed continuous variation in fatty acid content. Continuous variation for fatty acid content among the groundnut genotypes has been well documented (Khan *et al.*, 1974; Tai and Young, 1975; Norden *et al.*, 1987; Mercer *et al.*, 1990; Lopez *et al.*, 2001, 2002).

Estimates of different genetic parameters and their significance in three crosses are presented in Table 2. Generation means analysis for all the quality traits indicated that additive gene action was the major component; while dominance and epistatic interactions were also significant for some traits. The oleic and linoleic acid contents were controlled by additive gene action (Table 2 and 3). The O/L ratio in all the three crosses was controlled by additive gene action (Table 2) and the direction of the gene effect was consistent towards increasing the O/L ratio. The additive effect accounted for 43%, 83% and 96%, respectively, of the total genetic variation in all three crosses. In ICGV 88438 × ICGV 88448, in addition to the additive effects, additive × additive epistatic interaction (accounting for 43%), which is genetically fixable in groundnut, was also significant (Table 3). The O/L ratio is a measure of oil stability and can be easily manipulated in a breeding program (Young and Waller, 1972; Tai, 1972; Khan *et al.*, 1974; Tai and Young, 1975; Worthington and Hammons, 1977). There is a negative correlation between the percentage of oleic and linoleic acids (Norden *et al.*, 1987; Moore and Knauff, 1989; Mercer *et al.*, 1990), since linoleic acid is produced from the conversion of oleic acid (Mozingo and Steele, 1982). Thus, selection for high O/L ratio is relatively straight forward because selection of genotypes with high oleic acid results in lower levels of linoleic acid. The quantitative inheritance of O/L ratio and presence of epistatic interactions was also confirmed by Khan *et al.* (1974); Tai and Young (1975); Moore and Knauff (1989) and Knauff *et al.*, 1993. High heritability estimates of the

O/L fatty acid ratio were also reported by Tai (1972). Increase in the oleic acid content is much easier to achieve using two high oleic fatty acid mutant lines where the trait is governed by two recessive genes (Norden *et al.*, 1987; Moore and Knauff, 1989; Isleib *et al.*, 2006). Since there is a positive correlation between the oil content and O/L ratio (Dwivedi *et al.*, 1993), it should be possible to improve oil content and oil stability (through O/L ratio) simultaneously.

Iodine reacts readily with the double bonds of oil/fat molecule and the quantity of iodine absorbed by oil is an index of its degree of unsaturation. Low iodine number implies the presence of few unsaturated bonds and hence low susceptibility to oxidative rancidity. Iodine value was predominantly under the control of additive gene action, which accounted for 90% and 98% of the genetic variance in crosses ICGV 96234 × Hard Kernel Mutant and ICGV 96234 × JL 24, respectively. In ICGV 88438 × ICGV 88448, along with additive gene action (accounting for 30% of the variation), additive × additive (accounting for 23%) and additive × dominance (accounting for 25%) interactions were also significant (Table 2 and 3). The direction of the additive genetic effects (-0.8 ± 0.14 ; -3.0 ± 0.40 and -3.6 ± 0.23) in all the three crosses was consistent towards decreasing the iodine number (Table 2). Higher O/L ratio and lower IV generally suggest better stability and longer shelf life of groundnut oil (Mercer *et al.*, 1990).

Groundnut storage qualities and nutritional quality are both dependent on the relative proportions of the saturated and unsaturated fatty acids that make up the oil. The total amount of unsaturation is inversely proportional to the keeping quality of the oil, oxidative rancidity increases with increased level of the polyunsaturated fatty acids which cause associated odours and flavors (St. Angelo and Ory, 1973). The P/S fatty acid ratio in crosses ICGV 96234 × Hard Kernel Mutant and ICGV 96234 × JL 24 was under the control of additive gene action (which accounted for 87% of the variation in ICGV 96234 × Hard Kernel Mutant and 96% in ICGV 96234 × JL 24). In ICGV 88438 × ICGV 88448, in addition to the additive gene action (contributing to 23% of genetic variation), dominance gene action (30%) and additive × dominance (26%) interaction were also significant (Table 2 and 3). Though the heritable additive genetic effects can be fixed in groundnut, variance due to dominance and their interaction effects cannot be exploited due to self pollinating nature of the crop.

Palmitic, stearic, arachidic, behenic and lignoceric acids together form the total saturated fatty (TSF) acids in groundnut. The TSF and individual saturated fatty acids were under the control of additive gene effects in all the three crosses (Table 2 and 3). The direction of the effects

was consistently towards decreasing the TSF, which is a desirable quality trait. The later three saturated fatty acids are the undesirable long chain saturated fatty acids (LCSFA) (20-24 carbons: arachidic, behenic and lignoceric acids) (Treadwell *et al.*, 1983). These fatty acids have been shown to comprise 4-9% of the total composition (Worthington and Hammons, 1977). These LCSFA together and also individually were controlled by additive gene action and additive × additive interactions in all the three crosses. In addition to the above gene actions, for arachidic acid in ICGV 88438 × ICGV 88448 and behenic acid in ICGV 96234 × Hard Kernel Mutant, dominance × dominance type of epistatic interactions were also significant (Table 2 and 3).

Significant positive correlations also have been reported between the arachidic and behenic acids (Dwivedi *et al.*, 1993). The additive × additive interaction for LCSFA was also reported by Upadhyaya and Nigam (1999). Eicosenoic acid content was under the control of additive × additive and dominance × dominance type of inter-allelic interactions in ICGV 88438 × ICGV 88448, while the former was predominant in ICGV 96234 × Hard Kernel Mutant, only additive interaction was predominant in ICGV 96234 × JL 24. Presence of inter-allelic additive × dominance interactions could be specific to ICGV 88438 × ICGV 88448 (Table 2). As LCSFA are not desirable for health, genotypes with less content of these would be preferred.

The fatty acid composition and content in groundnut is influenced by environment, season and also the location and geographic area of production in addition to planting date, market grade and genotype (Mohamed-Som, 1984; Mozingo and Steele, 1982; Mozingo *et al.*, 1988; Treadwell *et al.*, 1983; Young and Worthington, 1974). Bovi (1982) observed a negative correlation between IV and soil temperature and suggested that the chemical composition of groundnut oil could be altered by adjusting the planting date. Environment was found to interact more strongly with epistatic interaction than with the additive or dominance gene action (Upadhyaya and Nigam, 1999). As this study was conducted only in one season, it does not account for genotype × environment interaction.

In a self pollinating crop, the additive and additive × additive genetic variance can be fixed in homozygous cultivars by following appropriate selection strategies. As oleic acid content, O/L ratio and IV are predominantly under the control of additive gene action, the selection for these traits can be practiced in early generations. Where additive × additive interactions are predominant, large populations should be carried forward to later generations to allow favorable combinations to come in a homozygous state before practicing selection.

Table 1 Means and standard errors (SE) of fatty acid contents and quality traits in parents, their F_1 , F_2 , B_1 ($F_1 \times P_1$) and B_2 ($F_1 \times P_2$) in three different crosses

	ICGV 88438 (P_1) \times ICGV 88448 (P_2)	ICGV 96234 (P_1) \times Hard Kernel Mutant (P_2)	ICGV 96234 (P_1) \times JL 24 (P_2)
Traits	Mean \pm SE	Mean \pm SE	Mean \pm SE
(1)	(2)	(3)	(4)
Palmitic acid			
P_1	9.95 \pm 0.06	9.94 \pm 0.11	10.29 \pm 0.15
P_2	11.21 \pm 0.27	13.96 \pm 0.14	12.86 \pm 0.11
F_1	10.50 \pm 0.13	12.19 \pm 0.21	11.93 \pm 0.21
B_1	8.92 \pm 0.25	11.02 \pm 0.20	10.94 \pm 0.11
B_2	10.42 \pm 0.14	11.17 \pm 0.24	12.10 \pm 0.22
F_2	10.11 \pm 0.06	11.39 \pm 0.08	11.97 \pm 0.08
Stearic acid			
P_1	3.13 \pm 0.20	3.31 \pm 0.20	2.60 \pm 0.13
P_2	2.90 \pm 0.17	2.23 \pm 0.13	3.05 \pm 0.17
F_1	3.08 \pm 0.18	3.10 \pm 0.18	3.24 \pm 0.23
B_1	3.23 \pm 0.23	2.96 \pm 0.25	3.29 \pm 0.27
B_2	3.15 \pm 0.20	2.67 \pm 0.17	3.55 \pm 0.21
F_2	3.02 \pm 0.06	2.60 \pm 0.04	3.09 \pm 0.06
Oleic acid			
P_1	53.13 \pm 0.29	53.25 \pm 0.46	53.09 \pm 0.61
P_2	49.77 \pm 1.28	41.36 \pm 1.15	37.47 \pm 0.26
F_1	51.65 \pm 0.54	43.46 \pm 0.57	44.15 \pm 0.97
B_1	52.68 \pm 0.93	49.00 \pm 0.72	46.69 \pm 0.58
B_2	52.01 \pm 0.59	47.27 \pm 0.94	40.84 \pm 0.97
F_2	52.34 \pm 0.25	48.21 \pm 0.22	43.68 \pm 0.37
Linoleic acid			
P_1	26.08 \pm 0.34	25.27 \pm 0.26	26.04 \pm 0.42
P_2	28.74 \pm 0.73	34.68 \pm 0.98	38.02 \pm 0.28
F_1	27.31 \pm 0.34	32.82 \pm 0.47	32.70 \pm 0.73
B_1	26.76 \pm 0.58	28.60 \pm 0.40	30.48 \pm 0.47
B_2	26.51 \pm 0.36	30.36 \pm 0.89	34.88 \pm 0.82
F_2	26.44 \pm 0.17	29.71 \pm 0.16	32.64 \pm 0.30
Arachidic acid			
P_1	1.49 \pm 0.06	1.58 \pm 0.04	1.40 \pm 0.05
P_2	1.42 \pm 0.06	1.16 \pm 0.06	1.44 \pm 0.07
F_1	1.48 \pm 0.05	1.53 \pm 0.07	1.45 \pm 0.06
B_1	1.66 \pm 0.07	1.48 \pm 0.07	1.49 \pm 0.06
B_2	1.56 \pm 0.06	1.38 \pm 0.07	1.57 \pm 0.06
F_2	1.53 \pm 0.02	1.30 \pm 0.02	1.49 \pm 0.02
Eicosenoic acid			
P_1	1.19 \pm 0.04	1.20 \pm 0.05	1.31 \pm 0.04
P_2	1.11 \pm 0.05	1.13 \pm 0.04	1.07 \pm 0.04
F_1	1.12 \pm 0.04	1.03 \pm 0.03	1.11 \pm 0.03
B_1	1.12 \pm 0.03	1.19 \pm 0.04	1.23 \pm 0.03
B_2	1.17 \pm 0.03	1.23 \pm 0.03	1.05 \pm 0.04
F_2	1.19 \pm 0.01	1.22 \pm 0.01	1.15 \pm 0.01

Inheritance of fatty acid content and related quality traits in groundnut

Behenic acid			
P ₁	3.68±0.06	3.83±0.06	3.77±0.14
P ₂	3.61±0.23	3.81±0.14	4.42±0.07
F ₁	3.73±0.09	4.21±0.13	4.09±0.09
B ₁	3.93±0.11	4.16±0.10	4.26±0.10
B ₂	3.88±0.08	4.05±0.09	4.40±0.09
F ₂	3.94±0.04	3.83±0.03	4.35±0.04
Lignoceric acid			
P ₁	1.30±0.10	1.59±0.06	1.46±0.16
P ₂	1.23±0.10	1.65±0.07	1.68±0.10
F ₁	1.07±0.07	1.65±0.03	1.42±0.09
B ₁	1.60±0.04	1.61±0.05	1.61±0.10
B ₂	1.28±0.07	1.80±0.05	1.60±0.06
F ₂	1.46±0.02	1.71±0.01	1.64±0.03
O / L ratio			
P ₁	2.04±0.04	2.11±0.04	2.05±0.06
P ₂	1.75±0.08	1.21±0.08	0.99±0.01
F ₁	1.90±0.04	1.33±0.03	1.38±0.07
B ₁	2.00±0.07	1.73±0.05	1.54±0.04
B ₂	1.98±0.05	1.60±0.08	1.20±0.06
F ₂	2.01±0.02	1.64±0.02	1.37±0.03
Iodine value (IV)			
P ₁	91.80±0.41	90.51±0.28	91.80±0.28
P ₂	93.46±0.23	96.53±0.71	98.92±0.34
F ₁	92.61±0.32	95.04±0.55	95.49±0.55
B ₁	92.55±0.43	92.62±0.32	6.33±0.43
B ₂	91.57±0.26	94.20±0.79	96.36±0.66
F ₂	91.74±0.14	93.87±0.14	95.00±0.22
Total saturated fatty acids (TSF)			
P ₁	19.55±0.19	20.25±0.29	19.52±0.24
P ₂	20.37±0.56	22.81±0.25	23.45±0.18
F ₁	19.87±0.32	22.69±0.38	22.13±0.33
B ₁	19.34±0.46	21.23±0.43	21.58±0.27
B ₂	20.30±0.29	21.06±0.26	23.21±0.30
F ₂	20.06±0.11	20.83±0.10	22.54±0.13
Polyunsaturated / Saturated fatty acid ratio (P/S)			
P ₁	1.34±0.03	1.25±0.02	1.33±0.02
P ₂	1.41±0.01	1.52±0.03	1.62±0.02
F ₁	1.41±0.01	1.45±0.03	1.48±0.03
B ₁	1.39±0.03	1.35±0.02	1.42±0.03
B ₂	1.31±0.02	1.44±0.04	1.50±0.03
F ₂	1.32±0.01	1.43±0.01	1.45±0.01
Total long chain saturated fatty acid (TLCSF)			
P ₁	6.47±0.11	7.00±0.11	6.63±0.24
P ₂	6.26±0.27	6.62±0.15	7.54±0.09
F ₁	6.28±0.12	7.39±0.18	6.95±0.15
B ₁	7.19±0.18	7.25±0.17	7.35±0.18
B ₂	6.72±0.13	7.23±0.13	7.57±0.14
F ₂	6.93±0.06	6.85±0.04	7.47±0.06

IV = (%oleic acid)(0.8601)+(%linoleic acid)(1.7321)+(%eicosenoic acid)(0.7854); TSF = palmitic acid + stearic acid + arachidic acid + behenic acid + lignoceric acid; P/S = linoleic acid / TSF; TLCSF = arachidic acid + Behenic acid + Lignoceric acid

Table 2 Estimates of different genetic parameters using six parameter model for different fatty acid content in cross 1: ICGV 88438 x ICGV 88448; 2 : ICGV 96234 x Hard Kernel Mutant and cross 3 : ICGV 96234 x JL 24

Trait	Mean (m)	additive (d)	dominance (h)	additive x additive (l)	additive x dominance (i)	dominance x dominance (l)
Palmitic acid						
Cross 1	11.8±0.65**	-0.6±0.14**	-5.5±1.89*	-1.2±0.63	-1.2±0.66	4.2±1.27**
Cross 2	13.1±0.59**	-2.0±0.11**	-5.4±2.06*	-1.1±0.71	3.5±0.68**	4.1±1.43
Cross 3	13.5±0.57**	-1.3±0.09**	-4.5±1.59*	-1.9±0.56**	0.4±0.51	2.9±0.65*
Stearic acid						
Cross 1	2.6±0.67**	0.1±0.009	1.2±1.95	0.4±0.66	-0.3±0.65	-0.8±1.34
Cross 2	2.3±0.59**	0.6±0.11**	0.4±1.73	0.4±0.58	-0.2±0.59	0.1±1.22
Cross 3	1.7±0.69*	-0.2±0.10*	4.2±2.02*	1.2±0.69*	0.06±0.67	-2.6±1.40*
Oleic acid						
Cross 1	50.2±2.64**	1.7±0.68	7.3±7.68	1.2±2.55	-0.6±2.74	-5.9±5.18
Cross 2	47.9±2.69**	5.9±0.61**	4.8±7.86	-0.6±2.62	-7.6±2.76*	-8.7±5.37
Cross 3	44.5±2.73**	7.8±0.32**	-2.9±7.56	0.8±2.71	-4.3±2.36	2.6±5.23
Linoleic acid						
Cross 1	27.6±1.62**	-1.3±0.39**	-4.5±4.64	-0.2±1.57	2.0±1.63	4.2±3.12
Cross 2	30.0±2.14**	-4.7±0.51**	-4.2±6.30	-0.02±0.08	4.8±2.23	7.3±4.33
Cross 3	32.1±2.28**	-5.9±0.26**	1.6±6.37	-0.1±2.27	3.4±2.01	-0.1±4.36
Arachidic acid						
Cross 1	1.2±0.21**	0.04±0.03	1.05±0.59	0.3±0.20	0.08±0.19	-0.8±0.14
Cross 2	1.04±0.19**	0.2±0.03**	0.6±0.57	0.3±0.19	-0.1±0.19	-0.3±0.40
Cross 3	1.3±0.18**	-0.02±0.02	0.6±0.53	0.1±0.18	-0.08±0.17	-0.5±0.36
Eicosenoic acid						
Cross 1	1.3±0.09**	0.04±0.03	-0.4±0.29	-0.2±0.09*	-0.2±0.10	0.1±0.21
Cross 2	1.1±0.12**	0.04±0.03	0.4±0.33	0.03±0.11	-0.2±0.12	-0.5±0.23*
Cross 3	1.2±0.10**	0.1±0.02**	-0.2±0.28	-0.03±0.09	0.08±0.09	0.06±0.19
Behenic acid						
Cross 1	3.9±0.35**	0.04±0.12	0.1±0.99	-0.3±0.32	-0.2±0.38	-0.4±0.68
Cross 2	2.9±0.29**	0.01±0.07	2.8±0.87**	0.9±0.29**	0.3±0.29	-1.7±0.64*
Cross 3	4.2±0.32**	-0.3±0.06**	0.7±0.89	-0.1±0.31	0.4±0.29	-0.8±0.60
Lignoceric acid						
Cross 1	1.5±0.15**	0.04±0.03	0.3±0.43	-0.2±0.15	0.4±0.15*	-0.6±0.28*
Cross 2	1.5±0.12**	-0.03±0.03	0.6±0.34	0.1±0.12	-0.4±0.12*	-0.4±0.23
Cross 3	1.6±0.12**	-0.1±0.03**	0.2±0.34	-0.05±0.12	0.18±0.11	-0.3±0.23
O/L ratio						
Cross 1	1.9±0.20**	0.2±0.04**	0.6±0.58	0.02±0.19	-0.1±0.20	-0.5±0.39
Cross 2	1.6±0.21**	0.5±0.04**	0.3±0.62	0.04±0.21	-0.6±0.21*	-0.60±0.42
Cross 3	1.5±0.18**	0.5±0.03**	-0.4±0.51	0.20±0.02	-0.4±0.17*	0.3±0.35
Iodine value (IV)						
Cross 1	92.0±1.20**	-0.8±0.14**	-1.7±3.41	0.6±1.19	2.9±1.10*	2.4±2.32
Cross 2	94.1±1.78**	-3.0±0.40**	-2.8±5.23	-0.6±1.74	1.7±1.83	4.8±3.65
Cross 3	94.8±1.87**	-3.6±0.23**	0.1±5.27	0.6±1.85	2.2±1.69	0.6±3.59
TSF						
Cross 1	21.0±1.33**	-0.4±0.29	-2.9±3.88	-1.1±1.29	-1.3±1.36	1.7±2.65
Cross 2	20.9±1.08**	-1.3±0.18**	-0.9±3.16	0.7±1.07	3.1±1.06*	1.9±2.19
Cross 3	22.3±0.94**	-1.9±0.14**	1.2±2.58	-0.8±0.93	0.9±0.82	-1.4±1.78
P/S ratio						
Cross 1	1.3±0.08**	-0.0±0.01**	-0.02±0.24	0.06±0.08	0.2±0.08	0.1±0.16
Cross 2	1.4±0.09**	-0.1±0.02**	-0.1±0.29	-0.04±0.09	0.01±0.09	0.2±0.20
Cross 3	1.4±0.09**	-0.2±0.01**	0.03±0.28	0.05±0.09	0.1±0.09	0.03±0.19
TLCSF						
Cross 1	6.6±0.53**	0.1±0.15	1.5±1.52	-0.3±0.51	0.3±0.55	-1.9±1.02
Cross 2	5.4±0.46**	0.2±0.08*	4.0±1.35*	1.4±0.46*	-0.2±0.45	-2.3±0.97*
Cross 3	7.1±0.48**	-0.5±0.08**	1.5±1.33	-0.04±0.47	0.5±0.43	-1.6±0.91

IV = (%oleic acid)(0.8601)+(%linoleic acid)(1.7321)+(%eicosenoic acid)(0.7854); TSF = palmitic acid + stearic acid + arachidic acid + behenic acid + lignoceric acid; P/S = linoleic acid / TSF; TLCSF = arachidic acid + Behenic acid + lignoceric acid ; ** - significant at 1% and * - significant at 5% level

Inheritance of fatty acid content and related quality traits in groundnut

Table 3 Per cent phenotypic variation explained for each trait in cross 1: ICGV 88438 x ICGV 88448; Cross 2 : ICGV 96234 x Hard Kernel Mutant and cross 3 : ICGV 96234 x JL 24

Trait	d	h	l	j	l
Palmitic acid					
Cross 1	44.76	2.93	28.06	-	23.00
Cross 2	88.91	2.63	-	5.08	1.85
Cross 3	92.97	2.24	2.22	-	2.50
Stearic acid					
Cross 1	55.77	-	-	24.18	15.46
Cross 2	88.51	-	-	-	-
Cross 3	63.05	23.96	-	-	-
Oleic acid					
Cross 1	74.69	-	13.66	-	-
Cross 2	83.05	-	-	2.50	-
Cross 3	97.77	-	-	-	-
Linoleic acid					
Cross 1	43.83	-	31.67	14.52	-
Cross 2	91.09	-	-	0.51	-
Cross 3	98.77	-	-	-	-
Arachidic acid					
Cross 1	-	33.95	-	-	35.68
Cross 2	87.76	-	-	-	-
Cross 3	1.93	41.96	-	-	-
Eicosenoic acid					
Cross 1	-	-	54.62	37.90	-
Cross 2	-	-	55.63	-	-
Cross 3	88.49	-	-	-	-
Behenic acid					
Cross 1	35.27	-	60.78	-	-
Cross 2	-	9.53	27.82	-	57.83
Cross 3	53.88	-	-	-	-
Lignoceric acid					
Cross 1	-	25.29	54.93	8.06	3.47
Cross 2	40.12	-	-	23.66	-
Cross 3	41.18	-	37.19	-	-
O/L ratio					
Cross 1	43.37	-	43.08	-	-
Cross 2	83.43	-	-	1.50	-
Cross 3	96.34	-	-	1.31	-
Iodine value					
Cross 1	29.70	-	22.87	25.43	-
Cross 2	90.91	-	-	-	-
Cross 3	98.69	-	-	-	-
TSF					
Cross 1	91.63	-	-	-	-
Cross 2	67.80	-	-	14.97	-
Cross 3	84.89	-	-	-	-
P/S ratio					
Cross 1	23.16	30.36	-	26.03	-
Cross 2	87.28	-	-	-	-
Cross 3	96.32	-	-	-	-
TLCSFA					
Cross 1	-	-	85.15	-	-
Cross 2	20.26	9.47	27.59	-	36.57
Cross 3	55.62	-	-	-	-

Iodine number (IV)= (%oleic acid)(0.8601) + (%linoleic acid)(1.7321)+(%eicosenoic acid)(0.7854); Total Saturated Fatty acids (TSF) = palmitic acid + stearic acid + arachidic acid + behenic acid + lignoceric acid; Polyunsaturated / Saturated fatty acids ratio (P/S) = linoleic acid / TSF; Total long chain saturated fatty acids (TLCSF) = arachidic acid + Behenic acid + lignoceric acid

References

- Ahmed, E.M. and Young, C.T. 1982. Composition, nutrition, and flavour of peanuts. pp. 655-688. in H.E. Pattee and C.T. Young, (eds.), *Peanut Science and Technology*. Amer. Peanut Res. Educ. Soc. Inc., Yoakum, TX.
- Bansal, U.K., Satija, D.R. and Ahuja, K.L. 1992. Combining ability in inter- and intra- growth habit crosses for quality traits in groundnut *Arachis hypogaea* L. *SABRAO Journal*, **24**: 1-6.
- Bansal, U.K., Satija, D.R. and Ahuja, K.L. 1993. Oil composition of diverse groundnut (*Arachis hypogaea* L.) genotypes in relation to different environments. *Journal of Science, Food and Agriculture*, **63**: 17-19.
- Bovi, M.L.A. 1982. Genotypic and environmental effects on the fatty acid composition, iodine value and oil content of peanut (*Arachis hypogaea* L.) *Ph.D Dissertation*. University of Florida.
- Branch, W.D., Nakayama, T. and Chinnan, M.S. 1990. Fatty acid variation among U.S. runner-type peanut cultivars. *Journal of American Oil Chemical Society*, **67**: 591-593.
- Cavalli, L.L. 1952. Analysis of linkage in quantitative inheritance. In: E.C.R. Reeve & C.H. Waddington (Eds.), *Quantitative Inheritance*, pp. 135-144. H.M.S.O., London.
- Chandramouli, K. and Kale, D.M. 1990. Hard seed Hk: A new mutant in groundnut. *Groundnut News*, **2** (2): 3.
- Dwivedi, S.L., Nigam, S.N., Jambunathan, R., Sharawat, K.L., Nagabhushanam, G.V.S. and Raghunath, K. 1993. Effect of genotypes and environment on oil content and oil quality parameters and their correlation in peanut (*Arachis hypogaea* L.). *Peanut Science*, **20**: 84-89.
- Dwivedi, S.L., Nigam, S.N. and Prasad, M.V.R. 1998. Induced genetic variation for seed quality traits in groundnut. *International Arachis Newsletter*, **18**: 44-46.
- FAO. 2007. FAO Statistical Databases. Available at www.fao.org.
- Isleib, T.G., Wilson, R.F. and Novitsky, W.P. 2006. Partial dominance, pleiotropism, and epistasis in the inheritance of the high-oleate trait in peanut. *Crop Science*, **46**: 1331-1335.
- James, S.L.H. and Young, C.T. 1983. Comparison of fatty acid content of imported peanuts. *Journal of American Oil and Chemical Society*, **60**: 945-947.
- Khan, A.R., Emery, D.A. and Singleton, J.A. 1974. Refractive index as basis for assessing fatty acid composition in segregating populations derived from intraspecific crosses of cultivated peanut. *Crop Science*, **14**: 464-468.
- Knauff, D.A., Moore, K.M. and Gorbett, D.W. 1993. Further studies on the inheritance of fatty acid composition in peanut. *Peanut Science*, **20**: 74-76.
- Lopez, Y., Baring, M.R. Simpson, C.E. and Burrow, M.D. 2002. Inheritance of the high-oleic trait in peanut: Unsolved puzzle. *Proceedings of American Peanut Research and Education Society*, **34**: 68-69.
- Lopez, Y., Smith, O.D., Senseman, S.A. and Rooney, W.L. 2001. Genetic factors influencing high oleic content in Spanish market type peanut cultivars. *Crop Science*, **41**: 51-56.
- Mather, K. and Jinks, J.L. 1982. *Biometrical Genetics*. Third edition. Chapman and Hall, London.
- Mercer, L.C., Wynne, J.C. and Young, C.T. 1990. Inheritance of fatty acid content in peanut oil. *Peanut Science*, **17**: 17-21.
- Moore, K.M. and Knauff, D.A. 1989. The inheritance of high oleic acid in peanut. *Journal of Heredity*, **80**: 252-253.
- Mohamed-Som, H.Z. 1984. Chemical composition and flavor of Virginia-type peanuts. M.S. thesis, Dept. of food Science., N.C. State Univ. Raleigh.
- Mozingo, R.W., Cofflet, T.A. and Wynne, J.C. 1988. Market grade effects on the fatty acid composition of five peanut cultivars. *Agronomy Journal*, **80**: 73-75.
- Mozingo, R.W. and Steele, J.L. 1982. Fatty acid composition of peanut genotypes in the Virginia-Carolina production area. *Proceedings of American Peanut Research and Educational Society*, **14**: 29-39.
- Norden, A.J., Gorbett, D.W., Knauff, D.A. and Young, C.T. 1987. Variability in oil quality among peanut genotypes in the Florida breeding program. *Peanut Science*, **14**: 7-11.
- O'Bryne, D.J., Knauff, D.A. and Shireman, R.B. 1997. Low fat-monounsaturated rich diets containing high-oleic peanuts improve serum lipoprotein profiles. *Lipids*, **32**: 687-695.
- St. Angelo, A. J. and Ory, R. L. 1973. Investigations of causes and prevention of fatty acid peroxidation in peanut butter. *Journal of American Peanut Research Educational Association*, **5**: 128-133.
- Tai, Y.P. 1972. Ph.D. Dissertation, Oklahoma State University, Stillwater, OK, 1972, p. 93.
- Tai, Y.P. and Young, C.T. 1975. Genetic studies of peanut proteins and oils. *Journal of American Oil and Chemical Society*, **52**: 377-385.
- Treadwell, K., Mason, M.E. and Wynne, J.C. 1983. Evaluation of fatty acid content of forty peanut cultivars. *Oleagineux*, **38** (6): 381-385.
- Torres, A.M., Moreno, M.T. and Cubero, J.I. 1993. Genetics of six components of autofertility in *Vicia faba*. *Plant Breeding*, **110**: 220-228.
- Upadhyaya, H.D. and Nigam, S. N. 1999. Detection of epistasis for protein and oil contents and oil quality parameter in peanut. *Crop Science*, **39**: 115-118.
- Worthington, R.E. and Hammons, R.O. 1977. Variability in fatty acid composition among *Arachis* genotypes: A potential source of product improvement. *Journal of American Oil Chemical Society*, **54**: 105A-108A.
- Young, C.T. and Waller, G.R. 1972. Rapid oleic/linoleic micro-analytical procedure for peanuts. *Journal of Agriculture, Food and Chemistry*, **20**: 1116-1118.
- Young, C.T. and Worthington, R.E. 1974. Fatty acid composition of Spanish peanut oils as influenced by planting location, soil moisture conditions, variety, and season. *Journal of American Oil and Chemical Society*, **51**: 312-315.

RAPD markers linked to self-compatible and self-incompatible genotypes of sunflower, *Helianthus annuus* L.

Deepa Mehta, K.S. Boora and R.K. Sheoran

Department of Biotechnology and Molecular Biology, CCS Haryana Agricultural University, Hisar-125 004, Haryana

(Received: June, 2008; Revised: June, 2009; Accepted: July, 2009)

Abstract

Thirteen highly self compatible and thirteen self incompatible genotypes of sunflower, *Helianthus annuus* (L.) were subjected to identify marker(s) closely linked to the respective locus. Bulk segregant analyses coupled with RAPD markers were used in this study. Two closely linked molecular markers, OPA-9 and OPE-2 for self compatible and self incompatible locus have been identified. Marker OPA-9 was located at 7.69 cM and marker OPE-2 was located at 11.53 cM from the respective locus. These markers may be converted into SCAR markers for utilizing in marker assisted breeding programmes.

Key words: Sunflower, self-compatible, self-incompatible, molecular markers

Introduction

Sunflower (*Helianthus annuus* L.) is highly cross pollinated crop due to protoandrous condition in which male flower matures earlier to the female flower. It also shows varying degree of self-incompatibility. Current commercial sunflower varieties/hybrids are self compatible. However, environmental conditions can influence the level of self fertility expression (Snow et al., 1998).

One of the important constraints limiting productivity in sunflower is the high percentage of empty and partially filled seeds. Seed setting in sunflower is a complex phenomenon and several workers have ascribed its physiological, genetic, nutritional and environmental factors (Vranceanu et al., 1976; Chaudhary and Anand, 1981 and Khanna, 1972). Although this crop is highly cross pollinated due to the presence of saprophytic self incompatibility mechanism, yet self fertility and autogamy is reported in the hybrids and open pollinated varieties and inbred lines to a varying extent (Fick, 1978; Shivraju et al., 1988, Gowda and Giriraj, 1989). One of the means to overcome this problem is by identifying self fertile and open pollinating lines (Gowda and Giriraj, 1989). Traditionally, identification and evaluation of a self compatible genotype is based on its morphological characters such as seed yield and seed set under different treatments viz., cloth bags, cloth bag with manual pollination and open pollination (Dodoamani et al., 1997). The development of molecular markers for self

compatibility and self incompatibility reduce time and efforts to identify self compatible and self incompatible genotypes.

Materials and methods

This study was conducted on 26 genotypes of *Helianthus annuus* (L.). Out of which thirteen were self compatible and thirteen were self incompatible. Genotypes were selected on the basis of high compatibility and self incompatibility.

DNA extraction and bulk preparation: Leaf samples were collected from each of the twenty six (13 self compatible + 13 self incompatible) genotypes of sunflower. DNA extraction was conducted following CTAB (cetyl trimethyl ammonium bromide) extraction method of Murray and Thompson (1980), modified by Saghai Maroog et al. (1984). Equal quantities of DNA were bulked from thirteen self compatible and thirteen self incompatible genotypes to give two DNA bulks each for self compatible and self incompatible genotypes.

RAPD analysis: Random decamer primers (Operon Technologies Inc. USA) were used to identify polymorphism. A total of 54 primers were used and of these 38 primers produced amplification genotypes.

Results and discussion

In breeding programme, the applicability of molecular markers depends on a fast detection method and on the specificity of the marker for the gene of the interest in genetically diverse breeding material. Here, we have described the development of molecular marker for the self compatible and self incompatible genotypes. Bulk segregant analysis was useful in the present study, since it was possible to detect a RAPD markers for self compatible and self incompatible genes.

Thirteen self-compatible and thirteen self-incompatible genotypes were taken for this study. Fifty four RAPD primers were used to find out polymorphism among the genotypes. Two genotypes, one highly self-compatible and other highly self incompatible were used to screen with 54 random oligos to find out the polymorphism. All the self compatible and self-incompatible genotypes were bulked in equal amount to prepare self compatible and self incompatible bulk, respectively. All the 54 RAPD primers were screened for polymorphism against the two bulks also. Out of these, thirty eight primers showed

polymorphism. Polymorphic markers were then screened against all the individual genotypes used for bulk preparation. A total of 109 discrete bands were produced by 54 primers. Out of 109 bands, 71 were polymorphic which corresponds to 65.13% and 38 were monomorphic which corresponds to 34.87% (Table 1). These primers produced with an average of 1.86 polymorphic bands per primer. Sivolap-Yu *et al.* (1998) used twenty one primers, out of which eleven primers showed polymorphism. Ji-Jing-Wang-Gang *et al.* (1996) identified molecular marker of nuclear restoration gene RF1 by carried out six hundred twenty RAPD reaction between fertile and sterile DNA bulks using eighty decamer operon primers.

Table 1 RAPD primers used for screening polymorphism

Primer	Number
Total primers used	54
Primers which produced amplification	45
Primers which produced polymorphic bands	38
Primers which produced monomorphic bands	7
Total fragment amplified	109
Total number of polymorphic band	71

Out of 54 primers, 38 primers which produced polymorphism among bulked were used to screen individual genotypes to identify markers linked to self compatible and self incompatible gene. RAPD primers produced polymorphic bands which is 70.37% of the total primers used. Dissimilarity value was calculated which varied from 0.33 to 1.00 (Table 2). Two primers OPA-9 and OPE-2 produced unique bands in self compatible and self incompatible genotypes only. Primer OPA-9 produced unique band in 11 self-compatible genotypes but no amplification in self-incompatible genotypes which is approx. 700 bp (Fig.1). This marker is located at a distance of 7.9 cM away from the locus governing self incompatible. Primer OPE-2 produced unique band in 10 self incompatible genotypes but no amplification in self-compatible genotypes which is approx. 650 bp (Fig.2). This marker is located at a distance of 11.53 cM away from the locus governing self compatibility. Dehmer and Friedt (1996) identified two RAPD markers for high oleic

acid content in sunflower. Smith (2005) developed molecular CAPS marker for self incompatibility locus in *Brassica napus*.

Table 2 RAPD primers produced polymorphic bands

Primers	Band scored		Total	Dissimilarity Value(1-F)
	Polymorphic	Monomorphic		
OPA4	3	1	4	0.50
OPA9	1	2	3	0.60
OPA11	1	0	1	1.00
OPA13	1	0	1	1.00
OPA15	2	0	2	1.00
OPA16	3	0	3	1.00
OPA10	1	0	1	1.00
OPB13	3	1	4	0.50
OPB15	2	1	3	0.34
OPB20	2	1	3	0.34
OPC6	2	0	2	1.00
OPC7	1	0	1	1.00
OPC9	1	0	1	1.00
OPC10	1	0	1	1.00
OPC11	0	1	1	1.00
OPC13	1	0	1	1.00
OPC14	3	2	5	0.50
OPC15	2	1	3	0.33
OPC16	1	0	1	1.00
OPC18	3	1	4	0.50
OPC19	0	3	3	0.34
OPD3	2	0	2	1.00
OPD8	2	0	2	1.00
OPD11	1	1	2	0.00
OPD13	1	2	3	0.33
OPD15	2	0	2	1.00
OPD18	4	1	5	0.60
OPD19	2	1	3	0.33
OPE2	1	1	2	0.00
OPE3	1	3	4	0.50
OPE5	3	1	4	0.34
OPE6	2	1	3	0.33
OPE8	3	1	4	0.50
OPE10	2	0	2	1.00
OPE14	2	1	3	0.34
OPE18	2	0	2	1.00
OPJ1	4	0	4	1.00
OPD2	2	0	2	1.00

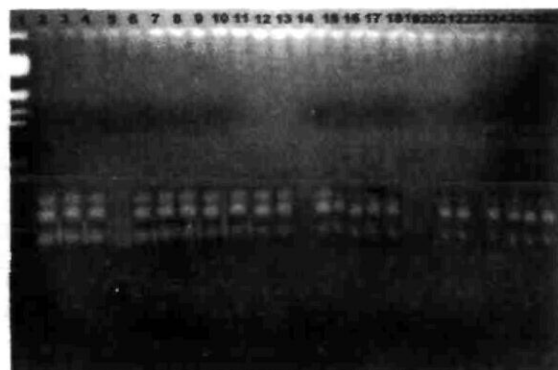


Fig 1: Electrophoretic pattern of self compatible and self incompatible genotypes with marker OPA-9

Lane 1: Lambda DNA double digest marker.; Lane 2-14: Self compatible genotypes; Lane 15-27: Self incompatible genotypes

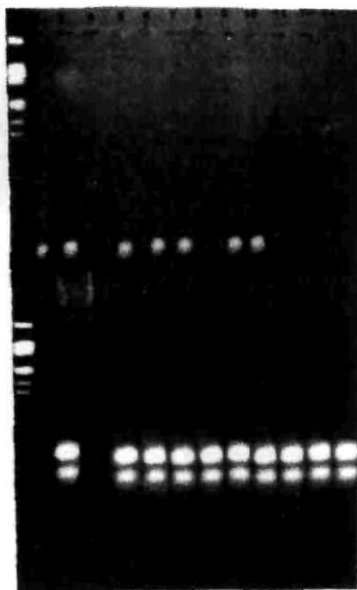


Fig 2: Electrophoretic pattern of self compatible and self incompatible genotypes with marker OPA-9
Lane 1: Lambda DNA double digest marker.; Lane 2-14: Self compatible genotypes; Lane 15-27: Self incompatible genotypes

Marker OPA-9 and OPE-2 inherited with locus for self incompatibility and self compatibility may be used for breeding purpose using marker assisted selection in sunflower. This can be use in identifying of self compatible and self incompatible gene(s) using map based cloning which can be further utilized in incorporation of self compatible gene(s) into sunflower via genetic transformation.

References

- Chaudhary, S.K. and Anand, I.J. 1981. Seasonal influence on seed filling in sunflower. *Proceedings 4th International SABRAO Congress, Kaula Lampur*, 22-24.
- Dehmer, K. J. and Friedt W. 1996. *Third European Symposium on Industrial Crop and Products*, Reims, France, 7:311-315
- Doddamani, I.K., Patil, S.A. and Ravi Kumar, R.L. 1997. Self compatibility and seed set in selected genotypes of sunflower (*Helianthus annuus* L.). *Crop Improvement*, 24: 207-212.
- Fick, G.N. 1978. *Breeding and Genetics*. J.F.Carter (ed) Sunflower Science and Technology. American Society of Agronomy. Madison, U.S.A, 279 - 338.
- Ji-Jing-Wang-Gang, Belhassen, E., Serieys, H and Berville, A 1996. Molecular markers of nuclear restoration gene Rf1 in sunflower using bulked segregant analysis RAPD. *Life-Sciences*, 39(5): 551-560.
- Gowda, S. and Giriraj, K. 1989. Evaluation of sunflower inbreds, hybrids and populations for self compatibility over seasons. *Indian Journal of Genetics and Plant Breeding*, 49:1-7.
- Khanna, K.R. 1972. Factors affecting the production of filled seeds in sunflower. *Euphytica*, 21:384-387.
- Murray, M.G. and Thompson, W.F. 1980. Rapid isolation of high molecular weight plant DNA. *Nucleic Acid Research*, 8: 4321-4325.
- Saghai, Maroog, M.A., Saliman, K.M., Jorgensen, R.A. and Allard, R.W. 1984. Ribosomal DNA spacer length polymorphism in barley. Mendelian inheritance, chromosomal location and population dynamics. *Proceedings National Academy of Sciences, U.S.A.*, 81: 8014-8018
- Shivraju, N., Giriraj, K., Shanta, R.H. and Seetharam, A. 1987. Autogamy in sunflower. *Journal of Oilseeds Research*, 4: 292 - 294.
- Sivolap-Yu, M., Solodenko, A.E. and Burlov, V.V. 1998. RAPD analysis of molecular genetic polymorphism in sunflower *Helianthus annuus*. *Genetika*, 34(2) : 266-271.
- Smith, K. L. 2005. *Plant Breeding*, 124: 105-109
- Snow, A.A.; Moran - Palina, P.; Reisberg, L.H. Wszelabi, A and Seiler, G.J. 1998. Fecundity, Phenology and seed dormancy of FI wild-crop hybrid in sunflower (*Helianthus annuus* L.). *American Journal of Botany*, 85(6): 794-801.
- Vranceanu, A.V., Stoenescu, F.M. and Scarlet, A. 1976. The influence of different genetic and environmental factors on pollen self compatibility in sunflower *Proceedings 8th International Sunflower Conference*, Minneapolis, U.S.A., 453-465.

Heterosis and combining ability for seed yield and other yield contributing characters in sunflower, *Helianthus annuus* L.

M. Sujatha and A. Vishnuvardhan Reddy

Department of Genetics and Plant Breeding, College of Agriculture, ANGRAU, Rajendranagar, Hyderabad-500 030, AP

(Received: June, 2008; Revised: April, 2009; Accepted: July, 2009)

Abstract

Four lines were crossed with 10 testers in a LxT mating design to estimate the heterosis and combining ability for yield and its component traits in sunflower (*Helianthus annuus* L.). Among the 40 hybrids studied for heterosis six recorded positive significant heterosis, heterobeltiosis and standard heterosis over two checks (KBSH I and PAC 1091) for seed yield and oil content. The variance due to SCA was greater than GCA for all the traits except head diameter, which indicated preponderance of non-additive gene action for all the traits while additive gene action for head diameter. The parents DCMS 36, DRS 9, DRS 102 and RHA 340 can be considered as superior parents and the crosses DCMS 36 x DRS 16, CMS 7-1A x RHA 340, CMS 7-1A x DRS 9 were considered as superior hybrids, as they observed high *per se* and significant *gca* and *sca* effects for seed yield/plant. These superior crosses involved parents with high x low, low x low and high x high *gca* effects, which in turn suggested the possible role of non-additive gene action in these crosses.

Key words: Sunflower, heterosis, combining ability, yield, yield components

Introduction

The discovery of cytoplasmic male sterility (Leclercq, 1969) and subsequent identification of restorers (Enn's *et al.*, 1970) have significantly contributed in genetic improvement of the crop as well as in exploitation of heterosis, leading to development and release of several hybrids for commercial cultivation. To develop sunflower hybrids with improved yield potential, the choice of parents through careful and critical evaluation is of paramount importance. Sunflower, being a cross pollinated crop offers a great scope for development of new and superior hybrids. The heterosis could be used as an indicative of the crosses, which are likely to throw productive transgressive segregants. Hence, there is an urgent need to collect basic information about these traits in order to conceptualize breeding strategies suited to specific conditions. The objective of this study is to determine the

combining ability of 14 parents for yield and yield components. The studies envisage assessing general combining ability of parents and specific combining ability of crosses through appropriate biometrical methods. Combining ability studies elucidates the nature and magnitude of gene action involved in the inheritance of character by providing the information on the two components of variance viz., additive and dominance variance, which are important to decide upon the parents and crosses to be selected for eventual success. Such information is required to design efficient breeding programme for rapid crop improvement.

Material and methods

Four lines CMS 234A, CMS7-1A, DCMS 6 and DCMS 36 were crossed with ten testers (DRS 45, DRS 52, DRS 16, DRS 22, RHA 340, DRS 9, DRS 102, DRS 55, DRS 34, and R83R6) in a line x tester model during rabi 2004. Forty F_1 hybrids along with their 14 parents were grown in a Randomized Block Design (RBD) with three replications during *kharif*, 2005 at Directorate of Oilseeds Research (DOR) farm, Rajendranagar, Hyderabad. These 40 F_1 hybrids, along with parents were evaluated for heterosis for nine morphological and quantitative characters in *kharif* 2005. The mean values were subjected to line x tester analysis (Kempthorne, 1957) to estimate combining ability effects and variances.

Both parents and F_1 s were raised in 5 rows of 3m length. Observations were recorded on 10 randomly selected plants from each entry in three replications for nine quantitative characters viz., plant height(cm), days to 50% flowering, days to maturity, head diameter, number of leaves/plant, number of seeds/plant, 100 seed weight, seed yield/plant and oil content.

Results and discussion

The heterosis in negative direction is considered desirable for plant height. Among 40 hybrids, 30 hybrids recorded significant positive heterosis, while six hybrid combinations exhibited significant negative heterosis (Table 4a). The hybrid, DCMS 6 X DRS 45 recorded the least heterosis, heterobeltiosis and standard heterosis for this character. Loganathan and Gopalan (2006 b) reported both positive and negative heterosis, while only negative heterosis has been reported by Phad *et al.*, (2002). For days to 50%

flowering and days to maturity, the hybrid DCMS 36 x DRS 45 registered the highest and negative standard heterosis. The present findings are in agreement with the earlier investigations by Kandhola *et al.* (1995). However, positive heterosis for these traits has also been reported by Gill and Sheoran (2002) and Phad *et al.* (2002).

Significant positive and negative heterosis has been recorded for head diameter in some of the crosses which is in agreement with the reports of earlier workers viz., Radhika *et al.* (2001), Goksay and Turan (2004) and Manivannan *et al.* (2005).

For number of seeds/plant, majority of the crosses showed positive heterosis, heterobeltiosis and standard heterosis. The hybrids DCMS 6 x DRS 102, CMS 7-1A x DRS 34 and DCMS 36 x DRS 45 recorded high heterosis percent over mid parent. These results are in accordance with the reports of Madrap and Makne (1993), Limbore *et al.* (1998), Lande *et al.* (1988), Goksoy *et al.* (2000) and Loganathan and Gopalan (2006b).

Both positive and negative heterosis, heterobeltiosis and standard heterosis were recorded for 100 grain weight. These results are in accordance with Loganathan and Gopalan (2006b), while only positive heterosis has been reported by Lande *et al.* (1993), Radhika *et al.* (2001), and Gill and Sheoran (2002) and only negative heterosis is being reported by Kadkol *et al.* (1984).

For seed yield/plant, 21 and 18 hybrids registered significant and positive heterosis and heterobeltiosis, respectively. Among 40 hybrids studied 12 hybrids over KBSH 1 and 14 hybrids over PAC 1091 recorded significant and positive standard heterosis. The hybrids CMS 7-1A x DRS 9 (80.76%), DCMS 36 x DRS 22 (72.86%) and DCMS 36 x DRS 9 (70.93%) registered high heterosis. These results are in accordance with Gangappa *et al.* (1993), Madrap and Makne (1993), Kandhola *et al.* (1995), Gill *et al.* (1998), Radhika *et al.* (2001) and Loganathan and Gopalan (2006b).

The hybrids exhibited both positive and negative heterosis for oil content. Twenty five out of 40 hybrids recorded significant and positive heterosis while 17 hybrids have recorded significant and positive heterobeltiosis. The hybrids DCMS 36 x DRS 102, DCMS 36 x DRS 22 and CMS 7-1A x DRS 22 showed highest positive heterosis. The above results are in agreement with the results of Kadkol *et al.* (1984), Kandhola *et al.* (1995), Rather and Sandha (1999), Gill and Sheoran (2002), Loganathan and Gopalan (2006b). CMS 7-1A x DRS 45, DCMS 36 x DRS 16, CMS 7-1A x RHA 340, DCMS 36 x DRS 22 and CMS 7-1A x DRS 9 are the five crosses which exhibited significant standard heterosis for seed yield and oil content.

Analysis of variance for combining ability revealed the variances due to lines was significant for head diameter and oil content. While, variance due to testers was

significant for days to 50% flowering, no of seeds/plant, seed yield/plant. The interaction effect (line x tester) was significant for all the traits. The variance due to specific combining ability was greater than the variance due to general combining ability except for head diameter, which indicated the predominant role of non additive gene action in the expression of these traits. Additive gene action for head diameter, non-additive gene action for these traits was earlier reported by Devi *et al.* (2005), Madhavilatha *et al.* (2005), Gopalan and Loganathan (2006a), Rather *et al.* (1998). The discrepancy among the results reported may be due to the differences in the selection of reference material.

The *per se* performance of parents (Table 5) was considered as the first important criterion for selection. Perusal of the *per se* performance of parents indicated that the parents, DCMS 36, DRS 63, RHA 340, DRS 16 were high yielders and DCMS 36, DRS 63, DCMS 15 and DSI 257 were the parents with high oil content among all the parents. Based on *per se* performance for seed yield per plant and oil content these four parents were identified as desirable parents. The second criteria of selection is the general combining ability (*gca*) effects of parents because the parents with high mean values may not necessarily be able to transmit their superior traits to their progenies. The results indicated that one line DCMS 36 and three testers RHA 340, DRS 9 and DRS 102 recorded significantly positive *gca* effects for seed yield/plant (Table 2). The line DCMS 36 also recorded positive and significant *gca* effects for number of leaves/plant, number of seeds/plant, 100 seed weight, seed yield/plant, days to 50% flowering and days to maturity. The tester parents RHA 340, DRS 9 and DRS 102 recorded positive significant *gca* effects for number of leaves/plant, number of seeds/plant. The parents which observed to be good general combiners for yield also possessed *gca* effects in the desired direction for yield components. Rao and Singh (1977) observed that no parent was found to contain all the favourable or unfavourable genes for all the characters as in the case of present study. In contrast a parent showing high *gca* effects for component trait is not necessarily good general combiner for grain yield i.e., inbreds with some of the desirable traits also possessed certain undesirable traits. Toms and Pooni (1995), observed that significant differences existed between both the CMS and restorer lines in their general combining abilities. Therefore, for improving a specific character, the parents showing high *gca* in desirable direction can be used as good donors for improvement of that character.

Association between *per se* performance and *gca* effects was not evident in the present study. Infact, in many cases, the lines and testers with high mean had low *gca* effects indicating the ineffectiveness of choice of parents based on *per se* performance for hybridization. Selection

of parents based on *gca* is more important than *per se* performance. Hence, based on *gca* effects, the parents viz., DCMS 36, DRS 9, DRS 102 and RHA 340 can be considered as superior parents for future use.

Among the '40' crosses evaluated some of them recorded significantly superior seed yield/plant. However the crosses DCMS 36 x DRS 16, CMS 7-1A x RHA 340, CMS 7-1A x DRS 9 recorded high seed yield/plant, which was on par with general mean. The cross DCMS 36 x DRS 16 registered high oil content. Hence based on *per se* performance, the above five crosses can be considered as superior for seed yield.

In contrast to the *gca* effects being attributable to additive genetic effects, *sca* denotes dominance and epistatic gene effects that are non-fixable. Parents with good combining ability and the resultant cross with non-significant *sca* are considered desirable (eg. DCMS 36 x DRS 34 is the cross having non-significant *sca* and parents with significant *gca* values) for population development programme due to presence of additive gene action.

Even in crosses with significantly high *sca* effects, if one of the parents involved are good combiner, then, these crosses can also be considered to varietal development due to the presence of additive type of epistasis. However, in case of later, selection should be postponed to later generations. In case of the hybrids with high mean, high *gca* and parents involved are poor combiners, they may

be useful for hybrid development.

Fifteen out of 40 crosses occupied first three ranks for five characters (Table 5). Of the 15, three crosses were between high x high, 11 crosses between high x low and only one cross - involved between low x low *gca* parents.

Considering the performance for seed yield/plant, the crosses DCMS 36 x DRS 34 recorded non-significant *sca* effect and in turn both the parents of the cross appeared to be involved are good combiners. In the case of the cross DCMS 36 x DRS 45 non-significant *sca* effect was recorded. However, one of the parent DCMS 36 was a good combiner and another parent DRS 45 was a poor combiner. The cross CMS 234A x DRS 16 registered significant *sca* effects and the gene action involved is of additive type of interaction, where as both the parents are poor combiners. Identification of heterotic crosses involving high x low *gca* cross combinations as revealed in the present study were earlier reported by Kadkol *et al.* (1984), Giniraj *et al.* (1987) and Limbore *et al.* (1997). In addition, crosses with high *sca* effects involving parents with high x high *gca* effects were also reported by Limbore *et al.* (1997) and low x low by Kadkol *et al.* (1984) and Giriraj *et al.* (1987).

From the foregoing discussion, it may be concluded that the crosses, DCMS 36 x DRS 16, CMS 7-1A x DRS 9 and DCMS 36 x DRS 45 were rated as the best crosses for adopting heterosis breeding method.

Table 1 Analysis of variance for combining ability for yield and its components in sunflower

Source of Variation	df	Plant height	Days to 50% flowering	Days to maturity	Head diameter	No. of leaves/ plant	No. of seeds/ plant	100 seed weight	Seed yield/ plant	Oil content
Replications	2	212.35	3.86	4.34	5.22	12.34	465.35	0.46	13.83	1.88
Treatments	53	2006.05**	32.23**	51.73**	60.92**	60.91**	93988.25**	2.99**	256.63**	110.49**
Parents	13	1180.09**	42.92**	21.34**	25.73**	54.35**	53248.95**	1.22**	60.76**	65.08**
Parents vs. Crosses	1	51261.86**	13.14*	812.98**	1002.99**	128.10**	411955.71**	20.57**	3025.31**	8.70*
Crosses	39	1018.40**	29.16**	42.34**	48.50**	61.38**	99415.01**	3.13**	250.93**	128.23**
Lines	3	818.62	20.10	13.17	467.63**	11.18	133290.02	5.13	66.96	91.44
Testers	9	1644.37	58.20*	25.31	19.58	69.08	168433.52*	3.42	496.04*	198.44
Lines x Testers	27	831.94**	20.49*	51.26**	11.57**	64.39**	72644.95**	2.80**	189.66**	108.92**
Error	106	102.15	2.86	1.81	1.81	5.67	1500.21	0.32	14.48	2.08
<i>gca</i> Variance		53.78	1.73	0.83	11.51	1.64	7112.45	0.18	12.71	0.39
<i>sca</i> Variance		243.26	5.87	16.48	3.25	19.57	23714.90	0.82	58.39	14.97
$\sigma^2_{gca} / \sigma^2_{sca}$		0.22	0.29	0.05	3.54	0.08	0.29	0.21	0.21	0.02
Degree of dominance		1.5	1.3	3.15	0.37	2.44	1.29	0.54	1.51	4.32

** = Significant at 1% level; * = Significant at 5% level

Table 2 Estimates of general combining ability (gca) effects for lines and testers for nine characters in sunflower

Parents	Plant height	Days to 50% flowering	Days to maturity	Head diameter	Leaves/plant	Seeds/plant	100 seed weight	Seed yield/plant	Oil content
Lines									
DCMS 15	-4.81**	-0.75**	-0.15	-2.34**	0.00	11.30	-0.33**	1.08	0.55*
DCMS 1	-1.60	-0.65*	-0.78**	-1.28**	0.85*	22.62**	0.47**	1.48*	-0.99**
DCMS 6	-1.00	0.85**	0.11	-2.25**	-0.33	22.48**	-0.36**	-1.08	-1.75**
CMS 7-1A	7.42**	0.55*	0.82**	5.87**	-0.53	-56.40**	0.22*	-1.48*	2.19**
SEi	1.84	0.30	0.24	0.25	0.43	7.07	0.10	0.69	0.26
Testers									
DRS 45	0.66	-2.15**	-0.40	-2.74**	-2.78**	10.83	-0.55**	-3.28**	-8.33**
DRS 52	3.26	1.85**	0.18	-0.72	-2.57**	-117.58**	-0.43**	-8.93**	-2.02**
DRS 27	-7.45*	-0.40	0.85*	-1.10**	0.97	-98.83**	0.06	0.64	-4.54**
DRS 19	9.62**	2.10**	1.93**	0.28	-0.78	10.25	0.55**	-0.92	4.09**
DRS 55	12.70**	1.10*	-0.40	0.28	1.97**	222.75**	-0.82**	5.32**	4.51**
DRS 16	-25.01**	-3.40**	-1.81**	0.97*	1.72*	124.50**	0.34*	10.80**	3.34**
DRS 28	-7.09*	-2.65**	-0.07	1.04**	2.23**	45.00**	0.75**	6.19**	1.86**
DRS 22	-0.01	-0.65	-2.15**	-0.49	-0.28	9.25	-0.43**	-3.20**	-0.89*
DRS 9	-1.94	1.10*	2.43**	1.18**	-2.77**	-19.33	0.45**	2.37*	1.06*
DRS 34	15.26**	3.10**	-0.57	1.29**	2.30**	-186.83**	0.08	-8.99**	0.92*
SEj	1.84	0.49	0.39	0.39	0.68	11.18	0.16	1.09	0.41

** = Significant at 1% level; * = Significant at 5% level

Table 3 Estimates of specific combining ability (sca) effects for nine characters in sunflower

Crosses	Plant height	Days to 50% flowering	Days to maturity	Head diameter	Leaves/plant	Seeds/plant	100 seed weight	Seed yield/plant	Oil content
DCMS 15 x DRS 45	-5.06	2.25*	2.73**	-2.05**	-0.25	-175.63**	-0.44	-11.03**	-0.30
DCMS 15 x DRS 52	-8.32	-1.75	0.81	-4.08**	-3.12*	61.78**	0.46	5.55*	0.92
DCMS 15 x DRS 27	0.38	-0.50	4.15**	0.09	-5.50**	256.70**	-0.07	8.29**	-4.13**
DCMS 15 x DRS 19	-12.68*	3.00**	5.06**	-0.09	1.74	-69.05**	-0.76*	-3.83	-5.61**
DCMS 15 x DRS 55	-3.77	0.00	-0.60	1.91*	2.49	-84.55**	0.62	-0.86	5.42**
DCMS 15 x DRS 16	8.94	0.50	-3.18**	-0.97	-0.25	58.70*	-0.40	-1.35	8.40**
DCMS 15 x DRS 28	-16.97**	-1.25	2.06**	-0.34	-2.25	4.20	-1.00**	-6.70**	-9.80**
DCMS 15 x DRS 22	6.93	-3.25**	-2.85**	1.78*	4.74**	-20.05	0.45	0.35	-1.84*
DCMS 15 x DRS 9	13.87*	-2.00*	-8.10**	2.20**	-1.75	55.20*	0.47	7.79**	5.20**
DCMS 15 x DRS 34	16.67**	3.00**	-0.10	1.53	4.16**	-87.30**	0.66*	1.79	1.72*
DCMS 1 x DRS 45	3.06	1.15	0.03	0.68	4.89**	57.03*	-0.06	4.16	0.11
DCMS 1 x DRS 52	-15.53**	2.15*	0.45	2.15**	1.18	-106.55**	-0.19	-5.10*	2.35**
DCMS 1 x DRS 27	-18.81**	-1.60	-6.21**	1.53**	-0.35	51.70*	0.90**	13.33**	12.87**
DCMS 1 x DRS 19	-0.89	-3.10**	2.36**	-0.15	-7.10**	127.61**	0.71*	-5.96**	0.60
DCMS 1 x DRS 55	-4.977	-3.10**	-3.96**	-2.14**	2.64	-70.88**	-0.98**	-7.96**	3.67**
DCMS 1 x DRS 16	34.74**	0.40	-2.55**	0.16	-0.10	53.36*	-1.77**	-4.06	-2.77**
DCMS 1 x DRS 28	17.82**	-0.35	3.70**	0.92	2.89*	-157.13**	1.06**	-2.22	-1.51
DCMS 1 x DRS 22	-16.76**	-0.35	2.78**	-2.37**	-5.10**	233.61**	-0.59	7.07**	-0.48
DCMS 1 x DRS 9	-12.23*	1.90	3.20**	-1.25	-2.60	-76.80**	1.05**	1.46	-9.54**
DCMS 1 x DRS 34	13.59*	2.90**	0.20	0.44	3.64**	48.03*	-0.11	-0.71	-5.30**
DCMS 6 x DRS 45	-13.03*	-0.35	5.80**	1.85*	-3.92**	139.20**	0.71*	11.56**	5.45**
DCMS 6 x DRS 52	7.42	1.65	-1.11	-0.36	2.87*	-31.38	-0.48	0.51	-0.65
DCMS 6 x DRS 27	20.27**	3.90**	-0.11	0.31	-0.17	-101.13**	-1.33**	-13.02**	-6.86**
DCMS 6 x DRS 19	4.50	-0.60	-5.53**	1.73*	6.07**	242.78**	0.89**	14.13**	7.03**
DCMS 6 x DRS 55	0.08	0.40	1.13	2.23**	-7.17**	-105.71**	0.52	-2.57	-10.23**
DCMS 6 x DRS 16	-21.93**	-0.10	1.55*	-0.31	5.07**	-253.46**	2.50**	1.41	-2.36**
DCMS 6 x DRS 28	4.78	-0.85	-5.20**	-2.22**	-2.92*	201.03**	-1.19**	2.15	4.73**
DCMS 6 x DRS 22	22.52**	2.15*	0.88	0.99	6.07**	-194.21**	0.08	-8.03**	-0.22
DCMS 6 x DRS 9	-2.27	0.40	3.30**	-2.02*	0.57	22.36	-1.42**	-7.90**	0.45
DCMS 6 x DRS 34	-22.37**	-6.60**	-0.70	-2.18**	-6.50**	80.53**	-0.28	1.76	2.65**
CMS 7-1A x DRS 45	15.03*	-3.05**	-8.56**	-0.47	-0.72	-70.60**	-0.20	-4.68*	-5.26**
CMS 7-1A x DRS 52	16.43**	-2.05*	-0.15	-0.21	-0.92	-73.85**	-0.54	-0.97	-2.63**
CMS 7-1A x DRS 27	-1.84	-1.80	2.18**	-2.14**	6.02**	-27.26	-0.24	-8.60**	-1.87*
CMS 7-1A x DRS 19	9.07	0.70	-1.90*	-1.80*	-0.72	-221.35**	0.66*	-4.33	-2.02*
CMS 7-1A x DRS 55	8.66	2.70**	3.43**	2.00*	2.02	261.150**	-0.16	11.40**	1.13
CMS 7-1A x DRS 16	-21.75**	-0.80	4.18**	1.13	-4.72**	141.40**	0.88**	6.01**	-3.26**
CMS 7-1A x DRS 28	-5.64	2.45*	-0.56	1.63*	2.27	51.9*	1.12**	6.78**	6.58**
CMS 7-1A x DRS 22	-12.69*	1.45	-0.81	-0.40	-5.72**	-19.35	-0.55	-1.39	2.54**
CMS 7-1A x DRS 9	0.63	-0.30	1.60*	0.06	3.77**	-0.767	-0.70*	-1.36	3.88**
CMS 7-1A x DRS 34	-7.89	0.70	0.60	0.19	-1.30	-41.26	-0.263	-2.84	0.92
SEii	5.83	0.97	0.77	0.77	1.37	22.36	0.32	2.19	0.83

Table 4a Estimates of heterosis, heterobeltiosis and standard heterosis (over KBSH 1 and PAC 1091) for plant height and days to 50% flowering in sunflower

Crosses	Plant height				Days to 50% flowering			
	Hetero sis	Hetero beltiosis	KBSH 1	PAC 1091	Hetero sis	Hetero beltiosis	KBSH 1	PAC 1091
DCMS 15 x DRS 45	10.81	-4.10	-9.16	-20.26**	8.57**	1.79	-1.72	-1.72
DCMS 15 x DRS 52	3.33	-4.62	-9.64	-20.68**	4.59 *	1.79	-1.72	-1.72
DCMS 15 x DRS 27	4.39	-6.15	-11.1	-21.96**	2.75	0.00	-3.45	-3.45
DCMS 15 x DRS 19	16.67*	-3.08	-8.19	-19.40**	6.90**	3.33	6.90**	6.90**
DCMS 15 x DRS 55	39.39**	6.15	0.56	-11.73*	-0.85	-4.92*	0.00	0.00
DCMS 15 x DRS 16	14.14	-13.08*	-17.66**	-27.72**	-2.7	-3.57	-6.90**	-6.90**
DCMS 15 x DRS 28	13.51	-19.23**	-23.49**	-32.84**	-3.64	-5.36*	-8.62**	-8.62**
DCMS 15 x DRS 22	21.63**	4.62	-0.90	-13.01*	-7.83**	10.17**	-8.62**	-8.62**
DCMS 15 x DRS 9	19.91**	8.46	2.74	-9.81	-0.88	-1.75	-3.45	-3.45
DCMS 15 x DRS 34	50.12**	23.85**	17.32**	2.99	6.78**	1.61	8.62**	8.62**
DCMS 1 x DRS 45	43.16**	43.16**	-0.90	-13.01*	3.70	-5.08*	-3.45	-3.45
DCMS 1 x DRS 52	17.07*	9.09	-12.56*	-23.24**	8.93**	3.39	5.17*	5.17*
DCMS 1 x DRS 27	6.68	2.19	-22.76**	-32.20**	-1.79	-6.78**	-5.17*	-5.17*
DCMS 1 x DRS 19	55.80**	48.42**	2.74	-9.81	-5.88**	-6.67**	-3.45	-3.45
DCMS 1 x DRS 55	71.78**	47.37**	2.02	-10.45	-8.33**	-9.84**	-5.17*	-5.17*
DCMS 1 x DRS 16	74.23**	49.47**	3.47	-9.17	-5.26*	-8.47**	-6.90**	-6.90**
DCMS 1 x DRS 28	90.67**	50.53**	4.20	-8.53	-4.42*	-8.47**	-6.90**	-6.90**
DCMS 1 x DRS 22	22.46**	21.58*	-15.84*	-26.12**	-5.08*	-5.08*	-3.45	-3.45
DCMS 1 x DRS 9	18.00*	12.30	-13.94*	-24.46**	3.45	1.69	3.45	3.45
DCMS 1 x DRS 34	79.54**	69.61**	17.42**	3.07	4.13*	1.61	8.62**	8.62**
DCMS 6 x DRS 45	17.56*	9.55	-12.19*	-22.92**	2.75	-6.67**	-3.45	-3.45
DCMS 6 x DRS 52	30.52**	30.52**	4.62	-8.17	9.73**	3.33	6.90**	6.90**
DCMS 6 x DRS 27	36.34**	32.45**	6.17	-6.8	9.73**	3.33	6.90**	6.90**
DCMS 6 x DRS 19	50.00**	33.64**	7.12	-5.97	0.00	0.00	3.45	3.45
DCMS 6 x DRS 55	63.67**	32.42**	6.15	-6.82	-0.83	-1.64	3.45	3.45
DCMS 6 x DRS 16	-3.45	-21.88**	-37.38**	-45.03**	-4.35*	-8.33**	-5.17*	-5.17*
DCMS 6 x DRS 28	58.26**	18.70*	-4.86	-16.48**	-3.51	-8.33**	-5.17*	-5.17*
DCMS 6 x DRS 22	52.63**	41.27**	13.24*	-0.6	0.84	0.00	3.45	3.45
DCMS 6 x DRS 9	19.60**	16.97*	-6.24	-17.70**	2.56	0.00	3.45	3.45
DCMS 6 x DRS 34	29.32**	14.33	-8.36	-19.55**	-9.84**	11.29**	-5.17*	-5.17*
CMS 7-1A x DRS 45	59.39**	53.92**	14.40*	0.43	-2.75	11.67**	-8.62**	-8.62**
CMS 7-1A x DRS 52	51.89**	46.36**	17.32**	2.99	2.65	-3.33	0.00	0.00
CMS 7-1A x DRS 27	28.32**	27.25**	-3.81	-15.57**	0.88	-6.67**	-3.45	-3.45
CMS 7-1A x DRS 19	70.21**	56.86**	16.59**	2.35	1.67	1.67	5.17*	5.17*
CMS 7-1A x DRS 55	91.37**	59.48**	18.53**	4.05	2.48	1.64	6.90**	6.90**
CMS 7-1A x DRS 16	11.22	-7.32	-31.11**	-39.53**	6.09**	-10.00**	-6.90**	-6.90**
CMS 7-1A x DRS 28	63.78**	26.05**	-6.32	-17.76**	1.75	-3.33	0.00	0.00
CMS 7-1A x DRS 22	31.47**	26.08**	-6.29	-17.74**	0.84	-1.67	1.72	1.72
CMS 7-1A x DRS 9	35.16**	33.12**	2.02	-10.45	0.85	-1.67	1.72	1.72
CMS 7-1A x DRS 34	59.43**	45.75**	8.33	-4.90	1.64	0.00	6.90**	6.90**

* = Significant at 5% level; ** = Significant at 1% level

Table 4b Estimates of heterosis, heterobeltiosis and standard heterosis (over KBSH 1 and PAC 1091) for days to maturity and head diameter in sunflower

Crosses	Days to maturity				Head diameter			
	Hetero sis	Hetero beltiosis	KBSH 1	PAC 1091	Hetero sis	Hetero beltiosis	KBSH 1	PAC 1091
DCMS 15 x DRS 45	-1.23	-4.76**	0.36	0.36	-27.27**	-35.66**	-34.29**	-45.88**
DCMS 15 x DRS 52	-3.16**	-6.12**	-1.08	-1.08	-17.49*	-35.66**	-34.29**	-45.88**
DCMS 15 x DRS 27	1.05	-2.04	3.23**	3.23**	14.04	-9.09	-7.14	-23.53**
DCMS 15 x DRS 19	0.00	0.00	5.38**	5.38**	37.66**	11.19	13.57	-6.47
DCMS 15 x DRS 55	-8.63**	-9.09**	-3.2**	-3.23**	36.13**	13.29	15.71*	-4.71
DCMS 15 x DRS 16	-12.24**	12.24**	-7.53**	-7.53**	19.15*	-2.10	0.00	-17.65**
DCMS 15 x DRS 28	-4.45**	-5.10**	0.00	0.00	18.64*	-2.10	0.00	-17.65**
DCMS 15 x DRS 22	-11.79**	12.24**	-7.53**	-7.53**	31.33**	6.99	9.29	-10.00
DCMS 15 x DRS 9	-11.57**	12.93**	-8.24**	-8.24**	39.57**	14.69	17.14*	-3.53
DCMS 15 x DRS 34	-7.82**	-7.82**	-2.87*	-2.87*	45.83**	17.72*	20.24*	-0.98
DCMS 1 x DRS 45	-4.76**	-8.16**	-3.23**	-3.23**	18.18*	18.18	-7.14	-23.53**
DCMS 1 x DRS 52	-4.21**	-7.14**	-2.15	-2.15	78.95**	54.55**	21.43**	0.00
DCMS 1 x DRS 27	-10.53**	13.27**	-8.60**	-8.60**	48.72**	31.82**	3.57	-14.71*
DCMS 1 x DRS 19	-3.40**	-3.40**	1.79	1.79	65.66**	49.09**	17.14*	-3.53
DCMS 1 x DRS 55	-12.69**	13.13**	-7.53**	-7.53**	28.78**	20.00*	-5.71	-22.35**
DCMS 1 x DRS 16	-12.24**	12.24**	-7.53**	-7.53**	60.40**	47.27**	15.71*	-4.71
DCMS 1 x DRS 28	-3.42**	-4.08**	1.08	1.08	60.89**	48.45**	16.64*	-3.94
DCMS 1 x DRS 22	-6.67**	-7.14**	-2.15	-2.15	22.00*	10.91	-12.86	-28.24**
DCMS 1 x DRS 9	-0.52	-2.04	3.23**	3.23**	48.51**	36.36**	7.14	-11.76
DCMS 1 x DRS 34	-8.16**	-8.16**	-3.23**	-3.23**	69.81**	52.73**	20.00*	-1.18
DCMS 6 x DRS 45	2.29*	-1.36	3.94**	3.94**	1.54	-12.00	-5.71	-22.35**
DCMS 6 x DRS 52	-4.91**	-7.82**	-2.87*	-2.87*	13.04	-13.33	-7.14	-23.53**
DCMS 6 x DRS 27	-3.16**	-6.12**	-1.08	-1.08	23.40**	-3.33	3.57	-14.71*
DCMS 6 x DRS 19	-10.54**	10.54**	-5.73**	-5.73**	31.09**	4.00	11.43	-8.24
DCMS 6 x DRS 55	-6.60**	-7.07**	-1.08	-1.08	35.51**	10.67	18.57*	-2.35
DCMS 6 x DRS 16	-7.14**	-7.14**	-2.15	-2.15	21.90**	-1.67	5.36	-13.24*
DCMS 6 x DRS 28	-11.64**	12.24**	-7.53**	-7.53**	0.41	-18.67*	-12.86	-28.24**
DCMS 6 x DRS 22	-7.69**	-8.16**	-3.23**	-3.23**	21.67**	-2.67	4.29	-14.12*
DCMS 6 x DRS 9	0.52	-1.02	4.30**	4.30**	9.50	-11.67	-5.36	-22.06**
DCMS 6 x DRS 34	-8.16**	-8.16**	-3.23**	-3.23**	10.99	-12.00	-5.71	-22.35**
CMS 7-1A x DRS 45	-11.70**	-14.43**	-10.75**	10.75**	32.17**	7.04	35.71**	11.76
CMS 7-1A x DRS 52	-2.65*	-5.15**	-1.08	-1.08	80.92**	31.23**	66.38**	37.02**
CMS 7-1A x DRS 27	0.53	-2.06	2.15	2.15	44.61**	6.93	35.57**	11.65
CMS 7-1A x DRS 19	-5.64**	-6.12**	-1.08	-1.08	61.21**	20.56**	52.86**	25.88**
CMS 7-1A x DRS 55	-3.06**	-4.04**	2.15	2.15	50.46**	15.49*	46.43**	20.59**
CMS 7-1A x DRS 16	-3.25**	-3.74**	1.43	1.43	80.58**	37.09**	73.81**	43.14**
CMS 7-1A x DRS 28	-5.68**	-5.84**	-1.79	-1.79	78.93**	36.34**	72.86**	42.35**
CMS 7-1A x DRS 22	-8.25**	-8.25**	-4.30**	-4.30**	59.50**	20.19**	52.38**	25.49**
CMS 7-1A x DRS 9	0.00	-1.03	3.23**	3.23**	89.09**	43.55**	82.00**	49.88**
CMS 7-1A x DRS 34	-5.64**	-6.12**	-1.08	-1.08	78.70**	33.58**	69.36**	39.47**

* = Significant at 5% level; ** = Significant at 1% level

Table 4c Estimates of heterosis, heterobeltiosis and standard heterosis (over KBSH 1 and PAC 1091) for number of leaves/plant and number of seeds/plant in sunflower

Crosses	No. of leaves/plant				No. of seeds/plant			
	Hetero sis	Hetero beltiosis	KBSH 1	PAC 1091	Hetero sis	Hetero beltiosis	KBSH 1	PAC 1091
DCMS 15 x DRS 45	14.29	9.09	-7.69	0.00	21.30**	5.66	-14.39**	8.39
DCMS 15 x DRS 52	-17.95**	-28.89**	-17.95*	-11.11	33.28**	22.80**	-0.51	25.97**
DCMS 15 x DRS 27	-2.44	-9.09	-23.08**	-16.67*	48.90**	42.10**	26.71**	60.43**
DCMS 15 x DRS 19	5.66	-9.68	7.69	16.67*	15.95**	10.20*	-0.89	25.48**
DCMS 15 x DRS 55	45.00**	31.82**	11.54	20.83*	68.54**	53.30**	24.20**	57.26**
DCMS 15 x DRS 16	20.93**	18.18*	0.00	8.33	46.55**	34.92**	29.94**	64.52**
DCMS 15 x DRS 28	-27.66**	-32.00**	-34.62**	-29.17**	24.44**	12.44**	12.87**	42.90**
DCMS 15 x DRS 22	41.46**	31.82**	11.54	20.83*	8.12*	-7.40*	5.22	33.23**
DCMS 15 x DRS 9	-4.76	-9.09	-23.08**	-16.67*	55.56**	37.21**	11.17**	40.75**
DCMS 15 x DRS 34	55.00**	40.91**	19.23*	29.17**	2.49	-11.53*	-28.32**	-9.25
DCMS 1 x DRS 45	33.33**	20.00*	15.38*	25.00**	42.11**	20.23**	4.46	32.26**
DCMS 1 x DRS 52	-3.64	-11.67	1.92	10.42	-13.30**	-22.58**	-32.74**	-14.84**
DCMS 1 x DRS 27	18.18*	4.00	0.00	8.33	-31.26**	-32.14**	-39.49**	-23.39**
DCMS 1 x DRS 19	-28.57**	-35.48**	-23.08**	-16.67*	9.51*	7.65	-3.18	22.58**
DCMS 1 x DRS 55	39.53**	20.00*	15.38*	25.00**	41.98**	25.22**	8.79*	37.74**
DCMS 1 x DRS 16	17.39*	8.00	3.85	12.5	22.39**	16.40**	12.10**	41.94**
DCMS 1 x DRS 28	-8.00	-8.00	-11.54	-4.17	-19.73**	-25.13**	-24.84**	-4.84
DCMS 1 x DRS 22	-9.09	-20.00*	-23.08**	-16.67*	20.08**	5.94	20.38**	52.42**
DCMS 1 x DRS 9	-11.11	-20.00*	-23.08**	-16.67*	3.77	-11.14*	-22.80**	-2.26
DCMS 1 x DRS 34	45.74**	25.33**	20.51**	30.56**	-1.52	-17.40**	-28.24**	-9.14
DCMS 6 x DRS 45	-13.04	-23.08**	-23.08**	-16.67*	54.42**	27.41**	17.83**	49.19**
DCMS 6 x DRS 52	-3.57	-10.00	3.85	12.5	-0.79	-13.77**	-20.25**	0.97
DCMS 6 x DRS 27	11.11	-3.85	-3.85	4.17	-19.35**	-20.80**	-26.75**	-7.26
DCMS 6 x DRS 19	12.28*	3.23	23.08**	33.33**	43.58**	41.60**	30.96**	65.81**
DCMS 6 x DRS 55	-13.64	-26.92**	-26.92**	-20.83*	43.06**	22.87**	13.63**	43.87**
DCMS 6 x DRS 16	31.91**	19.23*	19.23*	29.17**	-12.82**	-14.55**	-17.71**	4.19
DCMS 6 x DRS 28	-37.25**	-38.46**	-38.46**	-33.33**	34.87**	29.57**	30.06**	64.68**
DCMS 6 x DRS 22	33.33**	15.38*	15.38*	25.00**	-27.07**	-33.86**	-24.84**	-4.84
DCMS 6 x DRS 9	-4.35	-15.38*	-15.38*	-8.33	28.38**	7.16	-0.89	25.48**
DCMS 6 x DRS 34	-9.09	-23.08**	-23.08**	-16.67*	12.57**	-7.90	-14.82**	7.85
CMS 7-1A x DRS 45	12.20	9.52	-11.54	-4.17	23.20**	13.43*	-18.94**	2.63
CMS 7-1A x DRS 52	-9.80	-23.33**	-11.54	-4.17	10.24*	7.78	-22.97**	-2.47
CMS 7-1A x DRS 27	55.00**	47.62**	19.23*	29.17**	-9.60*	-18.57**	-27.39**	-8.06
CMS 7-1A x DRS 19	-3.85	-19.35**	-3.85	4.17	-23.44**	-31.30**	-38.22**	21.77**
CMS 7-1A x DRS 55	43.59**	33.33**	7.69	16.67*	118.11**	110.34**	50.32**	90.32**
CMS 7-1A x DRS 16	0.00	0.00	-19.23*	-12.5	46.09**	27.25**	22.55**	55.16**
CMS 7-1A x DRS 28	-8.70	-16.00*	-19.23*	-12.5	2.74	-12.06**	-11.72**	11.77*
CMS 7-1A x DRS 22	-10.00	-14.29	-30.77**	-25.00**	-5.57	-23.09**	-12.61**	10.65*
CMS 7-1A x DRS 9	21.95**	19.05*	-3.85	4.17	29.13**	20.50**	-13.89**	9.03
CMS 7-1A x DRS 34	28.21**	19.05*	-3.85	4.17	-8.5	-16.58**	-40.38**	24.52**

* = Significant at 5% level; ** = Significant at 1% level

Table 4d Estimates of heterosis, heterobeltiosis and standard heterosis (over KBSH 1 and PAC 1091) for 100-seed weight and seed yield/plant in sunflower

Crosses	100 seed weight				Seed yield/plant			
	Hetero sis	Hetero beltiosis	KBSH 1	PAC 1091	Hetero sis	Hetero beltiosis	KBSH 1	PAC 1091
DCMS 15 x DRS 45	-17.09*	-20.00*	-26.15**	-21.63*	-31.91**	-32.14**	-48.65**	-46.55**
DCMS 15 x DRS 52	7.88	1.25	-6.54	-0.82	22.64*	4.51	-21.46**	-18.25*
DCMS 15 x DRS 27	10.35	0.35	-7.37	-1.7	50.72**	45.22**	9.14	13.59
DCMS 15 x DRS 19	2.48	-3.75	-11.15	-5.71	2.99	-0.07	-24.89**	-21.83**
DCMS 15 x DRS 55	-1.8	-3.54	-10.96	-5.51	50.15**	30.41**	-1.99	2.01
DCMS 15 x DRS 16	10.16	-0.63	-8.27	-2.65	51.76**	46.90**	10.41	14.91
DCMS 15 x DRS 28	5.68	-4.38	-11.73	-6.33	13.98	13.97	-14.35	-10.86
DCMS 15 x DRS 22	14.6	1.11	-6.67	-0.95	15.46	6.22	-20.17**	-16.92*
DCMS 15 x DRS 9	33.64**	20.00*	10.77	17.55	74.11**	49.32**	12.22	16.80*
DCMS 15 x DRS 34	3.53	-6.69	7.31	13.88	-2.26	-8.17	-30.98**	-28.17**
DCMS 1 x DRS 45	14.43	12.34	-3.58	2.33	20.92*	19.07	-9.89	-6.22
DCMS 1 x DRS 52	17.4	16.17	-3.94	1.95	-15.99	-27.69**	-46.95**	-44.78**
DCMS 1 x DRS 27	60.21**	53.32**	26.78**	34.54**	71.49**	67.17**	22.65**	27.65**
DCMS 1 x DRS 19	61.86**	60.29**	32.55**	40.67**	-1.68	-3.47	-29.18**	-26.29**
DCMS 1 x DRS 55	-14.3	-17.35	-26.41**	-21.90*	26.38*	10.90	-18.64*	-15.32
DCMS 1 x DRS 16	2.94	-2.33	-19.23*	-14.29	45.66**	42.66**	4.67	8.93
DCMS 1 x DRS 28	82.25**	73.49**	43.46**	52.24**	31.68**	30.13**	-2.22	1.76
DCMS 1 x DRS 22	15.68	7.21	-11.35	-5.92	42.91**	32.93**	-2.47	1.51
DCMS 1 x DRS 9	75.78**	65.97**	37.24**	45.65**	53.38**	32.87**	-2.52	1.46
DCMS 1 x DRS 34	8.83	-6.46	7.57	14.16	-8.50	-13.05	-36.21**	-33.61**
DCMS 6 x DRS 45	18.61	11.13	-4.62	1.22	40.56**	34.98**	2.15	6.31
DCMS 6 x DRS 52	14.26	10.06	-10.9	-5.44	-1.04	-12.93	-39.34**	-36.87**
DCMS 6 x DRS 27	8.98	8.57	-17.95*	-12.93	-27.12**	-27.12*	-49.23**	-47.15**
DCMS 6 x DRS 19	16.55	12.17	-9.04	-3.47	63.02**	61.82**	14.41	19.07*
DCMS 6 x DRS 55	5.51	-2.81	-13.46	-8.16	41.37**	26.89*	-11.61	-8.00
DCMS 6 x DRS 16	96.91**	95.90**	46.92**	55.92**	59.87**	59.10**	11.91	16.48*
DCMS 6 x DRS 28	11.99	11.79	-16.15	-11.02	41.30**	36.16**	2.30	6.48
DCMS 6 x DRS 22	17.66	14.19	-14.36	-9.12	-19.23	-23.02*	-46.38**	-44.19**
DCMS 6 x DRS 9	-0.95	-1.97	-26.47**	-21.97*	9.94	-2.62	-32.16**	-29.39**
DCMS 6 x DRS 34	-7.09	-23.24**	-11.73	-6.33	-6.30	-8.72	-36.41**	-33.82**
CMS 7-1A x DRS 45	-4.31	-11.09	-11.09	-5.65	-16.78	-19.69*	-39.23**	-36.75**
CMS 7-1A x DRS 52	-6.48	-15.38	-15.38	-10.2	-9.22	-20.48	-44.03**	-41.75**
CMS 7-1A x DRS 27	13.91	0.00	0.00	6.12	-13.19	-13.63	-39.21**	-36.73**
CMS 7-1A x DRS 19	40.18**	26.92**	26.92**	34.69**	-4.28	-4.49	-32.47**	-29.72**
CMS 7-1A x DRS 55	10.48	-15.38	-15.38	-10.2	94.24**	73.55**	22.15**	27.13**
CMS 7-1A x DRS 16	19.21*	3.85	3.85	10.2	66.83**	66.78**	17.39*	22.18**
CMS 7-1A x DRS 28	59.94**	39.74**	39.74**	48.30**	55.05**	50.15**	12.82	17.42*
CMS 7-1A x DRS 22	12.81	-3.78	-3.78	2.11	11.03	5.31	-25.88**	-22.86**
CMS 7-1A x DRS 9	27.20**	10.32	10.32	17.07	33.89**	18.07	-16.90*	-13.51
CMS 7-1A x DRS 34	-6.98	-13.04	0	6.12	-25.04**	-27.34*	-48.86**	-46.78**

* = Significant at 5% level; ** = Significant at 1% level

Table 4e Estimates of heterosis, heterobeltiosis and standard heterosis (over KBSH 1 and PAC 1091) for oil content in sunflower

Crosses	Oil Content			
	Hetero sis	Hetero beltiosis	KBSH 1	PAC 1091
DCMS 15 x DRS 45	-15.86**	-28.31**	-44.91**	-31.25**
DCMS 15 x DRS 52	10.39*	-8.09*	-25.24**	-6.70
DCMS 15 x DRS 27	-23.95**	-39.22**	-45.04**	-31.41**
DCMS 15 x DRS 19	13.37**	-2.90	-26.32**	-8.04*
DCMS 15 x DRS 55	40.68**	11.18**	3.61	29.30**
DCMS 15 x DRS 16	48.24**	17.67**	8.34**	35.22**
DCMS 15 x DRS 28	-11.65**	-23.85**	-43.09**	-28.98**
DCMS 15 x DRS 22	7.69	-8.23*	-29.51**	-12.02**
DCMS 15 x DRS 9	35.44**	10.96**	-5.97	17.35**
DCMS 15 x DRS 34	23.12**	1.56	-15.43**	5.54
DCMS 1 x DRS 45	-30.76**	-32.15**	-47.87**	-34.93**
DCMS 1 x DRS 52	-3.96	-8.45*	-25.53**	-7.05
DCMS 1 x DRS 27	16.18**	5.47	-4.63	19.02**
DCMS 1 x DRS 19	14.79**	13.18**	-14.12**	7.18
DCMS 1 x DRS 55	13.84**	1.96	-4.98	18.59**
DCMS 1 x DRS 16	-9.43**	-18.44**	-24.91**	-6.28
DCMS 1 x DRS 28	0.41	-0.24	-25.46**	-6.97
DCMS 1 x DRS 22	-6.99	-8.84*	-29.98**	-12.61**
DCMS 1 x DRS 9	-35.08**	-39.29**	-48.55**	-35.79**
DCMS 1 x DRS 34	-20.83**	-25.35**	-37.84**	-22.42**
DCMS 6 x DRS 45	-16.41**	-16.57**	-35.89**	-19.99**
DCMS 6 x DRS 52	-18.12**	-20.54**	-35.36**	-19.33**
DCMS 6 x DRS 27	-49.91**	-53.75**	-58.18**	-47.80**
DCMS 6 x DRS 19	32.14**	31.56**	0.71	25.70**
DCMS 6 x DRS 55	-33.20**	-39.16**	-43.30**	-29.24**
DCMS 6 x DRS 16	-11.99**	-19.41**	-25.80**	-7.39
DCMS 6 x DRS 28	17.48**	16.08**	-11.14**	10.90**
DCMS 6 x DRS 22	-10.39**	-10.54*	-31.28**	-14.24**
DCMS 6 x DRS 9	-6.27	-10.80**	-24.41**	-5.66
DCMS 6 x DRS 34	1.32	-2.76	-19.03**	1.05
CMS 7-1A x DRS 45	-28.24**	-39.61**	-53.60**	-42.09**
CMS 7-1A x DRS 52	4.26	-14.24**	-30.24**	-12.93**
CMS 7-1A x DRS 27	-8.84*	-27.96**	-34.86**	-18.71**
CMS 7-1A x DRS 19	36.10**	15.12**	-12.65**	9.02*
CMS 7-1A x DRS 55	32.74**	3.75	-3.32	20.66**
CMS 7-1A x DRS 16	13.63**	-10.80**	-17.87**	2.50
CMS 7-1A x DRS 28	63.49**	39.16**	3.99	29.78**
CMS 7-1A x DRS 22	33.37**	12.24**	-13.78**	7.61
CMS 7-1A x DRS 9	38.23**	11.92**	-5.16	18.37**
CMS 7-1A x DRS 34	27.80**	4.17	-13.26**	8.26*

* = Significant at 5% level; ** = Significant at 1% level

Table 5 Superior hybrids identified from the investigation for *per se* performance and their combining ability and heterosis

Hybrid	<i>per se</i>	Combining ability		SH over KBSH 1
		sca	gca	
Seed yield/plant	(g)			
DCMS 36 x DRS 16	48.35	13.33**	h x l	22.65**
CMS 7-1A x RHA 340	48.15	11.40**	l x h	22.15**
CMS 7-1A x DRS 9	46.23	6.01**	l x h	17.39**
Oil content	(%)			
DCMS 36 x DRS 22	45.50	7.16**	h x l	5.46**
CMS 7-1A x DRS 102	45.50	6.67**	l x h	15.63**
DCMS 36 x DRS 16	45.50	5.88**	h x l	0.69**
100 seed weight	(g)			
DCMS 6 x DRS 9	7.64	2.50**	l x h	11.91
CMS 7-1A x DRS 102	7.46	1.06**	h x h	-
DCMS 36 x DRS 102	7.27	1.12**	h x h	12.82
No. of seeds/plant				
CMS 7-1A x RHA 340	1180	261.15**	l x l	50.32**
DCMS 6 x DRS 22	1028	242.78**	l x m	30.96**
DCMS 6 x DRS 102	1058	201.03**	l x h	30.06**
Head diameter	(cm)			
DCMS 6 x RHA 340	25.48	2.23**	h x h	18.57**
CMS 234A x DRS 34	24.33	2.20**	m x l	17.14**
DCMS 36 x DRS 52	24.20	2.15**	h x l	21.43**

References

- Devi, K.R., Ranganatha, A.R.G. and Ganesh, M. 2005. Combining ability and heterosis for seed yield and its attributes in sunflower. *Agricultural Science Digest*, 25(1): 11-14.
- Gangappa, E., Channakrishnaiah, K.M., Ramesh, S. and Harini, M.S. 1993. Exploitation of heterosis in sunflower (*Helianthus annuus* L.). *Crop Research*, 13(2): 339-348.
- Gill, H.S., Khurana, S.R., Yadava, T.P. and Sheoran, R.K. 1998. Expression of heterosis for different characters in sunflower over environments. *Haryana Agricultural University Journal of Research*, 28(2-3): 95-10.
- Gill, H.S. and Sheoran, R.K. 2002. Heterotic studies in sunflower over environments. *National Journal of Plant Improvement*, 4(1): 53-56.
- Giriraj, K., Hiremath, S.R. and Seenappa, K. 1987. Combining ability of converted male sterile lines of sunflower (*Helianthus annuus* L.). *Indian Journal of Genetics and Plant Breeding*, 47: 315-316.
- Goksoy, A.T., Turkec, A. and Turan, Z.M. 2000. Heterosis and combining ability in sunflower. *Indian Journal of Agricultural Sciences*, 70(8): 525-529.
- Goksoy, A.T. and Turan, Z.M. 2004. Combining abilities of certain characters and estimation of hybrid vigour in sunflower (*Helianthus annuus* L.). *Acta Agronomica Hungarica*, 52(4): 361-368.
- Kandhola, S.S., Behl, R.K. and Punia, M.S. 1995. Heterosis in sunflower. *Annals of Biology*, 11(1-2): 98-102.
- Kadkol, G.P., Anand, I.J. and Sharma, R.P. 1984. Combining ability and heterosis in sunflower. *Indian Journal of Genetics and Plant Breeding*, 44: 447-451.
- Kempthorne, O. 1957. *An introduction to genetic statistics*. John Wiley and Sons, Inc: New York.

- Lande, S.S., Narkhede, M.N., Weginwar, D.G. and Patel, M.C.** 1998. Heterotic studies in sunflower. *Annals of Plant physiology*, **12**(1): 15-18.
- Limboore, A.R., Weginwar, D.G., Londe, S.S., Gite, B.D. and Ghodke, K.M.** 1998. Heterosis in sunflower (*Helianthus annuus* L.). *Annals of Plant Physiology*, **12**(1): 38-42.
- Loganathan, P. and Gopalan, A.** 2006a. Combining ability in sunflower (*Helianthus annuus* L.). *Research on Crops*, **7**(1): 213-21.
- Loganathan, P. and Gopalan, A.** 2006b. Heterosis for yield and yield components in sunflower (*Helianthus annuus* L.). *Research on Crops*, **7**(1): 206-212.
- Madhavalatha, K., Reddy, A.V.V. and Devasenamma, V.** 2005. Hybrid vigour and combining ability in sunflower, *Helianthus annuus* L. hybrids involving CMS lines. *Journal of Oilseeds Research*, **22**(2): 309-312.
- Madrap, I.A. and Makne, V.G.** 1993. Heterosis in relation to combining ability effect and phenotypic stability in sunflower (*Helianthus annuus* L.). *Indian Journal of Agricultural Sciences*, **63**(8): 484-488.
- Manivannan, N., Vidhyavathi, P. and Muralidharan, V.** 2005. Diallel analysis in sunflower. *Indian Journal of Agricultural Research*, **39**(4): 281-285.
- Phad, D.S., Joshi, B.M., Ghodke, M.K., Kamble, K.R. and Gole, J.P.** 2002. Heterosis and combining ability analysis in sunflower (*Helianthus annuus* L.). *Journal of Maharashtra Agricultural Universities*, **27**(1): 115-117.
- Rao, N.M. and Singh, B.** 1977. Inheritance of some quantitative characters in sunflower. *Pantnagar Journal of Agricultural Research*, **2**(2): 144-16.
- Radhika, P., Jagadeshwar, K. and Khan.** 2001. Heterosis and combining ability through Line x Tester analysis in sunflower (*Helianthus annuus* L.). *Journal of Research ANGRAU*, **29** (2-3): 35-43.
- Rather, A.G. and Sandha, G.S.** 1999. Heterosis in sunflower. *Advances in plant sciences* **12**(1): 53-56.
- Toms, E.M. and Pooni, H.S.** 1995. An evaluation of crosses between some french male sterile and UK restorer lines of the Sunflower. *Helia*, **18** (22): 51-58.

Management of defoliators and capitulum borer in sunflower, *Helianthus annuus* L. through newer insecticides

B.V. Patil and H. Basappa¹

Oilseeds Research Station, Marathwada Agricultural University, Parbhani-431 402, MS

(Received: April, 2008; Revised: September, 2008; Accepted: February, 2009)

Abstract

The field study carried out at Oilseeds Research Station, Latur (M.S.) during kharif 2004-07 divulged that thiodicarb @ 0.075% was working more effectively against defoliators (*Trichoplusia ni* and *Spodoptera litura*) and spinosad @ 0.018% against capitulum borer (*Helicoverpa armigera*) whereas application of endosulfan @ 0.07% proved to be effective against stem borer (*Nupserha* sp near *vexator* Pascoe) in sunflower. However, treatment of endosulfan was found to be economic followed by profenofos to control defoliators, capitulum borer and stem borer. Moreover, no treatment could significantly reduce the activity of predators and honeybees over control.

Key words: Sunflower, defoliators, capitulum borer, stem borer, treatment, control

Introduction

Several species of both beneficial and harmful insects as well as microbial organisms are associated with sunflower (*Helianthus annuus* L.). Among biotic constraints in sunflower production, insect pests and diseases are of major concern. As many as 251 insect and acarid species are known to attack sunflower crop worldwide (Rajamohan 1976). Among defoliators, Tobacco caterpillar (*Spodoptera litura* Fabricius), Bihar hairy caterpillar (*Spilarctia obliqua*), green semilooper (*Thysanoplusia orichalcia* Fab.), cabbage green semilooper (*Trichoplusia ni*) of major importance. Outbreak of *Spodoptera litura* was noticed in sunflower growing areas of Karnataka and Maharashtra state of India. Capitulum borer (*Helicoverpa armigera* Hubner) is the most serious and destructive pest among all the insect pests of sunflower, the yield loss goes up to 50% under severe incidence (Anonymous, 2005b). The capitulum borer is highly polyphagous with about 181 host plants including important crop plants such as pulses, cotton, vegetables, oilseeds, etc., and pest is prevalent throughout India (Basappa and Bhat, 1999). Therefore, it is peremptory to take care of sunflower crop from this notorious pest. Recently sunflower cultivation in Marathwada region, (M.S., India) threatened a new pest

stem borer *Nupserha* sp. near *vexator* (Pascoe). Anonymous (2005a) reported 17.5% yield loss due to stem borer in sunflower. The present study has been undertaken to evaluate the efficacy of some insecticides of new generation for effective management of defoliators, capitulum borer and stem borer as well as its bio-safety to beneficial insects.

Material and methods

The field experiment was conducted during kharif 2004-07 at Oilseeds Research Station, Latur (M.S.) India. Total seven insecticides were tested (Table 1) along with untreated control in Randomized Block Design with three replications having a plot size of 4.2 x 4.5 m. Spacing adopted was 60 x 30cm. The sunflower variety used for experiment was Morden. The recommended package of practices was followed. Treatments have been imposed at ETL cross by the pest before flowering with the help of foot sprayer. Six leaves observed for larval population of defoliators (*Trichoplusia ni* and *Spodoptera litura* Fab.), capitulum borer (*Helicoverpa armigera* Hub.) and predator (*Coccinellids*) from randomly selected five plants of each treatment a day before and 3 days after spraying while the incidence of *N. vexator* recorded at the time of harvesting through stem cutting at collar region and percent incidence worked out. Honeybee's activity recorded for a week in the morning hours during full bloom stage and average honeybees visited per head per day was reported. The net plot (3.0 x 3.9m) yield was recorded separately. The data generated during four years were subjected to statistical analysis and cost benefit ratio for each treatment was also worked out.

Results and discussion

Four years pooled data presented in Table 1 revealed that the population of defoliators (*T. ni* & *S. litura*) and head borer (*H. armigera*) were uniformly distributed at the outset of experiment. Treatment of thiodicarb @ 0.07% was proved to be effective against defoliators and was remained at par with indoxacarb, spinosad, profenofos and endosulfan. However, spinosad application registered superior results against *H. armigera* over control and was at par with thiodicarb, indoxacarb, profenofos and endosulfan. Application of indoxacarb and profenofos was

¹ Principal Scientist (Entomology), Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP.

found effective for the control of *Trichoplusia*, *Spodoptera* and *Helicoverpa* in soybean (Shivamurthy *et al.*, 2009). Rest of the treatments i.e., chlorpyrifos @ 0.05% and dichlorvos @ 0.075% were also significantly superior over control for management of defoliators and *H. armigera*. Order of relative toxicity of various insecticides against *S. litura* was reported by Suby *et al.*, 2008 as emamectin benzoate > indoxacarb > spinosad > profenofos. Spraying of dichlorvos @ 0.05% in case of severe incidence of *S. litura* is effective (Prasad and Vimala Devi, 1999). Significant reduction in incidence of *N. vexator* recorded over control in the plots treated with endosulfan @ 0.07% and which was at par with rest of the treatments except dichlorvos and spinosad. The results corroborate the findings of Patil and Jadhav (2007). Treatments of dichlorvos and spinosad were showed poor performance against *N. vexator*. Data presented in Table 2 revealed that no treatment could significantly reduce population of predator (Coccinellids) which proved safety of all chemicals to the predators. The same trend of bio-safety was also observed in case of honeybees that no treatment could restrict the activity of honeybees during flowering of sunflower. Yield data disclosed that significant variation within treatment was also evident in seed yield. Highest seed yield (1337 kg/ha) registered with application of

thiodicarb which was 32.5 % increase over control. The treatment was also at par with endosulfan, indoxacarb and spinosad which were the 32.21, 31.11, and 24.87% significant increase in seed yield respectively. Profenofos was the next best treatment and recorded significant enhancement in the seed yield i.e., 21.90 % followed by chlorpyrifos 21.70%. Treatment of dichlorvos stood on par with untreated control in respect of yield. However, application of endosulfan proved to be most economic (1:4.9) followed by profenofos (1:4.6) and chlorpyrifos (1:4.5). Endosulfan was the most effective in controlling *Helicoverpa* and *Spodoptera* (Harvir Singh *et al.*, 2007). Indoxacarb was found as best treatments for the control of *H. armigera* in chickpea moreover endosulfan and Chlorpyrifos was also proved effective against *H. armigera* (Pradyumn and Tomar, 2008). Mortality in eggs of *Spodoptera* was recorded 92.67% with profenofos 50EC and 89.33% with thiodicarb 75WP (Patil *et al.*, 2007). Thus the present findings are in conformity with the earlier studies.

Acknowledgements: Authors are grateful to Director of Research, MAU, Parbhani and Project Director, DOR, Hyderabad for providing timely funds and facilities which enable us to conduct the experiments smoothly.

Table 1 Efficacy of newer insecticides against major pests in sunflower (four years pooled data, 2004-07)

Treatments	Mean defoliators (larvae/plant)		Mean head borer (larvae/plant)		Stem borer [incidence (%)]*
	Before spray	After spray	Before spray	After spray	
Thiodicarb 75WP	5.3	0.2	1.7	0.3	21.3
@ 0.075%	2.40	0.81	1.47	0.87	27.05
Indoxacarb 14.5 %	5.2	0.2	1.6	0.2	18.7
SC @ 0.015%	2.39	0.82	1.46	0.85	25.37
Spinosad 45 % SC	5.4	0.2	1.7	0.1	24.5
@ 0.018%	2.42	0.85	1.49	0.76	29.36
Profenofos 50 EC	5.3	0.3	1.6	0.3	19.9
@ 0.05%	2.40	0.88	1.46	0.87	26.21
Dichlorvos 76 EC	5.3	1.2	1.8	0.9	27.9
@ 0.075%	2.41	1.29	1.52	1.17	31.46
Chlorpyrifos 20 EC	5.1	0.6	1.7	0.6	19.4
@ 0.05%	2.36	1.06	1.47	1.04	25.95
Endosulfan 35 EC	3.9	0.3	1.7	0.2	15.4
@ 0.07 %	2.10	0.90	1.49	0.84	23.06
Control	5.3	3.6	1.7	1.5	33.1
	2.41	2.02	1.48	1.40	34.90
SEm +	0.02	0.06	0.03	0.05	1.27
CD (P=0.05)	N.S.	0.19	N.S.	0.15	3.78
CV (%)	2.00	11.00	4.00	10.0	9.00

Bold figures are root x + 0.5 transformed values; * = angular transformed values

Table 2 Bio-safety of newer insecticides to predators and honey bees in sunflower (Kharif, 2007)

Treatments	Mean Coccinellids/ plant		Mean honey bees / head (After spray)	Yield (kg/ha)	ICBR
	Before spray	After spray			
Thiodicarb 75WP @ 0.075%	1.1	0.7	1.3	1337	1:4.5
Indoxacarb 14.5 % SC @ 0.015%	1.28	1.11	1.35	1323	1:4.2
	1.3	1.0	1.2		
Spinosad 45 % SC @ 0.018%	1.33	1.22	1.30	1260	1:3.7
	1.5	1.1	1.5		
Profenofos 50 EC @ 0.05%	1.40	1.27	1.42	1230	1:4.6
	1.1	1.2	1.5		
Dichlorvos 76 EC @ 0.075%	1.25	1.30	1.40	1090	1:4.1
	1.5	0.8	1.5		
Chlorpyrifos 20 EC @ 0.05%	1.42	1.14	1.42	1228	1:4.5
	1.4	1.1	1.3		
Endosulfan 35 EC @ 0.07 %	1.37	1.26	1.35	1334	1:4.9
	1.3	1.1	1.3		
Control	1.35	1.25	1.35	1009	-
	1.4	1.3	1.4		
SEm +	1.37	1.35	1.38		
CD (P=0.05)	0.06	0.08	0.06	29.8	
CV (%)	N.S	N.S	N.S.	92.0	
	8.0	12.0	7.0	4.0	

Figures in bold are root x + 0.5 transformed values

References

- Anonymous. 2005a. Annual Progress Report: Sunflower, DOR, Hyderabad. p. 172.
- Anonymous. 2005b. Bio-control in Oilseed Crops, DOR, Hyderabad. p. 10.
- Basappa, H. and Bhat, N.S. 1999. Eco-biology and management of capitulum borer in sunflower. *Integrated Pest Management in Sunflower*. DOR, Hyderabad. p. 38.
- Harvir Singh, Basappa, H. and Vimala Devi, P.S. 2007. Evaluation of microbial pesticides for the management of capitulum borer, *Helicoverpa armigera* and *Spodoptera litura* in sunflower, *Helianthus annuus* L. *Extended summaries ISOR National Seminar*, Hyderabad. p. 186.
- Patil, B.V. and Jadhav, R.N. 2007. Control of stem borer, a new pest in sunflower through conventional insecticides. *Extended Summaries ISOR National Seminar*, Hyderabad. p. 184-86.
- Patil, R.K., Navi, S.S., Shekhappa and Spurthi, G.S. 2007. Ovicidal effect of different insecticides on *Spodoptera litura* (Fabricius). *Extended Summaries ISOR National Seminar*, Hyderabad. p. 197.
- Pradyumn Singh and Singh Tomar, S.P. 2008. Efficacy of different insecticides against *Helicoverpa armigera* (Hubner) on chickpea *Cicer arietinum*. *Indian Journal of Entomology*, 70 (2): 177-179.
- Prasad, Y.G. and Vimala Devi, P.S. 1999. Eco-biology and management of sunflower defoliators. *Integrated Pest Management in Sunflower*. DOR, Hyderabad. p 42-44.
- Rajamohan, N. 1976. Pest complex of sunflower a bibliography, *PANS*, 22: 546-563.
- Shivamurthy Naik, Chandrappa, M., Swamy, M. and Manja Naik, C. 2009. Efficacy of new insecticides against major insect pests of soybean, *Glycine max*. L. *Journal of Oilseeds Research*, 26 (special issue): 532-33.
- Suby, S.B., Brijesh Singh and Gupta, G.P. 2008. Efficacy of certain newer insecticides with novel modes of action on Tobacco caterpillar, *Spodoptera litura* (Fabricius). *Indian Journal of Entomology*, 70 (2): 95-99.

Studies on host resistance to *Botrytis* grey rot in castor

P. Janila, A. Ashok Kumar, N. Rajashekar Reddy, R. Sudhakar and S.K. Ahammed

Regional Agricultural Research Station, Acharya N.G. Ranga Agril. University, Palem-509 215, Mahabubnagar Dist., AP

(Received: September, 2007; Revised: June, 2009; Accepted: July, 2009)

Abstract

The gamma-rays irradiated mutagenized populations and germplasm accessions were screened for resistance to *Botrytis* grey rot disease in castor. "Detached spike inoculation technique" under controlled conditions is an efficient and robust technique to identify resistance based on number of days for disease development. All the test material succumbed to disease by 5th day of inoculation indicating absence of host-resistance. Six lines which recorded <10% disease incidence under field screening during kharif, 2005 also succumbed to disease. The field tolerance in PCS-170, an advanced breeding lines is attributed to its morphological features alone. Thus, field tolerance reported is often a case of disease escape and such material does not merit to be included in cross breeding programmes.

Key words: *Botrytis ricini*, castor, host-resistance, mutations, grey rot, high disease pressure and screening

Introduction

Botrytis grey rot (BGR) caused by *Botrytis ricini* Godfrey is one of the major diseases of castor in Andhra Pradesh. The first epidemic of the disease appeared in A.P. during Kharif 1987 (Moses and Reddy, 1998). BGR appears during cyclonic weather conditions causing severe yield losses. Under congenial conditions of high humidity and low temperatures the pathogen infects the flowers, capsules and converts them into grey fungal mass of mycelium and spores. BGR is important in A.P. and Tamil Nadu, where it has virtually threatened castor cultivation. During the last 12 years, epidemic of BGR was reported in 4 years and in the remaining years the losses range from 10 to 80%. As cyclonic depressions predispose the onset and spread of the disease, the BGR incidence varies between the years (Janila *et al.*, 2006). The *Etiology, epidemiology and management of the disease* is thoroughly reviewed by Raoof and Yasmeen (2006).

Resistance breeding is most appropriate approach for disease management; in the absence of source of resistance, mutation induction for resistance is a good alternative. Through international coordination and some financial assistance by IAEA and FAO from 1964 onwards it could be convincingly demonstrated, that ionizing

radiations and also certain chemicals, when handled properly, could induce many useful alterations in the genomes of crop plants. Over 2000 crop cultivars with one or more useful traits from induced mutations (mainly from x- and gamma-rays) were released worldwide during past seventy years (Ahloowalia *et al.*, 2004). List of officially released new varieties can be found in the FAO/IAEA Mutant Varieties Database (<http://mvgs.iaea.org/>). In castor three mutant varieties namely, Aruna, HC 8 and Sowbagya were released using induced mutations. Aruna was the ruling castor variety in the country during 1970's and in Andhra Pradesh it occupied large areas until the advent of GCH-4 in 1986-87.

The most commonly used radiations in crop improvement programme are gamma rays, which are ionizing radiation causing chromosomal and gene mutations. Gamma-rays induced pollen sterility and female mutations in castor were reported earlier (Chauhan *et al.*, 1990 and 1992). As induced mutation possesses enormous potential to create genetic variability, the programme to induce BGR resistant mutants was initiated in 2004.

An efficient and robust screening technique, which is a prerequisite to identify induced resistance, was standardized using vermiculate culture and detached spikes; thus named as "Detached spike inoculation technique". Using the technique large mutagenized populations and germplasm accessions were screened for resistance, we report screening of this materials and that none of them showed resistance. An advanced breeding line, PCS-170 showed field tolerance to BGR but this is attributed to various morphological features of the line.

As we continue to screen more mutagenized population to identify resistance to BGR disease, in the meanwhile we intend to develop a bioassay which will help to identify lines showing partial resistance, as the present method of screening i.e., detached spike inoculation technique will lead to loss of such partial resistance, if any. On the other hand field screening to identify complete/partial resistance is inadequate as more often low incidence is a case of 'disease escape'.

Material and methods

Dry seed treatment of two varieties namely, Kranthi and Haritha was done with gamma-rays at BARC, Mumbai and Gamma-rays irradiation facility, PHT, College of Agriculture, Hyderabad. Kranthi is selection from double

cross {(Pb-1 × RC -157B) × (JI 44 × 413 A)} released in 1996 while Haritha released in 2002 is selection from cross (PPL-4 × Jwala) and is resistant to Fusarium wilt. Three doses viz., (1) 55 KR - a dose below LD-50 (2) 60 KR- LD50 dose, and (3) 65 KR, a dose above LD-50 are used as recommended for successful isolation of mutants in castor by Janila *et al.* (2003). The M_1 and subsequent mutant populations were raised at the experimental plots of RARS, Palem. M_2 progenies were derived by selfing M_1 plants and each progeny constitutes 20 plants; Both M_1 and M_2 progenies were screened for grey rot resistance. At least five plants from each M_2 progeny were screened.

A total of 49 new germplasm accessions collected by different research workers during an exploration in four districts, i.e., Warangal, Khammam, Guntur and West Godavari of Andhra Pradesh and their derivatives were screened (Table 1). In addition ten old germplasm lines were also screened. Thus, a total of 120 lines made the test material including the released varieties viz., Kranthi, Haritha, Kiran, Jyothi, and 48-1 used as susceptible checks.

The 162 germplasm accessions from GMU, DOR, Hyderabad (Table 2) which were tested at RARS, Palem for *Botrytis* resistance under natural epidemic in *kharif* 2005. Field screening was done by sowing one row of each accession and after every 10 rows check rows (i.e., Kranthi) was sown. The six lines showing <10 % disease incidence were also tested for which at least two plants

from each lines were challenge inoculated.

In "detached spike inoculation technique" as described by Janila *et al.* (2006) (Plate 1) the spikes in which capsule formation was initiated and still had male flowers were selected and kept in sterile moistened vermiculate filled cups. The spikes were moistened following which spore suspension (10^6 spores/ml concentration) was sprayed. The inoculated spikes were bagged with polythene cover for 72 hours. The spikes were kept in controlled conditions (temp. $25 \pm 2^\circ\text{C}$ and RH 90%) for half an hour for 3 to 4 times a day. The disease appears after 48 hours and the spikes were fully covered with fungal mycelium and spores by 6th day.

Scoring helps to classify susceptible, tolerant and resistant based on number of incubation days required for development of disease symptoms. The test material was rated as susceptible when disease symptoms were observed after 3 days; tolerant, when symptoms were noticed after 5 days. The test material is rated as resistant when disease symptoms were not observed even up to 7 days of inoculation (Janila *et al.*, 2006). As absolute immunity may not be possible for disease resistance the said scale of scoring is adopted. Hence even if a plant can withstand the pathogen for 7 days without disease infection, it would greatly reduce the economic losses as the congenial conditions (cyclonic depressions) for *Botrytis* spread may not last for more than a week under field conditions.

Table 1 List of new germplasm lines and their derivatives

Morphological characters	Germplasm line
R 2SP	RG 2862/4; 2863/2; 2863/4; 2863/7; 2863/8; RG 2865/2; 2866/7; 2866/4; 2870/3; 2870/5; 2871/1; 2872/4; 2874/2; 2875/1; 2876/1; 2878/1; 2882/3 & 4; 2884/4; 2885/3; 2888; 2888/5; 2888/6; 2890/1; 2892; 2892/3; 2893/2; 2896; 2896/6; 2898/1, 2, 3, 5, & 6; 2899/1; 2900/1; 2905/1; 2905/3; 2906/1; 2911/1; 2911/4; 2914; 2916/2; 2927/2; 2928; 2928/4; 2934/7;
R2NSP	RG 2894/1; 2900; SAA 70/2;
R 3SP	RG 2864; 2866/5; 2884/2; 2891; 2891/6; 2902/2; 2904/1; 2915/1; 2930/3; 3288;
R 3NSP	RG 2865/3; 2869/1
R 2 SP/NSP	RG 2863/5; 2872/1; 2888/9; 2900/2; 2911/2;
R 2/3 SP	RG 2896/1; 2902/3; 2923/1; 2926/2; 2928/1; 2933;
R 2/3 SP/NSP	RG 2863/9
R3SP/NSP	RG 2879/2
R/G 2NSP	RG 2862/6; 2897/6;
R/G 2/3 SP	RG 2869; 2863/6; 2868/9; 2878/3; 2884/1; 2890/2;
R/G 2 SP	RG 2863/10; 2870; 2871/2; 2888/3; 2897/5; 2898; G/R 2SP; 2928/6 & 8; 2933/2;
G 2/3 SP	RG 2862/2; 2882/1; 2882/2; 2888/4; 2927/5; 2930/1;
G 2 SP	RG 2865/1; 2866/4; 2867/1; 2872/3; 2874/1; 2876/3; 2885/2; 2885/5; 2896/3; 2896/4; 2899/4; 2905/5; 2911/3; 2913/1; 2914/1; 2917/1; 2923/2;
G 3 SP	RG 2862/1; 2863/1; 2872;
R 0/1 SP	RG 2878/5
R/G 2/3 SP/NSP	RG 2888/1

Acronyms given for morphological characters: R - red stem; G- green stem; 2 - double bloom; 3 - triple bloom; 0- no bloom; 1 - single bloom; SP - spiny capsules; and NSP - non-spiny capsules.

Table 2 List of germplasm accessions screened under field conditions in *kharif*, 2005

Germplasm entries	Botrytis grey rot Grade (0-9 scale)
RG - 2124, 2125, 2126, 2131, 2132, 2133, 2135, 2217, 2267, 2268, 2286, 2323, 2338, 2340, 2341, 2345, 2349, 2350, 2359, 2360, 2366, 2367, 2368, 2369, 2382, 2383, 2384, 2385, 2386, 2388, 2397, 2398, 2399, 2803, 2846, 2862, 2863, 2864, 2865, 2866, 2878, 2787, 2836, 2980, 2995, 3006, 3034, 3128, 3129, 3130, 3131, 3132, 3133, 3150, 3152, 3153, 3132, 3154, 3157, 3158, 3159, 3165, 3166, 3168, 3171, 3172	9
RG -2127, 2129, 2136, 2139, 2140, 2270, 2275, 2277, 2281, 2283, 2342, 2343, 2346, 2347, 2351, 2352, 2357, 2358, 2362, 2370, 2371, 2373, 2376, 2377, 2378, 2379, 2380, 2381, 2391, 2392, 2393, 2869, 2871, 2872, 2873, 2875, 2877, 3124, 3138, 3139, 3145, 3148, 3162, 3163, 3164, 3170	7
RG - 2142, 2297, 2344, 2348, 2354, 2355, 2364, 2365, 2372, 2374, 2375, 2387, 2390, 2394-1, 2395, 2396, 2867, 2868, 2874, 2876, 2758, 3008, 3058, 3125, 3126, 3127, 3134, 3135, 3136, 3140, 3142, 3143, 3144, 3146, 3149, 3155, 3160, 3161, 3173	5
RG - 2289, 2353, 2356, 2363, 3141, 3151,	3
RG - 3054, 3137, 3156, 3167,	No spike formation

Scale : 0 - No incidence ; 1 - 1% of capsules infected ; 3 - 10 % of capsule infected; 5 - 11-25 % of capsules infected; 7 - 26-50 % of capsules infected; 9 - >50 % of capsules infected

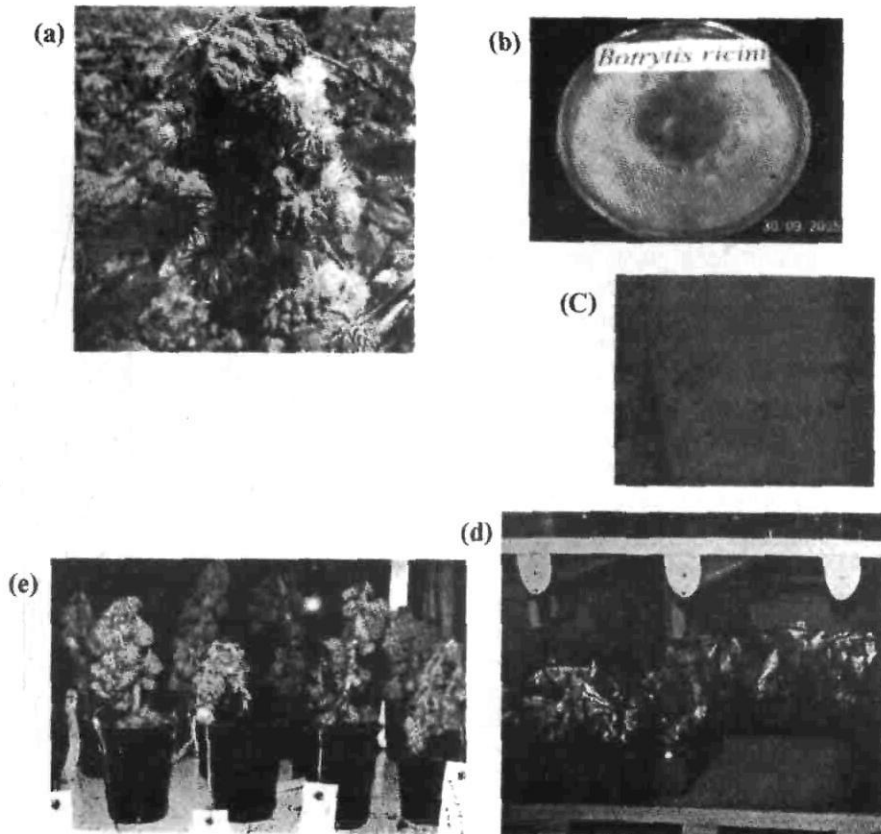


Plate 1: (a) Botrytis infection on capsules (b) pure culture of *Botrytis ricini* on PDA (c) Spore suspension at 10 X magnification (D) Inoculated spikes in polythene bags under controlled conditions (e) Disease symptoms on detached spikes controlled conditions

Results and discussion

During the process of standardization of "detached spike inoculation technique" fungal hyphae were first observed on male flowers (pollen). Moreover, for *Botrytis cinerea* it was reported that germination of conidia was first observed on senescent petals and pollen grains indicating that the exogenous nutrients from these tissues are essential for germination and subsequent growth of germ tubes and hyphae were seen on other plant parts (Huang *et al.*, 1999 and 2000). Hence for all further screening the spikes with male flowers were selected. Though "Detached spike inoculation technique" is adequate to identify complete resistance, alternate bioassays are required to identify partial resistance. Thus, standardization of methodologies for quantification of partial resistance through bioassays will be attempted to identify partial resistant sources. The screening studies on mutagenized populations and germplasm accessions are discussed in the following sections.

Studies on mutagenized populations: A total of 848 R1 plants were challenge inoculated in culture room and disease scoring was done and all of them succumbed to disease and clear disease symptoms were observed on 5th day of inoculation. The M₂ generation constitutes first segregating mutant population; hence recessive mutants can be identified in this generation. Hence, 270 M₂ progenies were tested by taking 5 spikes from each progeny thus making a total of 1350 plants which were challenge-inoculated and plants from five progenies viz., H-55-36, H-55-10, H-55-09, H-55-49, and H-55-15 progenies ('H' denotes variety name 'Haritha' and 55 denotes the irradiation dosage which is 55 KR) showed tolerance. The higher order spikes of these five progenies were selfed and M₃ generation was raised. However, when the M₃ progenies were tested all the plants recorded susceptibility indicating lack of inheritance of the identified tolerance.

Studies on germplasm accessions: The results of challenge-inoculation studies on 49 fresh germplasm accessions along with their respective selections (making a total of 120 lines as indicated in Table 1) are presented in Table 3. All the lines have developed disease symptoms by 3rd day, indicating susceptibility. Out of the 162 accessions screened during *kharif*, 2005 at RARS, Palem, six accessions, viz., RG 2289, 2297, 2353, 2356, 2363, 3141, and 3150 recorded <10 % disease infection and are categorized as resistant as per 0-9 scale of disease score. However, when we challenge inoculated these six accessions under high disease pressure by 5th day clear disease symptoms were noticed on entire spike. During 2000-01 AICRP testing, 11 accessions recorded <10 % incidence at DOR, Hyderabad; however, 7 of them were found to be susceptible when tested again in 2001-02 (Anonymous, 2001 and 2002). In 2003-04, 68 germplasm lines were screened at DOR, Hyderabad (under artificial

inoculation in the field) and RARS, Palem (under natural conditions). Six lines, viz., RG-2836, 2758, 2819, 2719, 2752, and 2816 were reported to be resistant from DOR while only one of them i.e., RG-2752 showed <10% disease infection at RARS, Palem (Anonymous, 2004). Thus recording of low incidence disease under natural field screening is surely a case of disease escape; hence such material should not be included in cross breeding programmes.

From our breeding material we have identified an advance breeding line, PCS-170 (Plate 2), which is derived from a cross between PCS-122 and PCS-124 showing field tolerance to *Botrytis* grey rot due to the presence of scaly leaves (highly reduced leaf lamina as seen in Plate 2). This line inherits the features of PCS-122, which attribute field tolerance like narrow drooping capsules with short spines as well as reduced leaf lamina; and at the same time possess better agronomic feature like higher test weight; long spikes and >90% pistillate nature of spike. The agronomic performance of this line has to be specifically tested under closed spacing conditions while comparing with check varieties because the per plant yield will remain definitely lower than check varieties but the per plot yield may be at par as more plant population can be maintained in a given area.

Identification of natural or induced host-resistance is the best strategy for disease management. In other crops induced host-resistance to diseases were reported earlier for example, in barley mildew resistant mutant were induced by X-rays by Hansel and Zakovsky (1956); and altered adult plant resistance in wheat mutants to *Puccinia striiformis* f.sp. *tritici* reported by Boyd and Minchin (2004), etc. It is also interesting to note that most spring barley varieties contain various mutant alleles of the disease resistant gene *mlo* in Europe and Australia (<http://www.crpmb.org/mlo/#Pifanelli>). So far, no allele for resistance to *Botrytis ricini* has been described earlier in castor and even from the present study we could not isolate any mutant showing partial/complete resistance. In the absence of host-resistance development of resistant varieties by conventional approaches is a distant dream, as any approach of conventional breeding for disease resistance necessitates available genetic variability in terms of host-resistance and knowledge of inheritance pattern of the same has to be established before adopting a breeding procedure. Further, the nature of disease appearance and spread make the management practices ineffective; thus the alternate strategies like identification of advanced breeding lines with field tolerance, systemically acquired resistance, Biological control, QTL mapping of partial resistance, and transgenic approach can be worked upon to give solution to the problem of *Botrytis* disease in castor. Nevertheless, induction of resistant mutants constitutes one of the important strategies to identify complete/partial resistant mutants.

Acknowledgements: "The research for this publication was conducted as part of the programme 'Biotechnology for Dryland Agriculture in Andhra Pradesh' with financial support of the Research and Communications Division, Ministry of Foreign Affairs, the Government of the

Netherlands. Responsibility for the contents and for the opinions expressed rests solely with the authors; publication does not constitute an endorsement by RARS, Palem or BTU or the funding agency".

Table 3 Screening of new germplasm lines and their derivatives for BGR resistance

Days for appearance of initial symptom's	Days to which the spike is completely covered with mycelium	Germplasm line
2	5	RG- 2869; 2862/2, 4 & 6; 2863/1,2,4,5,6, & 7
3	5	RG 2864; 2865/1, 2 & 3; 2866/4,5 & 7; 2867/1; 2868/1 & 9; 2870, 2870/3 & 5; 2871/1 & 2; 2872; 2872/1, 3 & 4; 2874/1 & 2; 2875/1; 2876/1 & 3; 2878/1, 3 & 5; 2879/2; 2882/1, 2, 3 & 4; 2884/1, 2 & 4; 2855/2, 3 & 5; 2888; 2888/1, 3, 4, 5, 6 & 9; 2890/1 & 2; 2891; 2891/6; 2892; 2892/3; 2893/2; 2894/1; 2896; 2896/1, 3, 4 & 6; 2897/5 & 6; 2898; 2898/1, 2, 3, 5 & 6; 2899/1 & 4; 2900; 2900/1 & 2; 2902/2 & 3; 2904/1; 2905/1, 3 & 5; 2906/1; 2911/1, 2, 3, 4; 2913/1; 2914; 2914/1; 2915/1; 2916/2; 2917/1; 2923/1 & 2; 2926/2; 2927/2 & 5; 2928; 2928/1, 3, 4, 6 & 8; 2930/1 & 3; 2933; 2933/2; 2934/7; 3288; SAA 70/2
3	6	RG 2862/1

In all the material > 50 % capsules are infected, hence all of them score 9 on 0-9 scale

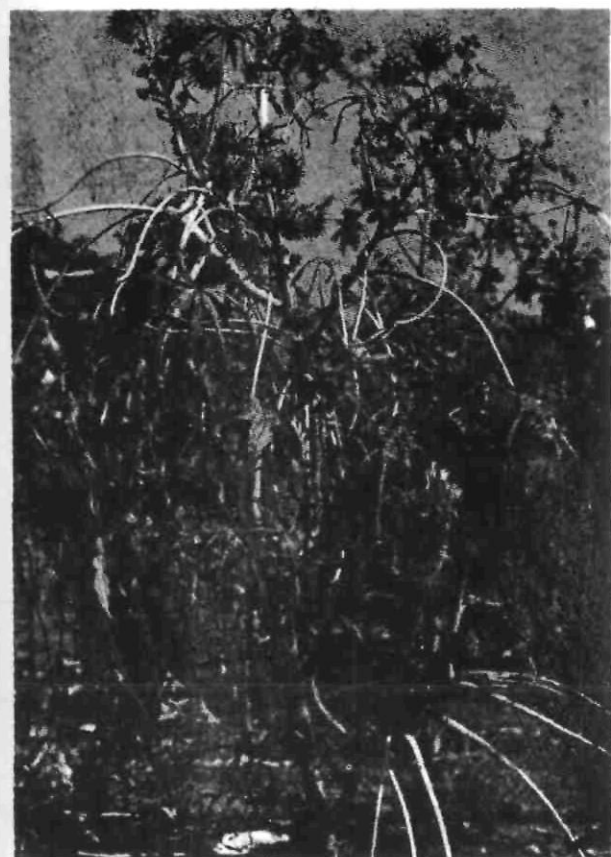


Plate 2 Highly reduced leaf lamina

References

- Ahloowalia, B.S., Maluszynski, M. and Nichterlein, K. 2004. Global impact of mutation derived varieties. *Euphytica*, **135**: 187-20.
- Anonymous, 2001. Annual Report 2000-01, Directorate of Oilseeds Research, Hyderabad, India. pp.118.
- Anonymous, 2002. Annual Report 2001-02, Directorate of Oilseeds Research, Hyderabad, India. pp. 149.
- Anonymous, 2004. Annual Report 2003-04, Directorate of Oilseeds Research, Hyderabad, India. pp.1-127.
- Boyd, A. L. and Minchin, P. N. 2001. Wheat mutants showing altered adult plant disease resistance. *Euphytica*, **112**: 361-368.
- Chauhan, S.V.S., Singh, K.P. and Kinoshita, T. 1990. Gamma ray induced pollen sterility in castor. *Journal of Faculty of Agriculture*, **64** (3): 229-234.
- Chauhan, S.V.S., Singh, K.P. and Saxena, B.K. 1992. Gamma-ray induced female mutations in castor. *Indian Journal of Genetics*, **52**(1): 26-28.
- Deverall, B. J. 1995. Plant protection using natural defense systems of plants, *Advances in Plant Pathology*, **11**: 211.
- Hansel, H. and Zalovsky, J. 1956. Mildew-resistant barley mutants induced by X-rays. *Euphytica*, **5**: 347-352.
- Huang, H. C., Acharya, S. N. and Erickson, R. A. 2000. Etiology of alfalfa blossom blight caused by *Sclerotinia sclerotiorum* and *Botrytis cinerea*. *Plant Pathology Bulletin*, (Taiwan), **9**: 11-16.

Studies on host resistance to *Botrytis* grey rot in castor

- Huang, H.C., Kokko, E.G. and Huang, J.W. 1998.** Epidemiological significance of pollen in fungal diseases. *Recent Research Developments in Plant Pathology*, 2: 91-109.
- Janila, P., Ashok Kumar, A. and Sujatha, M. 2003.** Effective dose of gamma rays for induced mutations in castor. In: "National Seminar on Stress Management in Oilseeds" Jan 28-30 organized by DOR, Hyderabad. pp. 422-423.
- Janila, P., Ashok Kumar, A. and Rajashekar Reddy, N. 2006.** Botrytis grey rot disease of castor in Andhra Pradesh and screening for identification of resistant source In: *National Seminar on Drought adaptations for sustainable agriculture and livelihood in dry land areas - problems prospects and policies*, 15-16 Feb 2006 at RARS, ANGRAU, Palem. pp. 128-135
- Moses, G. J. and Ranga Reddy, R. 1998.** Grey mould of castor in Andhra Pradesh. *Journal of Research, Andhra Pradesh Agricultural University*. XVII (1): 74-75.
- Raoof, M. A. and Yasmeen, M. 2006.** Etiology, epidemiology and management of Botrytis grey mold of castor, *Ricinus communis* L. *Journal of Oilseeds Research*, 23(2), 144-50.

Performance of castor, *Ricinus communis* L. genotypes at different integrated nutrient management practices under irrigated conditions

Narayan S. Mavarkar, T.K. Prabhakara Setty¹ and S. Sridhara

College of Agriculture, Navile, Shimoga

(Received: July, 2008; Revised: December, 2008; Accepted: February, 2009)

Abstract

Field experiments were conducted under irrigated condition during *kharif* season of 2003 and 2004 at College of Agriculture and Zonal Agricultural Research Station, Navile, Shimoga, Karnataka to evaluate the performance of different genotypes of castor under varied integrated nutrient management systems. Maximum bean yield and oil yield were recorded by DCH-177 (2662 and 1344.3 kg/ha) as compared to DCS-9 (2103 and 1019.6 kg/ha, respectively). Apart from this, significant difference in the yield components namely test weight (31.3g), number of capsules (72.4) and length of primary spike (50.9cm) were observed in DCH-177 as compared to DCS-9. Recommended dose of fertilizer along with poultry manure @ 3 t/ha recorded significantly highest total bean and oil yield of castor as compared to recommended rate of fertilizer alone.

Key words: Castor, integrated nutrient management, irrigated

Introduction

Castor is a drought tolerant crop but responds well for irrigation and nutrient supply. Drastic reduction in yield due to moisture stress either at primary, secondary or tertiary spike development stages have been reported by several researchers (Patel and Pathak, 2002). Due to increase in fertilizers cost and their detrimental effect on the soil health, the reduction in use of chemical fertilizer and supplementing it through organic manures like FYM, castor cake, pressmud and poultry manures have become necessary to sustain productivity and profitability. Several attempts were made to study the integrated effect of organic manures along with fertilizers on the growth and yield of castor (Baby Akula and Bapi Reddy, 1998; Arangarasan *et al.*, 1999; Raghavaiah, 1999 and Patel and Pathak, 2002). However, no attempts have been made to study the integrated use of inorganic fertilizers with organic manures like poultry manure and pressmud under irrigated conditions. Hence, an attempt is made to study the combined effect of inorganic fertilizers along with poultry manure and pressmud on the growth and yield of castor.

Materials and methods

Field experiments were conducted under irrigated condition during *kharif* season of 2003 and 2004 at the College of Agriculture and Zonal Agricultural Research Station, Navile, Shimoga. The station is located at 14° .0 to 14° .1'N latitude and 75° .40' to 75° .42'E longitude with an altitude of 650 meters above mean sea level. The experiment was conducted on Alfisols. Soil was slightly acidic (6.2) and low in electrical conductivity of 0.30 dS/m. The organic carbon content was 0.43% and low in available N (260 kg/ha), high in P (98.58 kg/ha) and medium in K (173.83 kg/ha). The experiment was laid out in Factorial RCBD with three replications with a gross plot size of 5.4 x 4.8 m and net plot size of 3.6 x 3.6. In this experiment, there were two genotypes (DCH-177 and DCS-9) of castor tested under four levels of integrated nutrient management practices, viz., recommended dose of fertilizer (RDF) (F₁), 150% RDF (F₂), RDF + pressmud @ 3 t/ha (F₃) and RDF + poultry manure @ 3 t/ha (F₄). The RDF for castor is 60:40:30 kg N:P:K/ha. The spacing for hybrid was 90x60 cm and for variety, 60 x 45 cm between rows and plants, respectively.

The basal dose of fertilizers was applied at the time of sowing as per the treatments during both the years. Fifty per cent of the recommended nitrogen and entire P₂O₅ and K₂O were applied as basal and remaining 50% nitrogen was applied in two equal splits as per treatment at 45 and 65 days after sowing. The organic manures (pressmud and poultry manure) used for study were applied as per the treatments. The crop was irrigated five times during the crop growth period amounting to a depth of 5 cm at each irrigation.

The observations on castor growth, number of leaves and number of branches/plant and yield components viz., number of spikes/plant, number of capsules/spike, 100-seed weight and bean yield were recorded on randomly selected five plants from the net plot.

Results and discussion

Castor hybrid DCH-177 recorded maximum bean yield as compared to variety DCS-9. On an average there is 26.5% increase in bean yield over DCS-9 (Table 1). This can be attributed to exploitation of hybrid vigour. Further, there

¹ Director of Research, University of Agricultural Sciences, Bangalore.

Performance of castor genotypes at different integrated nutrient management practices under irrigated conditions

were significant differences in the yield components namely length of primary spikes, number of capsules and test weight, as compared to DCS-9, a castor variety. Findings of Raghavaiah *et al.* (2003), Sreedhar Chauvan *et al.* (2003) indicated that significantly higher yield was obtained by DCH-177 as against DCS-9 under rainfed conditions. The growth parameters like plant height, number of leaves and number of branches/plant have contributed for obtaining higher yield of DCH-177 as

compared to DCS-9 (Table 2), which influenced the hybrid positively in terms of absorption of nutrients, use of solar radiation and natural resources more efficiently as compared to DCS-9 (Lakshamma and Lakshmi Prayaga, 2001). These growth and yield parameters have influenced positively the final seed yield of castor in the present investigation, thus leading to higher yield in DCH-177 than DCS-9.

Table 1 Yield components, bean yield and oil content of castor as influenced by genotypes and INM practices under irrigated condition

Treatment	Length of primary spikes (cm)			Number of capsules/spike			Test weight (g)			Total yield (kg/ha)			Oil yield (kg/ha)		
	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled	2003	2004	Pooled
Genotype (G)															
G ₁	48.1	53.7	50.9	64.9	80.0	72.4	30.9	31.8	31.3	2545	2778	2662	1275	1412	1344
G ₂	23.7	29.5	26.6	25.6	32.2	28.9	23.5	24.4	23.9	2015	2192	2103	969	1070	1020
SEm ±	0.38	0.62	0.50	0.28	0.32	0.30	0.14	0.37	0.25	21.7	34.6	28.1	15.3	17.3	15.9
CD (P=0.05)	1.14	1.85	1.49	0.84	0.97	0.90	0.43	1.09	0.76	64.4	102.9	83.7	45.3	51.4	47.0
INM Practices (F)															
F ₁	31.4	37.1	34.3	30.2	42.3	36.3	25.8	26.8	26.3	1912	2153	2033	920	1045	982
F ₂	36.1	42.1	39.1	44.1	58.0	51.0	27.4	28.3	27.8	2268	2483	2376	1103	1227	1165
F ₃	38.1	44.6	41.3	55.0	62.3	59.0	28.3	29.0	28.6	2502	2712	2607	1241	1378	1309
F ₄	39.1	45.6	42.3	56.7	64.3	60.5	28.4	29.1	28.8	2557	2757	2657	1248	1379	1313
SEm ±	0.60	0.98	0.79	0.44	0.51	0.48	0.23	0.58	0.47	34.3	54.79	47.5	29.4	32.4	30.2
CD (P=0.05)	1.80	2.93	2.37	1.33	1.53	1.43	0.68	1.73	1.38	101.9	163.2	141.4	86.7	95.5	89.2
G × F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2 Plant height, number of leaves, number of branches and number of spikes/plant of castor as influenced by genotype and INM practices under rainfed condition

Treatment	Plant height(cm)			No. of Leaves/plant			No. of Branches/plant			No. of spikes/plant		
	2003	2004	mean	2003	2004	mean	2003	2004	mean	2003	2004	mean
Genotype (G)												
G ₁	161	172	167	37	42	40	7.1	8.4	7.8	10	11	11
G ₂	140	148	144	31	34	32	5.0	6.1	5.5	8	9	9
SEm ±	1.3	0.6	1.1	0.94	0.34	0.69	0.17	0.10	0.16	0.16	0.22	0.19
CD (P=0.05)	4.0	1.7	3.9	2.80	1.02	2.01	0.53	0.31	0.49	0.48	0.64	0.58
INM practices (F)												
F ₁	139	151	145	30	36	33	5.1	6.0	5.5	8	9	8
F ₂	154	163	158	34	39	36	5.7	7.1	6.4	9	10	10
F ₃	156	165	160	37	40	38	7.1	8.0	7.5	9	11	10
F ₄	157	169	163	37	41	39	7.3	8.6	7.9	10	11	10
SEm ±	2.1	1.4	1.2	1.49	0.54	1.25	0.28	0.2	0.54	0.25	0.35	0.32
CD (P=0.05)	6.3	4.3	3.6	4.32	1.58	3.74	0.83	0.64	1.61	0.76	1.02	1.00
G × F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

F₁=Recommended dose of fertilizer (RDF), NS= Non-significant, F₂= 150% RDF, G₁=DCH-177 Castor Hybrid, F₃=RDF + pressmud @ 3 t/ha, G₂= DCS-9 Castor variety, F₄= RDF + poultry manure @ 3 t/ha

Significantly higher oil yield was recorded in DCH- 177 as compared to DCS-9 which was mainly due to more oil content (50.5%), more bean yield/plant, capsules/spike and bean yield/ha as compared to DCS-9. These results are in conformity with the findings of Raghuram Reddy *et al.* (1999) and Raghavaiah *et al.* (2003). Application of

RDF + poultry manure @ 3 t/ha recorded significant highest total yield of castor as compared to recommended dose of fertilizer alone. There is 30.71% increase in total castor yield by combining RDF with poultry manure. Similarly application of RDF with pressmud has also increased the total castor yield to an extent of 28.24%

followed by 150% of RDF (16.87%), as compared to application of RDF alone (Table 1). Baby Akula and Bapi Reddy (1998); Arangarasan *et al.* (1999); Raghavaiah (1999) and Patel and Pathak (2002) have reported the similar trend due to adoption of INM practices.

The significant yield increase of castor by various combinations of recommended dose of fertilizer with organic manures could be due to the variation in the yield components such as number of spikes/plant, length of primary spikes, number of capsules/spike and test weight. Application of RDF integrated with poultry manure recorded higher number of spikes/plant, which works out to be 20.24% increase over application of recommended dose of fertilizer (RDF) alone. The numbers of capsules/spike and test weight were also positively influenced by application of recommended dose of fertilizer along with poultry manure than RDF alone, the increase being 66.6% and 9.41%, respectively. The increase in the number of capsules/plant may be attributed to more length of primary spike (Table 1), which in turn is due to sufficient and continuous availability of nutrients with the application of pressmud, or poultry manure along with RDF under irrigated condition. The additional application of fertilizers over RDF increased the number of capsules/spike and test weight to a lesser extent as compared to combined application of RDF with pressmud or poultry manure, indicating the continuous and proper availability of nutrients in synergy with the crops demand under integrated nutrient management practice. Significant increase in castor yield by combined application of FYM + RDF + seed treatment with *Azospirillum* has been reported.

Combined application of RDF with poultry manure or pressmud resulted in significantly increase in growth components such as plant height, number of leaves/plant and number of branches/plant over RDF alone (Table 2). Subba Reddy *et al.* (1993); Baby Akula and Bapi Reddy (1998); Patel and Pathak, (2002) and Raghavaiah, (2005) have also reported increased growth components of castor due to integration of organics with inorganic fertilizers. The secondary plant nutrients in particular sulphur are also needed for growth and seed development of castor for the synthesis of higher ATP and oil. Their availability can be improved with supply of optimum level of moisture.

Significantly higher oil yield was obtained with combined application of RDF + poultry manure as compared to RDF alone (Table 1). There is an increase in the oil yield to an extent of 33.7% followed by RDF + pressmud (33.2%) followed by 150% RDF (18.8%) as compared to RDF alone. The energy rich crop like castor requires more N and sulphur to synthesize and accumulate the oil. Combined application of pressmud or poultry manure with RDF enhanced the oil content in castor due to better

availability of N and S. On an average pressmud has supplied 69 kg of sulphur and poultry manure has supplied 16.5 kg S/ha. These results are in conformity with the findings of Sreedhar Chauvan *et al.* (2003) and Patel and Pathak (2002).

Based on this study it can be concluded that cultivation of castor DCH-177 is more profitable than DCS-9. Further, application of poultry manure or pressmud along with RDF will produce better yield of castor.

References

- Arangarasan, V., Palaniappan, S.P. and Chelliah, S. 1999. Response of castor (*Ricinus communis*) to *Azospirillum* and Phosphobacteria inoculation. *Journal of Oilseeds Research*, 16 (1) : 121-122.
- Baby Akula and Bapi Reddy. 1998. Integrated nutrient management in rainfed castor. *Journal of Oilseeds Research*, 15 (1): 115-117.
- Lakshamma, P. and Lakshmi Prayaga. 2001. Physiological analysis of yield variations in rainfed castor (*Ricinus communis* L.). *Journal of Oilseeds Research*, 18 (2): 244-246.
- Patel K.S. and Pathak H.C. 2002. Integrated nutrient management for irrigated castor (*Ricinus communis*). *Journal of Oilseeds Research*, 19(2): 235-236.
- Raghavaiah, C.V. 1999. Performance of castor (*Ricinus communis* L.) hybrids under different levels of fertilizer in rainfed conditions on Alfisols. *Journal of Oilseeds Research*, 16 (2): 295-298.
- Raghavaiah, C.V. 2005. Nutrient management in castor (*Ricinus communis* L.) and castor based cropping systems. *Indian Journal of Fertilizer*, 1 (3): 23-33.
- Raghavaiah, C.V., Muralidharudu, Y., Padmaiah, M., Lavanya, C., Lakshamma, P., Joseph Jeevan Royal, T. and Ammaj, P. 2003. Production potential of castor (*Ricinus communis* L.) genotypes under farmer's field conditions in sodic vertisols of semi-arid tropics. *Journal of Oilseeds Research*, 20 (2): 249-253.
- Raghuram Reddy, P., Vanaja, M., Hanumantha Rao, C., Maruthi Sankar, G.R., Venkateshwaralu, S. and Eastin, D. 1999. Performance of castor (*Ricinus communis* L) genotypes with normal and delayed seeding under irrigated and rainfed conditions. *Indian Journal of Agricultural Sciences*, 69 (2): 96-100.
- Sreedhar Chauvan, Yakadri, M. and Chandrashekar Rao, P. 2003. Influence of seeding lime on oil content and oil yield in castor cultivars during rabi season. *Journal of Oilseeds Research*, 20 (1) : 137-138.
- Subba Reddy, G., Venkateshwaralu, B. and Maruthi Sankar, G.R. 1993. Effect of different organic materials as sources of nitrogen on growth and yield of castor. *Journal of Oilseeds Research*, 10 (1) : 151-152.

Suitability of containers and moisture content for proper storage of safflower, *Carthamus tinctorius* L. seeds

Pratibha Parihar, S. Nema and S. Kumar

Department of Food Science & Technology, Jawaharlal Nehru Krishi Vishwa Vidyalyaya, Jabalpur-482 004, MP

(Received: June, 2007; Revised: February, 2009; Accepted: March, 2009)

Abstract

The present study was carried out to evaluate the suitable conditions and container for safe storage of safflower, *Carthamus tinctorius* L. seeds. The studies revealed that 6 to 8% moisture was the safest from germination and fungal infestation points of view. However, 10-12% moisture was most favourable for fungal infestation along with changes in the quality of seeds. The best containers for storage were gunny bags and/or baked earthen pots. During storage, there were no changes in oil and protein content of seeds. However, free fatty acids increased steadily during storage.

Key words: Containers, fungal infestation, safflower seeds

Introduction

Safflower (*Carthamus tinctorius* L) is one of the important rain fed and drought tolerant rabi oilseed crop and known for its oil quality oil which is rich in linoleic acid. India is the largest producer of safflower seeds in the world. After harvesting, the seeds have to be stored for oil extraction and also for sowing in the next year. During this, the conditions of storage and moisture content of seeds play an important role in seed quality. In view of this, the present study was planned to explore the suitable conditions for proper storage of safflower seeds.

Materials and methods

Three types of containers viz, gunny bags (permeable), baked earthen pots (semi permeable) and plastic boxes (impermeable) were used to store 2 kg of safflower seeds at 6, 8, 10 and 12% moisture for 6 months under ambient conditions. The samples were withdrawn at 2 months intervals and used for various analysis. Moisture and oil contents were determined as per AOAC (1980). Protein content was estimated by using conventional Micro-kjeldahl digestion and distillation procedure as per AOAC (1980). Germination percentage and free fatty acids determined as per AOAC method (1980). Fungal infestation of seeds was recorded as per ISTA (1976).

Results and discussion

The results showed that seeds germination was not affected if seeds were stored in gunny bags and baked

earthen pots till 4 months of storage at 6 to 8% moisture level (Table 1).

Table 1 Germination level (percentage) during storage of safflower seeds at various moisture levels in different containers

Container	Moisture (%)	Storage period (months)			
		0	2	4	6
Gunny bag	6	84.0	83.5	78.1	55.6
	8	83.8	83.1	78.0	54.0
	10	83.0	82.8	74.8	31.6
	12	82.1	82.8	73.8	25.0
Baked earthen pots	6	84.1	83.1	77.8	55.6
	8	83.8	82.6	77.1	54.0
	10	82.6	82.5	73.6	30.1
	12	83.3	81.3	72.3	22.8
Plastic boxes	6	83.3	81.6	67.0	37.3
	8	83.3	81.3	66.6	30.3
	10	82.1	80.8	59.1	28.8
	12	81.5	79.6	55.5	20.1

However, further increase in moisture levels, there was a decreasing trend in germination and it came to very low after 6 months of storage. Plastic boxes had marked decrease in germination of seeds at all moisture levels. This suggested that types of storage container, moisture levels and duration of storage had more influence on germination of safflower seeds. Germination was very much affected at higher moisture levels. The maximum germination (84.16%) was observed in baked earthen pots at 6% moisture and minimum (20.16%) at 12% moisture in plastic boxes. Similar findings were also made by Shcherbakov *et al.* (1974). The percentage of moisture in safflower seeds varied from 6.04 to 12.54% depending on initial level of moisture and storage containers (Table 2).

Table 2 Moisture content (percentage) during storage of safflower seeds at various moisture levels in different containers

Container	Moisture (%)	Storage period (months)			
		0	2	4	6
Gunny bag	6	6.2	6.3	6.9	6.8
	8	8.2	8.3	8.8	8.8
	10	10.2	10.2	10.6	10.6
	12	12.1	12.2	12.5	12.5
Baked earthen pots	6	6.2	6.4	6.9	6.8
	8	8.1	8.3	8.9	8.7
	10	10.1	10.3	10.6	10.6
	12	12.1	12.2	12.5	12.5
Plastic boxes	6	6.0	6.1	6.1	6.0
	8	8.0	8.0	8.1	8.0
	10	10.0	10.1	10.1	10.1
	12	12.0	12.1	12.1	12.1

The variation in moisture percentage was prominent in gunny bags and baked earthen pots. It was continuously increased on increasing the storage periods. However, in plastic boxes, it was more or less similar in variations. The maximum moisture (12.54% percentage) was observed in baked earthen pots after four months of storage and minimum 6.04% in plastic boxes after two months of storage. These findings support the previous observations made by Anonymous (1975).

During storage, a number of fungal species were found on seeds i.e., *Curvularias* and *Aspergillus*, species. The infestation was maximum in plastic boxes in comparison to gunny bags and baked earthen pots at 12% moisture.

The fungal diseases infestation had increased with the increase of moisture levels during storage. Similar results were also obtained in niger seeds by Nema *et al.* (2006).

Table 3 Fungal infestation (percentage) during storage of safflower seeds at various moisture levels in different containers

Storage period (months)	Moisture (%)	Container														
		Gunny bags					Baked earthen pots					Plastic boxes				
		CS	AF	AN	AL	AS	CS	AF	AN	AL	AS	CS	AF	AN	AL	AS
0	6	-	5	3	-	-	-	1	2	-	4	-	6	-	10	16
	8	-	4	6	-	4	-	3	2	-	4	-	10	-	12	16
	10	-	8	8	-	6	-	5	5	-	3	-	10	-	14	30
	12	-	9	11	-	8	-	6	9	-	6	-	24	-	22	36
2	6	-	5	4	-	-	-	4	-	-	5	-	-	10	-	14
	8	-	7	8	-	12	-	7	10	-	-	-	-	14	-	17
	10	-	10	11	-	14	-	8	14	-	7	-	-	16	-	20
	12	-	12	9	-	-	-	9	15	-	12	-	-	26	-	46
4	6	2	25	-	-	14	2	-	9	-	17	4	-	22	20	-
	8	6	-	-	-	19	4	-	20	-	30	6	-	30	6	12
	10	7	-	8	14	18	8	-	-	-	22	10	-	-	20	14
	12	9	20	27	19	28	-	-	-	30	-	-	35	-	41	24
6	6	16	20	-	-	27	16	-	-	-	10	22	-	-	15	6
	8	20	-	30	-	24	36	23	34	-	-	25	-	-	14	-
	10	30	-	32	-	19	50	-	-	-	34	66	-	-	-	30
	12	50	-	-	20	30	52	-	-	-	02	50	-	24	-	26

CS = *Curvularias* spp.; AF = *Aspergillus flavus*; AN = *Aspergillus niger*; AL = *Aspergillus lichuensis*; AS = *Aspergillus* spp.

As represented in Table 4, 5 and 6, that there were no difference in oil and protein contents of safflower seeds with respect to moisture levels. However, free fatty acids increased steadily from 1.40 to 2.85% during storage at different moisture levels.

Table 4 Oil content (percentage) during storage of safflower seeds at various levels in different containers

Container	Moisture (%)	Storage period (months)			
		0	2	4	6
Gunny bag	6	29.0	29.0	29.1	28.8
	8	29.2	29.3	29.1	29.0
	10	29.1	29.3	29.2	29.0
	12	29.2	29.3	29.3	29.0
Baked earthen pots	6	29.1	29.0	29.1	28.8
	8	29.2	29.2	29.2	28.9
	10	29.2	29.2	29.3	29.0
	12	29.2	29.3	29.3	29.0
Plastic boxes	6	28.9	28.9	28.6	28.3
	8	28.9	28.9	28.5	28.3
	10	29.0	29.0	28.7	28.1
	12	29.0	29.0	28.8	28.2

These results were in conformity with the previous observations made by Malyshev *et al.* (1973). Based on the above findings, it was concluded that safflower seeds could be stored safest at 6 to 8% moisture in gunny bags and/or baked earthen pots without much change in the quality of seeds.

Table 5 Protein content (percentage) during storage of safflower seeds at various levels in different containers

Container	Moisture (%)	Storage period (months)			
		0	2	4	6
Gunny bag	6	16.2	15.8	15.7	15.7
	8	16.1	15.8	15.7	15.7
	10	15.9	15.8	15.6	15.5
	12	15.9	15.8	15.6	15.5
Baked earthen pots	6	16.0	16.0	15.7	15.6
	8	16.0	15.8	15.6	15.6
	10	15.9	15.7	15.6	15.5
	12	15.9	15.7	15.5	15.4
Plastic boxes	6	16.0	15.9	15.5	15.3
	8	15.9	15.7	15.5	15.3
	10	15.8	15.7	15.4	15.1
	12	15.8	15.6	15.2	15.0

Suitability of containers and moisture content for proper storage of safflower seeds

Table 6 Free fatty acid content (percentage) during storage of safflower seeds at various levels in different containers

Container	Moisture (%)	Storage period (months)			
		0	2	4	6
Gunny bag	6	1.5	1.4	1.6	1.7
	8	1.4	1.5	1.6	1.8
	10	1.5	1.6	2.0	2.4
	12	1.6	1.6	2.2	2.7
Baked earthen pots	6	1.5	1.5	1.6	1.8
	8	1.5	1.5	1.7	1.8
	10	1.5	1.6	2.1	2.5
	12	1.6	1.7	2.1	2.8
Plastic boxes	6	1.5	1.6	1.8	2.1
	8	1.5	1.6	1.8	2.2
	10	1.6	1.7	2.1	2.6
	12	1.6	1.7	2.3	2.9

References

- Anonymous. 1975. Storage of oilseeds and pulses Annual Reports ICAR Scheme on Post Harvest Technology, College of Agril. Engg., Jabalpur.
- AOAC, 1980. Official Method of Analysis Association of Official Approved method of analysis 14th ed. Association of Official Analytical Chemist Washington, D.C.
- ISTA, 1976. International Rules for Seed Testing, Annexure Seed Science and Technology, 51-177.
- Malyshev, A.M., Pavlenkova, T.P. and Kudinov, P.I. 1973 Lipid and fatty acid changes in safflower seeds due to prolonged storage. *Pishchevaya Tekhnologiya*, 1:28-30.
- Nema, S., Parihar, P. and Raghuwashi, K.M.S. 2006. Effect of different containers and moisture content on storage of niger seed. *Indian Phytopathology*, 59 (4): 503-506.
- Shcherbakov, V.G., Zhuravlev, A.I. and Lovanav, V.G. 1974. Germination ability and quality of sunflower seeds during storage. *Zavetiya Vysshikh Uchevnykh Zavedenii Pishchevaya Tekhnologiya*, 5:15-19.

Effect of supplementation of red palmolein, iron and vitamin C on vitamin A and iron status of adolescent girls

K. Aparna and K. Manorama

College of Agriculture, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad-500 030, AP

(Received: January, 2009; Revised: June, 2009; Accepted: June, 2009)

Abstract

Effect of supplementation of red palm oil, iron and Vitamin C on serum Vitamin A and blood hemoglobin levels was studied in adolescent girls. Deacidified Deodorised Red Palm Oil (DDRPO) is a refined palm oil with its carotene content retained upto 85% and therefore an excellent source of natural vitamin A. Fifteen anemic adolescent girls were supplemented with placebo for 30 days, placebo + iron (Ferrous sulphate, 200mg) for the next 45 days followed by deacidified, deodorized red palm oil (DDRPO) snack (supplying half RDA of vitamin A) + iron tablets for a further period of 45 days and DDRPO + iron tablets + vitamin C (25mg) for the last 45 days. Blood levels of hemoglobin, serum vitamin A and β -carotene were analyzed at baseline and after every period of supplementation. Blood hemoglobin, vitamin A and β -carotene status improved significantly after supplementation. Maximum hemoglobin ($7.63 \pm 0.97 \mu\text{mol/l}$) levels were observed in the period of supplementation with both vitamin A and iron rather than with iron supplementation alone ($5.73 \pm 0.56 \mu\text{mol/l}$), which improved further with addition of vitamin C. Vitamin A ($1.28 \pm 0.03 \mu\text{mol/l}$) and β -carotene ($0.58 \pm 0.10 \mu\text{mol/l}$) status improved significantly with DDRPO supplementation.

Key words: Red palmolein, adolescent supplementation

Introduction

Red Palm Oil (RPO) (*Elaeis guineensis*) is the only conventional edible oil of vegetable origin which contains a very high quantity of carotenoids in the unsaponifiable, non-glyceride fraction (Goh, 1985). As a source of β -carotene, which is the pre-cursor of vitamin A, it can improve vitamin A status and alleviate the symptoms of vitamin A deficiency (Saritha and Manorama, 1997).

In India, iron deficiency anemia and hypovitaminosis A are two of the most prevalent nutritional problems. Several studies in humans and experimental animals have shown that there is an interaction between vitamin A nutriture and iron nutrition and metabolism (Hodges *et al.*, 1978; Beire *et al.*, 1979; Donoghue *et al.*, 1981). Iron deficiency

seems to deteriorate vitamin A metabolism leading to a reduction in serum retinol and an increase in hepatic retinol and retinyl ester (Oliveria *et al.*, 2008). These studies indicate that lack of vitamin A may lead to mild anemia characterized by low serum iron, and elevated levels of this mineral in storage depots, particularly the liver. Epidemiological studies in both children and adults support this concept (Mejia *et al.*, 1977) and nutritional interventions with vitamin A in humans revealed a positive effect on iron nutrition (MohanRam *et al.*, 1977; Mejia and Arroyave, 1982). However, there are no studies on hematological effect of supplementing adolescent girls with vitamin A, iron and vitamin C together. Evidence is also available showing that improvement in vitamin A status by supplementing or food fortification with vitamin A also improves indicators of iron status. A study by Mejia *et al.*, (1977) showed that interventions to improve vitamin A status should include iron supplementation and *vice-versa* in communities where infections are prevalent. Based on these array of evidences, the present study was planned to evaluate the effect of iron supplementation alone in comparison with iron + DDRPO and Vitamin C supplementation, in elevating serum levels of hemoglobin and vitamin A in anemic adolescent girls.

Materials and methods

Fifteen adolescent girls with depleted levels of hemoglobin and serum retinol were selected after screening 30 girls from a local sub-urban school in Hyderabad city, Andhra Pradesh, India. Baseline information regarding height, weight, general dietary intake and intake of protective foods was collected. During the entire period of study which was of five and half months duration, all the 15 girls were given placebo ("*Besan laddu*", a sweet snack preparation) for 30 days, followed by a cross-over to placebo given along with iron tablets (60 mg/day) twice a week for 45 days, after which, 50% of the RDA of β -carotene (1200 $\mu\text{g/day}$) was supplemented through "*Besan laddu*" made with DDRPO, along with iron tablets (60 mg) given twice a week for the next 45 days, followed by "*Besan laddu*" made with RPO supplying 50% of RDA of β -carotene + 60 mg iron tablets + 25 mg of Ascorbic acid tablets, twice a week for the last 45 days. DDRPO with the brand name "*Carotino*" manufactured by Global palm products, Malaysia was obtained courtesy Ms. Global Nutrition Products (P)Ltd, Ahmedabad, India. At the

end of every supplementation period 2ml of blood was collected by intravenous puncture and serum was stored at -20°C until analysis. Estimation of hemoglobin was done by the Cyanmethemoglobin method (Baker and Ramachandran, 1984) and serum Vitamin A and β -carotene was determined by HPLC method (Beire *et al.*, 1979). One way analysis of variance was done to compare the data of different treatments in the study as described by Fisher (1950).

Results and discussion

Anthropometric data revealed that none of the subjects was obese and almost all the girls had normal height, weight and BMI. There was no significant difference in the weights, heights and body mass index before and after the study (Table 1). Results of the diet survey indicated that the recommended intake of 100g of green leafy vegetables a day was not met. Milk, which is a good source of vitamin A was consumed in small quantities, only in tea or coffee. Curd was consumed by most of the subjects in a dilute form i.e., buttermilk. The low intake of green leafy vegetables and milk and milk products and other protective foods like eggs and fleshy foods is reflected in low blood and serum levels of iron and vitamin A in the subjects. At baseline, hemoglobin levels were significantly higher ($6.75 \pm 1.39 \mu\text{mol/l}$) than the placebo ($5.45 \pm 0.96 \mu\text{mol/l}$) and placebo + iron supplementation periods ($5.73 \pm 0.56 \mu\text{mol/l}$) (Table 2). There was a slight, non-significant increase in the hemoglobin levels during placebo + iron supplementation period when compared to placebo period. Results showed that the initial hemoglobin levels were significantly lower than after supplementation with DDRPO + iron (7.63 ± 0.97) and DDRPO + iron + vitamin C (8.11 ± 0.47) though there was no significant difference between DDRPO + iron and DDRPO + iron + vitamin C supplementation periods. Iron supplementation alone did not have any significant benefit in improving blood hemoglobin levels. The immediate decrease in the hemoglobin levels from 6.75 ± 1.39 to $5.45 \pm 0.96 \mu\text{mol/l}$, can be attributed to various factors like poor dietary intake of iron, poor absorption or may be due to other factors which cannot be attributed to any known cause. Mean serum retinol levels at baseline ($0.57 \pm 0.03 \mu\text{mol/L}$) and during placebo + iron ($0.37 \pm 0.04 \mu\text{mol/l}$) and DDRPO supplementation periods were found to be significantly different from each other (Table 2). The serum retinol levels ranged from $0.37 \pm 0.04 \mu\text{mol/l}$ to $1.28 \pm 0.03 \mu\text{mol/l}$

during the study period. There was a significant decrease in serum retinol levels during the placebo ($0.45 \pm 0.002 \mu\text{mol/l}$) and placebo + iron ($0.37 \pm 0.04 \mu\text{mol/l}$) supplementation periods when compared to baseline levels. There was a significant increase in the serum retinol levels during the DDRPO + iron ($1.03 \pm 0.04 \mu\text{mol/l}$) and DDRPO + iron + vitamin C ($1.28 \pm 0.03 \mu\text{mol/l}$) supplementation periods when compared to baseline, placebo and placebo + iron supplementation periods. Vitamin A and vitamin C supplementation through DDRPO and ascorbic acid tablets seem to have helped in enhancing hemoglobin levels in all the subjects. With respect to serum β -carotene values, there was a significant increase observed during DDRPO + iron ($0.30 \pm 0.04 \mu\text{mol/l}$) and DDRPO + iron + vitamin C ($0.58 \pm 0.10 \mu\text{mol/l}$) supplementation periods (Table 2). During the baseline, placebo and placebo + iron supplementation periods, insignificant amount of β -carotene was detected in the serum of adolescent girls. A comparative study by Manorama *et al.* (1996) on school children fed snacks prepared with crude red palm oil (RPO) for one month with massive vitamin A dosed groups showed that serum retinol and β -carotene levels increased more than two-fold in RPO fed groups. It has been reported (Olson, 1993) that ingestion of large amounts of β -carotene and other pro-vitamin A carotenoids over a significant period of time will improve vitamin A status.

There was a significant increase in both iron and vitamin A status of the subjects when supplemented with iron, DDRPO and vitamin C. Ascorbic acid increases iron bioavailability as they are both metabolically interrelated (Derman *et al.*, 1980; Rathee and Pradhan, 1980). In iron depleted women consuming a diet with predicted poor iron availability, ascorbic acid was found to enhance body iron retention for 5.5 weeks (Hunt *et al.*, 1990).

Conclusion: The integrated supplementation with DDRPO, iron and vitamin C may bring about desired elevation in serum iron, retinol and β -carotene levels rather than supplementing with individual micronutrients. Considering that every year millions of children, adolescent, pregnant and lactating women suffer from the physiological consequences of vitamin A and iron depletion, it is important to pay serious attention to the association of integrated supplementation while planning nutritional health programs.

Table 1 Anthropometric measurements of 15 subjects at baseline and at the end of the study

Anthropometric measurement	Baseline	End of study period
Height (cm)	155.21 ± 5.51	155.34 ± 5.52
Weight (kg)	43.44 ± 5.50	44.04 ± 5.05
Body Mass Index (BMI)	17.97 ± 1.72	18.20 ± 1.49

Values are expressed as mean \pm SEM

Table 2 Effect of supplementation of iron, DDRPO and vitamin-C on hemoglobin, retinol and b-carotene levels of adolescent girls

Period	Hemoglobin ($\mu\text{mol/L}$)	Retinol ($\mu\text{mol/L}$)	β -carotene ($\mu\text{mol/L}$)
Baseline	6.75* \pm 1.39	0.57** \pm 0.03	0.002 \pm 0.001
Placebo (30 days)	5.45 \pm 0.96	0.45* \pm 0.002	0.004 \pm 0.0015
Placebo+iron (45 days)	5.73 \pm 0.56	0.37 \pm 0.04	0.005 \pm 0.002
DDRPO+ iron (45 days)	7.63** \pm 0.97	1.03*** \pm 0.04	0.30* \pm 0.04
DDRPO + iron + vit.C (45 days)	8.11** \pm 0.47	1.28*** \pm 0.03	0.58** \pm 0.10

Values are expressed as mean \pm SEM; *, **, *** significant differences ($P < 0.05$)

Acknowledgements: The authors acknowledge the support of Mr.Rohit Gandhi, Managing Director, Global Nutrition Products (P) Ltd., Ahmedabad, India, for providing raw materials, DDRPO and chemicals for the study. The encouragement and laboratory facilities provided by Dr (Mrs) Vijaya Khader, Ex-Dean, Faculty of Home Science, Acharya N.G Ranga Agricultural University, is also acknowledged.

References

- Baker, S.J. and Ramachandran, K. 1984. The design and analysis of iron supplementation trials- A report of INACG, Washington, 5-7.
- Beire, J.G., Foliver, T.J.B.S and Catignani, L. 1979. Simultaneous determination of tocopherol, retinol and β -carotene in plasma by HPLC. *American Journal of Clinical Nutrition*, 32: 2143-2149.
- Derman, D.P. Bothwell, T.H., Macphail, A.P., Terrance, T.D., Bezwada, W.R and Charlton, R.W. 1980. Importance of ascorbic acid in the absorption of iron from infant foods. *Scandinavian Journal of Haematology*, 25: 193-201.
- Donoghue, S., Kronfeld, D.S., Berkowitz, S.J., Copp and R.L. 1981. Vitamin A nutrition of the equine: growth, serum biochemistry and hematology. *Journal of Nutrition*, 3: 365-374.
- Fisher, RA. 1950. In: *Statistical Methods for research workers*. Edinburgh. Oliver and Boyd.
- Goh, S.H. 1985. Minor constituents of palm oil. *Journal of American Oil Chemists Society*, 62: 237-240.
- Hodges, R.E., Sauberlich, H.E., Canham, J.E, Wallance, N., Rucker, R.B., Meija, L.A and MohanRam M. 1978. Hematopoietic studies in vitamin A deficiency. *American Journal of Clinical Nutrition*, 31: 876-885.
- Hunt, J.R., Muller, L.M., Lykken, G.I., Gallaghen, S.K and Nielsen, F.H. 1990. Ascorbic acid : effect of ongoing iron absorption and status in iron-depleted young women. *American Journal of Clinical Nutrition*, 51: 649-655.
- Manorama, R., Brahmam, G.N.V. and Rukmini, C. 1996. Red Palm Oil as a source of β -carotene for combating Vitamin A deficiency. *Plant foods for Human Nutrition*, 49:75-82.
- Meija, L.A. and Arroyave, G. 1982. Effect of vitamin A fortification of sugar on iron metabolism in preschool children in Guatemala. *American Journal of Clinical Nutrition*, 36: 87.
- Meija, A.L., Hodges, R.E., Arroyave, G., Viteri, F and Torun, B. 1977. Vitamin A deficiency and anemia in Central American children. *American Journal of Clinical Nutrition*, 30: 1175-1184.
- MohanRam, M. Kulkarni, K.A. and Reddy, V. 1977. Hematological studies in vitamin A deficient children. *International Journal of Vitamin and Nutrition Research*, 47: 389-393.
- Oliveria, J.M., Michelazzo, F.B., Stefanello, J., Rondo, P.H. 2008. Influence of iron on vitamin A nutritional status. *Nutrition Reviews*, 66(3): 141 - 147.
- Olson, J.A. 1993. The irresistible fascination for carotenoids and vitamin A. *American Journal of Clinical Nutrition*, 57: 833-839.
- Rathee, S. and Pradhan, K. 1980. Effect of ascorbic acid on availability of iron from an egg-based whole day diet of college girls. *Indian Journal of Nutrition and Dietetics*, 17: 90-94.
- Saritha, M. and Manorama, R. 1997. The protective effect of red palm oil in combating vitamin A deficiency. *Asia Pacific Journal of Clinical Nutrition*, 6: 246-250.

Attempts to transfer *Ogura* cytoplasm based CMS-FR system in *Brassica rapa*

Gurpreet Kaur, Shashi K. Banga, Navjyot Kaur and S.S. Banga

Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana, Punjab

(Received: December, 2008; Revised: January, 2009; Accepted: January, 2009)

Abstract

Hybrid breeding is a promising approach to increase yield potential of *Brassica rapa*. However, no hybrid has so far been commercialized due to lack of suitable CMS- fertility restorer system. Attempts were made to transfer *ogura* (*ogu*) cytoplasm based CMS system from a *B.napus* donor to *B.rapa*. Male sterile plants with narrow petals and reduced anthers resembling *B. rapa* were isolated in BC₂ generation from the cross, *B. napus*/*B. rapa*/*B. rapa*. Attempts were also made to transfer fertility restorer gene(s) from a partially fertile but aneuploid *B.napus* germplasm. Fertile segregants having plant and floral morphology similar to *B. rapa* were identified in BC₃ generation of *B. napus* / *B.rapa* hybridizations. Cytological analysis of fertile alloplasmic plants resembling *B. rapa* revealed higher chromosome number, that ranged up to 2n=30 even in BC₃ generation. Selected plants have been backcrossed again to *B.rapa* to facilitate introgression of fertility restorer gene(s) and to recover euploid chromosome number (2n=20). ISSR markers were utilized to tag gene(s) for fertility restoration and a marker UBC 827 was found to be polymorphic for fertile vs. sterile segregants. Further studies are underway.

Keywords: *Brassica rapa*, CMS-FR, ISSR markers

Brassica rapa is an important catch and cash oilseed crop in India. Area under its cultivation is, however, continuously declining possibly due to poor productivity levels as a consequence of limited crop breeding gains in the recent past. Hybrid breeding is now being viewed as an option to improve its yield potential. This breeding approach has not been pursued seriously, so far, due to lack of suitable CMS- fertility restorer system. Researches are currently underway at Punjab Agricultural University to transfer *ogura* (*ogu*) cytoplasm based CMS-*Rf* system from relevant *B.napus* donors.

Refined *ogu* CMS *B.napus*, fertile aneuploid *B.napus* germplasm and euplasmic *B.rapa* genotypes formed the

basic plant materials. CMS *B.napus* was developed following transfer of sterilizing cytoplasm from refined *ogu* CMS *B. juncea* developed previously by Kirti *et al.* (1993). To study chromosome number of fertile plants, buds were fixed in Carnoy's fixative II and squash preparations were made in 2% acetocarmine. DNA was isolated from euplasmic, sterile and putative restorer plants by standard procedure (Doyle and Doyle 1990). ISSR markers were used to differentiate their fertility and sterility reaction.

Ogu CMS *B.napus* plants were crossed as female with *B. rapa* followed by recurrent backcrossing with *B. rapa*. Male sterile plants having morphology of *B. rapa* were isolated during BC₂ generation. Sterile plants possessed flowers with narrow petals and reduced anthers (Fig. 2 and Fig. 3). However, female fertility and nectarines were normal. Attempts were also made to transfer fertility restorer gene(s) to *B. rapa*. A fertile *B.napus* aneuploid germplasm, obtained during 1990s from France and carrying *ogura* cytoplasm was used as the donor *Rf* gene(s). Fertile plants having plant and floral morphology similar to *B. rapa* were identified in BC₃ generation following *B. napus* / *B.rapa* hybridization. Cytological analysis of fertile alloplasmic plants resembling *B. rapa* revealed chromosome number that ranged up to 2n=30 even in BC₃ generation. Since, *Rf* gene(s) are located on C genome, chromosomes belonging to this genome were preferentially transmitted in fertile backcross segregants. Thus, despite extensive homoeology between A and C genomes, it has not been possible to achieve introgression of *Rf* genes in *B.rapa* even after four cycles of recombination. Selected plants have been further backcrossed to *B.rapa* to facilitate introgression of fertility restorer gene(s) and to recover euploid chromosome number (2n=20). ISSR markers were utilized in an attempt to develop molecular tags for *Rf* gene(s) in order to develop marker assisted selection protocol. For this, 100 ISSR primers were assayed to differentiate between euplasmic *B.rapa*, and male sterile/ fertile segregants putative for fertility restorer gene(s). Out of these, 62 primers amplified and only one UBC 827 differentiated alloplasmic sterile and fertile plants (Fig. 3). These may be associated with chromosome(s) harbouring fertility restorer gene(s). Further studies are underway

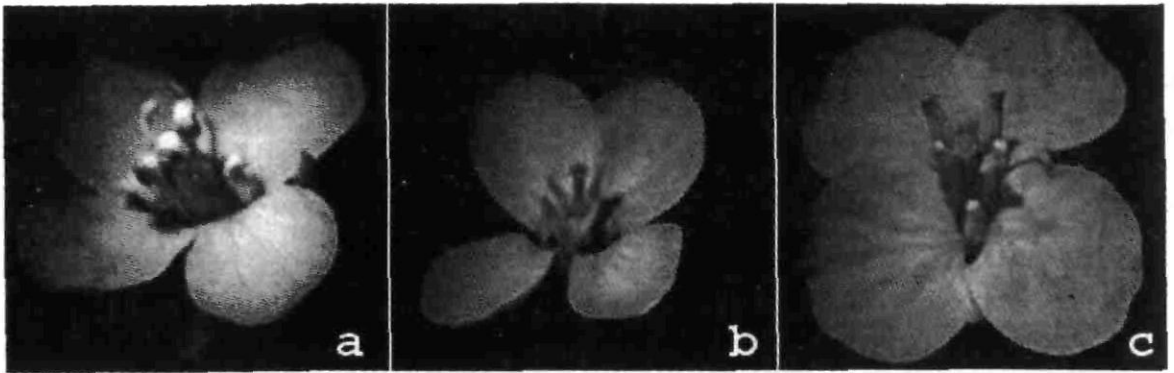


Fig. 1. Flowers of (a) euplasmic, (b) *ogura* CMS and (c) putative FR plants

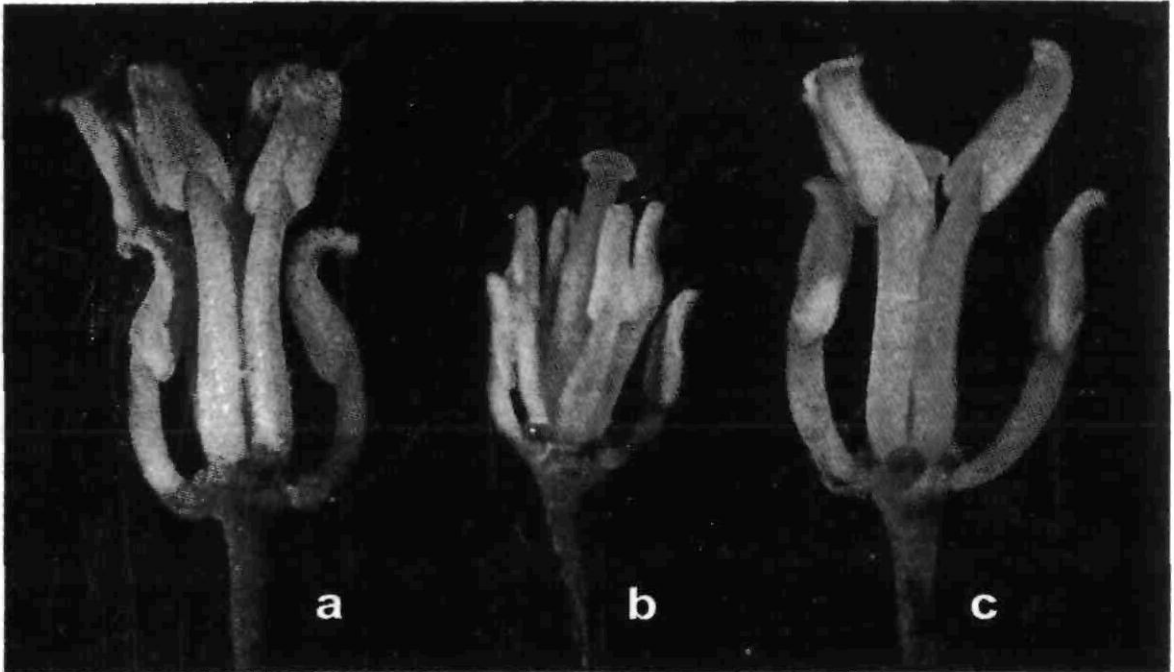


Fig. 2. Anther size and placement with respect to stigma in (a) euplasmic, (b) *ogura* CMS and (c) putative FR plants



Fig. 3. Molecular profile of ISSR markers viz., UBC 821, 824, 827, 828 and 841 as observed for (1) euplasmic, (2) putative FR and (3) *ogura* CMS plants

References

Doyle, J.J. and Doyle, J.L. 1990. Isolation of plant DNA from fresh tissues. *Focus*, 12 :13-15.

Kirti, P.B., Banga, S.S., Prakash, S. and Chopra, V.L. 1995. Transfer *ogu* cytoplasmic male sterility in *Brassica juncea* and improvement of male sterile through somatic cell fusion. *Theoretical and Applied Genetics*, 91 : 517-521.

NPJ-93 (Pusa Vijay) : A juvenile stage high temperature tolerant variety of Indian mustard

D.K. Yadava, V. Sujata, B. Dass, S.C. Giri and T. Mohapatra

Division of Genetics, Indian Agricultural Research Institute, Pusa, New Delhi-110 012

(Received: January, 2009; Revised: January, 2009; Accepted: February, 2009)

Abstract

A new variety of *Brassica juncea* i.e., NPJ-93 (Pusa Vijay) was identified which resisted the high temperature when sown in September as well as under laboratory conditions. The entry is tolerant to salinity also.

Keywords: Salinity, temperature tolerant, rapeseed-mustard

Out of the four cultivated oiliferous Brassicas, *Brassica juncea* alone occupies 90% of the total area under different *Brassica* spp. Although this is a hardy crop in the Brassica group and has substantial degree of tolerance to various biotic and abiotic stresses, yet the area and productivity of this crop fluctuates widely due to the various biotic and abiotic factors year after year. Over the last two decades wide fluctuation in the area and productivity leading to unstable production has been witnessed (Anonymous, 2008). Several factors are responsible for these fluctuations viz., drought, high temperature at sowing time, cold, frost and fog at pod formation and maturity, and attack of diseases like white rust and Alternaria blight. Therefore, an initiation was made for breeding genotypes with high degree of tolerance to high temperature at seedling stage in order to provide normal plant vigour and healthy juvenile growth to assure optimum plant stand.

The available germplasm of *Brassica juncea* was screened for high temperature tolerance by sowing it in the month of September, when the day temperature touches upto 40°C. Few genotypes of synthetic *B. juncea* and SEJ-2 were found as highly temperature tolerant to seedling stage high temperatures. Crosses were made between some of high yielding varieties which were susceptible to high temperature at seedling stage with the tolerant germplasm lines for this trait. Phenotyping for high temperature tolerance in segregating generations starting from F₂ onwards was done by sowing the crop in the month of September. Progenies of the cross Synthetic *Brassica juncea* x VSL-5 were found to be very promising under high temperatures in terms of good germination as well as very less seedling mortality leading to optimum plant stand. In F₆ the promising single plant progenies were

evaluated for the seed yield under field evaluation and the high temperature tolerance was tested under artificial screening too under laboratory conditions and six promising advance lines were bulked and tested in the Station Trial during rabi 2000-01. One of the high temperature tolerant progeny derived from the cross Synthetic *Brassica juncea* x VSL-5, later on designated as NPJ-93, was found very high yielding as compared to the checks Varuna and Pusa Jagannath and it was again tested in the Common Varietal Trial of IARI during 2001-02. On the basis of the superior performance, this genotype was contributed to the Initial Varietal Trial (Timely sown irrigated mustard) of the All India Coordinated Research Project on Rapeseed Mustard during 2002-03. NPJ-93 established its superiority over the checks and was promoted to AVT-I in Zone II (Punjab, parts of Rajasthan, Haryana, Western UP, Plains of J & K) and was tested during 2003-04 in Advance Varietal Trial I.

NPJ-93 (Pusa Vijay) was tested in 15 trials including coordinated and common varietal trials and large scale demonstrations at IARI for three years and it was released in 2006 for NCR Delhi including parts of Rajasthan, Haryana, UP and entire Delhi and was notified in 2008 (Anonymous, 2008). Weighted mean seed yield of this variety in All India Coordinated trials over 11 locations for two years in Zone II was 2293 kg/ha and it has shown 41.6, 13.6, 12.4 and 17.0% higher seed yield over Varuna (NC), Kranti (NC), RL-1359 (ZC) and PBR-91 (ZC), respectively (Table 1) (Anonymous 2004, 2005). For oil yield also it has exhibited 47.2, 14.9, 13.0 and 15.1% superiority over Varuna (NC), Kranti (NC), RL-1359 (ZC) and PBR-91 (ZC), respectively in Zone II (Table 2). In IARI's Common Varietal Trial of mustard NPJ-93 has exhibited 8.5% and 20.5% seed yield superiority over the checks Pusa Bold and Pusa Jai Kisan, respectively (Table 1). At Delhi location this variety was tested in six trials (CVT, IVT, AVT-I, demonstrations) during three years (2002-2005) and it exhibited superiority over all the existing popular varieties viz., Varuna (47.0%), Kranti (29.2%), RL-1359 (42.7%), PBR-91 (41.1%), Pusa Bold (19.6%), Pusa Jai Kisan (23.5%) and Pusa Jagannath (27.1%) (Table 3). It also gave 10.9 and 14.2% higher seed yields over the checks Pusa Jagannath and Pusa

Bold during 2004-05 at farmers' fields in the NCR, Delhi (Table 3). This variety is tolerant to high temperatures at seedling stage as compared to popular varieties Varuna and Pusa Jagannath and show less than 5% seedling mortality when exposed to higher temperatures under artificial as well as natural screening (Table 4). It also tolerates salinity up to 12dS/m. It is bold seeded variety (5.3 g/1000 seeds) with 38.5% average oil content. It is of medium plant height and plants attain average plant height of 185 cm. It has a very prolonged reproductive phase with flower initiation at 40 days after sowing and maturity in 145 days. Average primary branched in this variety are 4.5 with on an average 12 secondary branches/plant. The silique is long with 13.5 seeds/silique. The silique does not

shatter on maturity. Plant has a strong stem and does not lodge up to harvest of the crop. It is also showing promise to various diseases like white rust, powdery and downy mildew and *Sclerotinea* stem rot as compared to the check Varuna. Due to its high temperature tolerance at seedling stage, the initial plant stand is established and the crop gives good yields under optimum plant stand. The variety will prove to be boon for the farmers of northern and western plains where high temperature during sowing period is a major problem. Moreover, it can also be used as a donor for high temperature tolerance breeding programme.

Table 1 Performance of variety NPJ-93 in common and coordinated trials under irrigated conditions from *rabi* 2002-03 to *rabi* 2004-05 in Delhi and zone-II

Variety	Seed yield (kg/ha)				Per cent increase over checks and QV
	2002-03 CVT- Irr. (1)	2003-04 IVT Irr. (5)	2004-05 AVT-I Irr. (6)	Weighted mean over years (11)	
NPJ-93	2410	2715	1870	2293	--
Varuna (NC)	--	1934	1304	1619	41.6
Kranti (NC)	--	2253	1783	2018	13.6
RL-1359 (ZC)	--	2538	1544	2041	12.4
PBR-91 (ZC)	--	--	1599	1599	17.0
Pusa Bold (LC)	2222	--	--	--	8.5
Pusa Jai Kisan (LC)	2000	--	--	--	20.5

Values in parenthesis indicate number of locations, NC = National check; ZC = Zonal check; LC = Local check

Table 2 Oil yield of variety NPJ-93 in common and coordinated trials under irrigated conditions from *rabi* 2002-03 to *rabi* 2004-05 in Delhi and zone-II

Variety	Oil yield (kg/ha)				Per cent increase over checks
	2002-03 CVT- Irr. (1)	2003-04 IVT Irr. (5)	2004-05 AVT-I Irr. (6)	Mean (11)	
NPJ-93	891	1052	715	889	--
Varuna	--	712	495	604	47.2
Kranti	--	856	692	774	14.9
RL-1359	--	979	594	787	13.0
PBR-91	--	--	621	621	15.1
Pusa Bold	822	--	--	822	8.4
Pusa Jai Kisan	710	--	--	710	25.5
Mean	816	875	647	--	--
Range	644-928	605-1052	495-769	--	--
SD	89	95	90	--	--

Values in parenthesis are number of locations.

Table 3 Performance of variety NPJ-93 (Pusa Vijay) in Delhi under irrigated conditions from *rabi* 2002-03 to *rabi* 2004-05

Varieties	Seed yield (kg/ ha)						Increase over checks (%)	
	Demo. 2002-03	2002-03 CVT	Demo. 2003-04	2003-04 IVT	Demo. 2004-05	2004-05 AVT-II		
NPJ-93	2183	2410	2569	2478	2419	2762	2470	--
Varuna	1587	--	1507	1156	2025	2131	1681	46.9
Kranti	1786	--	1682	1589	2112	2334	1901	29.9
RL-1359	--	--	--	1556	--	1905	1731	42.7
PBR-91	--	--	--	--	--	1750	1750	41.1
Pusa Bold	--	2222	1895	--	1950	--	2022	19.6
Pusa Jai Kisan	--	2000	--	--	--	--	2000	23.5
Pusa Jagannath	1429	--	2153	--	2251	--	1944	27.1

Table 4 Reaction of NPJ-93 (Pusa Vijay) to high temperature at seedling stage under natural conditions in Delhi

Variety	Rabi 2004-05 (DOS 03.09.2004)			Rabi 2005-06 (DOS 27.09.2005)		
	Germination (%)	Seedling mortality after one month (%)	Remarks	Germination (%)	Seedling mortality after one month (%)	Remarks
NPJ-93	90	4.4	Highly Tolerant	94	3.2	Highly Tolerant
Varuna	92	17.4	Tolerant	95	10.5	Tolerant
Pusa Jagannath	90	15.6	Tolerant	95	9.7	Tolerant

References

Anonymous. 2004, 2005. AICRP Rapeseed and Mustard Annual Reports, National Research Centre on Rapeseed and Mustard, Bharatpur-321 303.

Anonymous. 2007. AICRP Rapeseed and Mustard Annual Reports, National Research Centre on Rapeseed and Mustard, Bharatpur-321 303.

Anonymous. 2008. The Gazette of India. No. 2458(E) dated 16.10.2008. Page 2 Sr. No. 44.

Efficacy of herbicides against weeds in groundnut, *Arachis hypogaea* L.

Virender Sardana and Parvender Sheoran

Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana-141 004, Punjab

(Received: April, 2007; Revised: December, 2008; Accepted: February, 2009)

Abstract

Metalachlor (Pre-emergence) 1.5 l/ha followed by pendimethalin (PE) @ 0.75 l/ha + one hand weeding at 30 days after sowing or fluchloralin 0.75 l/ha were most effective and economic for weeds management in groundnut, *Arachis hypogaea*.

Keywords: Groundnut, *Arachis hypogaea* herbicides, efficacy

Summer cultivation of semi-spreading and bunch type varieties of groundnut has been recommended in Punjab due to their higher yield potential. Weed menace is one of the major limiting factors in realizing potential productivity of groundnut grown in summer season. When grown under assured irrigations, it provides favourable environment for fast growth of weeds which interfere with pegging, pod development and harvesting of groundnut besides competing for essential and scarce resources like moisture, nutrients and light. The bunch type (*Arachis hypogaea* L subsp. *Fastigiata* var. *vulgaris*) varieties though have higher yield potential, have poor competitive ability against weeds due to their prostrate growth compared to semi-spreading and spreading varieties of groundnut. Several annual grasses and broadleaf weeds invade this crop causing heavy yield losses (Gnanamurthy and Balasubramaniyan, 1998; Ghosh, 2000; Solanki *et al.*, 2005). The problem of *Commelina benghalensis* and some other hardy weeds is fast increasing in groundnut growing areas of the state. The currently recommended herbicides and their doses (fluchloralin @ 0.675 liter a.i./ha and alachlor @ 2.5 l a.i./ha) are not effective against some of these weeds particularly *Commelina benghalensis*. Manual weeding is very expensive, cumbersome and time consuming. Keeping in view the urgent need to find out more effective herbicides for weed management, the present investigation was carried out on loamy sand soils of Punjab Agricultural University, Ludhiana during summer 2005. The study comprised 15 treatments in a Randomized Complete Block Design with 3 replications (Table 1). A bunch type groundnut variety SG 99 was sown on 18 May and harvested on 25 September 2005. The crop was raised with recommended agronomic practices. The treatments comprised pre-plant incorporation (PPI) of fluchloralin (0.675 and 0.75 l a.i./ha)

or trifluralin (1.0 l a.i./ha applied alone or in combination with one hand weeding at 30 days after sowing), or pre-emergence (PE) application of oxyfluorfen (0.25 and 0.50 l a.i./ha), pendimethalin (0.75 l a.i./ha alone or in combination with one hand weeding at 30 days after sowing), metolachlor (1.0 and 1.5 l a.i./ha and 1.0 l a.i./ha + one hand weeding at 30 days after sowing), alachlor (2.5 l a.i./ha), tank mix application of pendimethalin (0.5 l a.i./ha) + alachlor (1.25 l a.i./ha) as pre-emergence, hand weeding twice at 3 and 6 weeks after sowing and unweeded control. Application of herbicides as PPI was made just before sowing followed by light planking whereas PE application was made a day after sowing. These herbicides as per treatments were mixed in 500 l water/ha and sprayed with knap sack sprayer using flat fan nozzle. The plot size was 4.8 x 3.6 m². Field was heavily infested with *Commelina benghalensis*, *Eleusine aegyptiacum*, *Digitaria sanguinalis*, *Cyperus rotundus* and *Cynodon dactylon*. Different weed control treatments reduced weed population at 30 days after sowing (DAS) and density as well as drymatter of weeds at harvest as compared to weedy conditions (Table 1). The lowest weed density at 30 DAS was observed with two hand weeding given at 21 and 42 DAS. Among the herbicides, pre-emergence (PE) application of oxyfluorfen @ 0.25 and 0.50 l/ha, pre-plant incorporation (PPI) of fluchloralin @ 0.675 l/ha and tank mix application of pendimethalin (0.5 l/ha) and alachlor (1.25 l/ha) as PE provided similar control of weeds at 30 DAS. However, at harvest, lowest weed density was observed with application of pendimethalin (PE) @ 0.75 l/ha followed by application of fluchloralin (PPI) @ 0.675 and 0.75 l/ha and alachlor (PE) @ 2.5 l/ha. Dry matter of weeds was lowest with PE application of metolachlor @ 1.5 l/ha. Mohanty and Kar (1997), Singh *et al.* (1997), Ghosh (2000) and Solanki *et al.* (2005) reported similar effectiveness of hand hoeings, fluchloralin, alachlor and pendimethalin. Different weed management practices did not differ in significantly influencing 100-kernel weight and shelling percentage (Table 2). The highest pod yield was obtained with metolachlor (PE) @ 1.5 l/ha. This was at par with pendimethalin (PE) @ 0.75 l/ha + one HW at 30 DAS; fluchloralin (PPI) @ 0.675 l/ha or trifluralin (PPI) @ 1.0 l/ha. The lowest pod yield (1214 kg/ha) was recorded in unweeded control which was 53.8% lower than that obtained with application of metolachlor (PE) @ 1.5 l/ha.

Efficacy of herbicides against weeds in bunch type groundnut

There was no marked influence of weed management practices on oil content. The highest gross income, net returns and B:C ratio were obtained with application of metolachlor @ 1.5 l/ha. Application of oxyfluorfen (0.5 l/ha), trifluralin (1.0 l/ha), pendimethalin (0.75 l/ha) alone or in conjunction with one HW and fluchloralin (0.75 l/ha)

resulted in comparable yields, and B:C ratio. Gross income and net returns with two hand weedings were lower than application of trifluralin or pendimethalin supplemented with one HW. This study thus, reiterates herbicide based weed control as more cost effective than manual weeding in summer groundnut.

Table 1 Influence of weed control treatments on density and drymatter of weeds in summer groundnut

Herbicide	Dose (l a.i./ha)	Weed density (No./m ²)		Weed dry matter (g/m ²)
		30 DAS	Harvest	
Oxyfluorfen (PE)	0.25	13.0 (3.8)	23.3 (4.9)	95.7
Oxyfluorfen (PE)	0.50	16.7 (4.2)	23.3 (4.9)	57.7
Trifluralin (PPI)	1.0	21.5 (4.8)	21.3 (4.7)	67.7
Trifluralin (PPI) + HW(30 DAS)	1.0	20.2 (4.6)	18.0 (4.3)	67.0
Pendimethalin (PE)	0.75	23.0 (4.8)	10.7 (3.4)	62.7
Pendimethalin (PE) + HW(30 DAS)	0.75	24.3 (5.0)	13.3 (3.8)	58.3
Metolachlor (PE)	1.0	22.3 (4.8)	16.7 (4.2)	55.3
Metolachlor (PE)	1.5	26.5 (5.2)	20.7 (4.6)	49.7
Metolachlor (PE) + HW(30 DAS)	1.0	22.7 (4.8)	22.7 (4.8)	58.3
Fluchloralin (PPI)	0.675	15.0 (4.0)	11.3 (3.5)	62.3
Fluchloralin (PPI)	0.75	25.5 (5.10)	12.3 (3.6)	52.3
Alachlor (PE)	2.5	19.0 (4.5)	13.3 (3.8)	74.0
Pendimethalin + Alachlor (PE)	0.5 + 1.25	12.7 (3.6)	20.7 (4.6)	93.0
Hand weedings	21 and 42 DAS	6.3 (2.8)	20.7 (4.6)	51.3
Unweeded control	-	33.3 (5.9)	28.7 (5.4)	182.7
CD (P=0.05)	-	7.3 (0.8)	6.0 (0.7)	20.9

PPI = Pre-plant incorporation; PE = Pre-emergence; Figures in parenthesis are the root x+1 transformed values.

Table 2 Influence of weed control treatments on yield attributes, pod yield, oil content and economics of summer groundnut

Herbicide	Dose (l a.i./ha)	Shelling (%)	100 kernel weight (g)	Pod yield (kg/ha)	Oil content (%)	Gross income (Rs./ha)	Net returns (Rs./ha)	B:C ratio
Oxyfluorfen (PE)	0.25	68.8	64.4	1722	50.7	26174	9591	1.58
Oxyfluorfen (PE)	0.50	66.4	65.3	2119	51.7	32214	15131	1.88
Trifluralin (PPI)	1.0	71.2	65.6	2167	51.9	32933	16017	1.95
Trifluralin (PPI) + HW(30 DAS)	1.0	68.4	64.8	2021	50.9	30714	12448	1.68
Pendimethalin (PE)	0.75	69.9	65.8	2119	51.0	32209	15126	1.88
Pendimethalin (PE) + HW(30 DAS)	0.75	70.7	67.3	2206	52.2	33536	15103	1.82
Metolachlor (PE)	1.0	69.1	65.7	1778	52.6	27021	10138	1.60
Metolachlor (PE)	1.5	68.1	66.0	2627	51.6	39931	22648	2.31
Metolachlor (PE) + HW(30 DAS)	1.0	66.4	64.9	1436	51.9	21832	3599	1.20
Fluchloralin (PPI)	0.675	68.8	64.4	1795	52.0	27284	10526	1.63
Fluchloralin (PPI)	0.75	70.1	66.8	2198	53.5	33415	16526	1.98
Alachlor (PE)	2.5	69.1	64.5	1412	51.7	21472	3889	1.22
Pendimethalin + Alachlor (PE)	0.5 + 1.25	71.3	64.2	1374	51.0	20895	3562	1.20
Hand weedings	21 and 42 DAS	69.9	66.3	1980	52.4	30096	10413	1.53
Unweeded control	-	71.6	64.9	1214	53.6	18458	2375	1.15
CD (P=0.05)	-	NS	NS	483	NS	-	-	0.42

PPI = Pre plant incorporation; PE = Pre-emergence, Price of groundnut = Rs. 1520/q

References

- Ghosh, D.C. 2000. Weed management in rainfed groundnut (*Arachis hypogaea*). *Indian Journal of Weed Science*, 32: 92-93.
- Gnanamurthy, P.N. and Balasubramanian, P. 1998. Weed management practices and their influence on weed growth and yield of groundnut (*Arachis hypogaea* L.). *Indian Journal of Agronomy*, 43: 122-125.

- Mohanty, S.K. and Kar, M. 1997. Study on the efficacy of different weed management practices against weeds in groundnut (*Arachis hypogaea*). *Indian Journal of Weed Science*, 29: 85-87.
- Singh, A.K., Mahapatra, B.S. and Sharma, G.L. 1997. Chemical weed control in spring groundnut (*Arachis hypogaea* L.). *Indian Journal of Weed Science*, 29: 34-38.
- Solanki, R.M., Bhalu, V.B., Jadav, K.V. and Kelaia, G.R. 2005. Studies on integrated weed management in irrigated groundnut. *Indian Journal of Weed Science*, 37: 119-120.

Integrated nutrient management in summer groundnut, *Arachis hypogaea* L. under north Gujarat agro-climatic conditions

D.C. Chudhari, D.M. Patel, G.N. Patel and S.K. Patel

Department of Agronomy, C.P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar-385 506, Gujarat

(Received: August, 2008; Revised: January, 2009; Accepted: February, 2009)

Abstract

Application of castor cake @ 2 t/ha resulted in higher uptake of N, P and K in groundnut. There was a marked increase in growth, yield attributes and quality parameters of groundnut after application of castor cake.

Keywords: Groundnut, integrated nutrient management, castor cake, *Rhizobium*

In Gujarat groundnut is being cultivated in an area of 19.31 lakh ha during *khariif* and 0.91 lakh ha during summer season with a production of 17.21 and 1.41 lakh tonnes and average productivity of 891 and 1549 kg/ha (DOA, 2005), respectively, which is far below the potential productivity. Hence, in order to step up the productivity of the groundnut balanced fertilization is essential. To rationalize the fertilizer requirement based on integrated nutrient management (INM) in groundnut especially during summer season to enhance its productivity the present investigation was undertaken.

A field experiment was conducted during summer seasons of the year 2006 at Agronomy Instructional Farm, C.P. College of Agriculture, SDAU, Sardarkrushinagar (Gujarat). The soil of the experimental plot was loamy sand in texture, slightly alkaline (pH 7.5), low in organic carbon (0.15 %) and available N (149 kg/ha), medium in available phosphorus (46 kg/ha) and high in available potassium (K⁺) (287 kg/ha). The experiment was laid out in a Randomized Block Design with three replications. Total sixteen treatment combinations comprised of four levels of chemical fertilizer viz., F₁- 25% of recommended dose of fertilizer (RDF), F₂- 50% of RDF, F₃- 75% of RDF and F₄- 100% of RDF; two levels of organic manure viz., M₁-castor cake @ 1 t/ha and M₂- castor cake @ 2 t/ha (N, P₂O₅ and K₂O content of castor cake were 4.4, 1.8 and 0.5%, respectively) and biofertilizer viz., C₁-Control (no inoculation) and C₂-inoculation with rhizobium. The recommended dose of summer groundnut crop is 25-50-0 NPK kg/ha. Castor cake was applied at the time of bed preparation in opened furrow as per treatments. The required quantity of N and P was applied as basal through urea and DAP, respectively as per treatments. Rhizobium culture strain IGR-6 was prepared by dissolving 100 g

jeggery in 1:1 of boiled cooled water followed by addition of required quantity of rhizobium culture. Groundnut seeds (cv.GG-2) were treated with the liquid culture and dried in shade for a period of three hours. The crop was sown on February 4, 2006 at a spacing of 45 cm x 10cm and harvested on May 29, 2006. The plant samples were ground, digested and analyzed for N by Microkjeldahl method, P by Vanadomolybdophosphoricacid yellow colour method and K by Flame photometric method (Jackson, 1973). The uptake of N, P and K was determined by multiplying nutrient concentration with yield of kernels, shells and haulms. Oil content in the kernel was estimated by Nuclear Magnetic Resonance Spectrophotometer (NMRS).

Effect of chemical fertilizer: Amongst doses of fertilizer, application of 100% RDF (25-50-00 NPK kg/ha) to summer groundnut recorded significantly higher values for most of the growth attributes (Table 1) than rest of the fertilizer doses but it was at par with 75 % RDF.

The significant increase in pods and haulm yield was observed with the application of 100 % RDF but remained at par with 75 % RDF (Table 2). Similar results were also reported Kachot *et al.* (2001). Maximum net return with BCR value of 1.46 was obtained with 100% recommended dose of fertilizer.

Effect of organic manure: The remarkable increase in mean values of all growth and yield attributes as well as quality parameters of groundnut was noted due to application of castor cake (Table 1). It might be attributed to multifarious role of castor cake in terms of nutrients supply (N, P and K) as well as improvement in physical, chemical and biological properties of soil. The results lend support reported by Gaur *et al.* (1984). Applications of castor cake @ 2 t/ha significantly increased pods and haulm yields which was 4.8 and 3.2% higher than castor cake @ 1 t/ha. The increase in pods yield was probably due to improvement in all yield attributes under study. Almost similar results were also obtained by Gaur *et al.* (1984).

Effect of biofertilizer: Rhizobium inoculation showed significantly the maximum values of growth and yield attributes as well as quality parameters (Table 1) over no

inoculation. This might be due to the increased activity of nitrogen fixing bacteria because of more multiplication due to favourable conditions. Similar increase of pods and haulm yield as well as better net return with BCR was observed with inoculation of rhizobium as compared to no inoculation. The results are in conformity with those reported by Mohamoud and Elfar (2000).

Nutrient uptake: An application of 100% RDF significantly increased the uptake of N, P and K by groundnut crop (Table 2), which was statistically at par with 75 % RDF. It might be due to enhancement of plant nutrients like N and P due to application of 100% RDF to groundnut crop resulted in higher pods and haulm yields. The present

findings were in agreement with those reported by Khanparia (1996).

Use of castor cake @ 2 t/ha resulted in significantly higher uptake of N, P and K as compared to 1 t castor cake/ha. It might be due to better nutrients availability and proliferation of root system with higher rate of castor cake. The results are in agreement with those reported by Gaur *et al.* (1984). Similarly higher uptake of N, P and K by groundnut crop was recorded by rhizobium inoculation than no inoculation. Rhizobium inoculation attributed more availability of nitrogen through biological nitrogen fixation. The findings are supported by Mahmoud and Elfar (2000).

Table 1 Growth, yield and quality attributes of groundnut as influenced y chemical fertilizer, organic and biofertilizer

Treatment	Plant height (cm)	No. of branches / plant	Plant spread (cm)	Dry matter production (g/plant)	No. of root nodules/ plant	No. of pods/plant	Test weight (g)	Shelling (%)	Oil content (%)	Protein content (%)
Chemical fertilizer (F)										
F ₁ : 25% RDF	38	6	35.29	33	82.1	17	37.6	68.0	45.1	19.9
F ₂ : 50% RDF	38	6	37.43	34	84.1	20	38.3	69.2	47.5	20.7
F ₃ : 75% RDF	41	7	39.68	36	89.7	20	41.4	70.3	47.6	20.8
F ₄ : 100% RDF	42	6	41.27	37	92.8	22	43.2	70.9	48.3	21.6
SEm ±	0.7	0.3	0.55	0.6	1.4	0.5	0.7	0.6	0.4	0.2
CD (P= 0.05)	2.0	0.7	1.60	1.8	4.1	1.3	2.0	1.6	1.1	0.5
Organic manure (M)										
M ₁ : Castor cake @ 1 t/ha	38	6	37.74	34	85.4	19.3	39.4	68.8	46.7	20.6
M ₂ : Castor cake @ 2 t/ha	41	7	39.09	36	88.9	20.2	40.9	70.5	47.5	20.9
SEm ±	0.5	0.2	0.39	0.4	1.0	0.3	0.5	0.4	0.3	0.1
CD(P= 0.05)	1.4	0.5	1.13	1.3	2.9	0.9	1.4	1.2	0.8	0.4
Biofertilizer ©										
C ₁ : Control	38.9	6	37.68	35	84.6	18.9	36.6	68.7	46.4	20.4
C ₂ : Rhizobium	40.5	7	39.16	36	89.7	20.5	43.6	70.5	47.8	21.1
SEm ±	0.5	0.2	0.39	0.4	1.0	0.3	0.5	0.4	0.3	0.1
CD(P= 0.05)	1.4	0.5	1.13	1.3	2.9	0.9	1.4	1.2	0.8	0.4
C V (%)	6.0	13.3	4.98	6.1	5.6	7.9	6.1	2.8	2.9	2.9

Table 2 Pods, haulm yield, economics and nutrient uptake as influenced by chemical fertilizer organic manure and biofertilizer

Treatment	Pod yield (kg/ha)	Haulm yield (kg/ha)	Net realization (Rs./ha)	BCR	Nutrient uptake (kg/ha)		
					N	P	K
Chemical fertilizer (F)							
F ₁ : 25% RDF	1935	3793	19472	1.3	106.1	22.7	68.9
F ₂ : 50% RDF	2014	3971	20492	1.4	110.4	23.4	81.6
F ₃ : 75% RDF	2130	4227	22169	1.5	116.8	26.3	90.3
F ₄ : 100% RDF	2199	4383	23009	1.5	121.8	27.0	94.1
SEm ±	46	58			1.8	0.4	1.3
CD (P= 0.05)	134	168			5.3	1.0	3.9
Organic manure (M)							
M ₁ : Castor cake @ 1 t/ha	2021	4029	21224	1.5	111.6	24.5	82.3
M ₂ : Castor cake @ 2 t/ha	2118	4158	21347	1.3	115.9	25.2	85.1
SEm ±	33	41			1.3	0.3	0.9
CD (P= 0.05)	95	119			3.7	0.7	2.7
Biofertilizer ©							
C ₁ : Control	2003	4007	20821	1.4	110.5	24.3	81.9
C ₂ : Rhizobium	2136	4180	21751	1.4	117.0	25.4	85.6
SEm ±	33	41			1.3	0.3	0.9
CD (P= 0.05)	95	119			3.7	0.7	2.7
CV (%)	7.77	4.91			5.6	5.0	5.5

References

- Directorate of Agriculture. 2005. Districtwise area, production and productivity of important food and non-food crops in Gujarat State.
- Gaur, A.C., Neelakantan, S. and Dargan, K.S. 1984. *Organic manures*, Indian Council of Agricultural Research, New Delhi. pp 38.
- Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Private Limited, New Delhi.
- Kachot, N.A., Malavia, D.D., Solanki, R.M. and Sagarka, B.K. 2001. Integrated nutrient management in rainy season groundnut (*Arachis hypogaea* L.). *Indian Journal of Agronomy*, **50** (2):152-155.
- Khanparia, N.K. 1996. Effect of increasing levels of phosphorus and potassium and their interaction on yield and nutrient of groundnut in sandy loam soil. *Soils and Crops*, **6** (1):20-23.
- Mohamoud, S.M. and Elfar, O.A. 2000. Effect of inoculation with Brady rhizobium (Hypogaeas) and N fertilization on productivity of peanut on sandy calcareous soil. *Journal of Agricultural Sciences*, **31** (3):57-70.

Productivity of groundnut, *Arachis hypogaea* L. varieties under different sowing dates

Virender Sardana and S.S. Kandhola

Oilseeds Section, Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana-141 004, Punjab

(Received: June, 2008; Revised: March, 2009; Accepted: April, 2009)

Abstract

To get the higher productivity of groundnut should be sown in last week of April to third week of May in Punjab. Bunch type variety, SG 99 gave higher yield than other varieties.

Keywords: Groundnut, sowing date, bunch type

Groundnut contains about 50% edible oil of superior quality comprising mainly oleic and linoleic acids. Due to higher protein content, low sugar content and presence of several essential minerals (phosphorus, calcium, magnesium and potassium) and vitamins (E, K and B), groundnut kernels are consumed directly as roasted or salted peanuts or utilized in diverse ways such in confectionary, snacks, candies, peanut butter and fortified foods. Groundnut was once the most important oilseed crop of Punjab occupying about 60% of the total area under oilseeds till 1970 after which it went into oblivion under Green Revolution when rice replaced most of the area under it. Due to the serious adverse effects of rice-wheat monoculture on the natural resources, soil health, environment, ecological balance etc., attempts are being made to revive the area under groundnut cultivation in the state. This would also help in overcoming edible oil shortage besides exploiting vast export potential of groundnut that exists for its varied end uses. It can be achieved with high yielding varieties that fit well into cropping systems.

Agro-climatic conditions of Punjab are quite suitable for cultivation of groundnut during spring, summer and kharif/rainy seasons. Summer cultivation of groundnut is becoming popular in the state due to higher productivity. Productivity potential of varieties differs in case of bunch and spreading type varieties and also with season of cultivation (Ahmad, 1992; Patel *et al.*, 1998). Proper matching of phenological development of groundnut varieties with prevailing environmental conditions is required to realize potential productivity. An attempt was made to assess the productivity potential of semi spreading and bunch type varieties across varied sowing times.

The field experiment was conducted in 2004 at the Punjab Agricultural University, Ludhiana on loamy sand soil of low

organic carbon (0.27%) and available nitrogen (185 kg/ha) and medium phosphorus (18.8 kg/ha). The treatments consisted of 4 sowing dates (28 April, 18 May, 8 June and 28 June) in the main plots and 3 varieties (SG 99, SG 84 and M 522) in the sub plot in a split plot design with 4 replications. Both the Spanish bunch type varieties viz., SG 99 and SG 84 (*Arachis hypogaea* L. subsp. *fastigiata* var. *vulgaris*) were sown at a spacing of 30cm x 15cm whereas for semi-spreading variety M 522 (*Arachis hypogaea* L. subsp. *hypogaea* var. *hypogaea*), spacing of 30cm x 22.5cm was maintained. The gross plot size was 4.5 x 3.6 m accommodating twelve rows whereas net plot was kept as 3.6 x 3.0 m. All other recommended agronomic practices were followed. The crop was harvested at physiological maturity.

Sowing of 28 April and 18 May resulted in significant increase in plant height and 100 kernel weight compared to 8 June and 28 June sowings (Table 1). April sowing also resulted in significantly taller plants, more number of primary branches and also immature kernels as compared to May sown crop. Late sowing of 28 June resulted in significantly lowest oil content (Table 1).

The pod as well as oil yields of groundnut sown on 28 April were at par with that sown on 18 May (Table 1). Similarly sowing on 8 June and 28 June resulted in statistically similar pod and oil yields. However, early sowing (28 April and 18 May) resulted in significantly higher pod and oil yields over 8 June and 28 June sowings. Groundnut sown on 18 May out performed 8 June and 28 June sowing by 52.7 and 71.5%, respectively for pod yield and 40.0 and 75%, respectively for oil yield. Studies carried out elsewhere revealed that partitioning of photosynthates from source to sink (pods) was adversely affected by delay in sowing resulting in reduction in yield components and pod yield (Padma *et al.*, 1991). Higher pod yield in earlier sowing could be attributed to the longer period available for vegetative and reproductive phenophases which ultimately resulted in better expression of yield attributes (Padhi, 1994; Patel *et al.*, 1998 and Karanjikar *et al.*, 2004). Reduction in overall growth period due to sharp decrease in temperature with onset of autumn season resulted in lower yield of June sown crop compared with April and May sowing. These findings corroborate with the findings of Patel *et al.* (1991). Differences in varieties for

various yield attributes, pod and oil yields were significant (Table 1). However number of immature kernels and oil content differed non-significantly. Pod and oil yields of SG 99 markedly exceeded SG 84 which significantly out yielded M 522. Thus, SG 99 out yielded SG 84 by 22.7% for pod yield and 18.3% for oil yield (mainly due to higher plant population) which in turn produced in 10.5% more pod yield and 24.6% more oil yield than M 522. However, number of primary branches per plant, number of pods per plant and 100 kernel weight were the highest in M 522 due to its semi spreading habit. SG 84 resulted in significantly lowest 100 kernel weight.

The pod yield and oil yield produced by SG 99 when sown on 18 May was at par with its sowing on 28 April but

significantly higher than other two varieties sown on any of the 4 dates (Table 2). Sowing of M 522 on 28 June resulted in lowest pod and oil yields. There was significant reduction in pod yield with delay in sowing to 8 June and 28 June compared to 28 April in all the varieties, whereas yields of all varieties were statistically similar in 28 April and 18 May sowings. Pod and oil yields of all the varieties sown on 8 June and 28 June were statistically at par (Table 2).

For higher productivity, groundnut should be sown during last week of April to third week of May. Bunch type variety, SG 99 gave higher yield than other varieties under agroclimatic conditions of Punjab.

Table 1 Growth, yield attributes, pod yield and oil yield of groundnut varieties as influenced by sowing dates

Treatments	Pod yield (q/ha)	Plant height (cm) at harvest	Number of primary branches/plant	Number of pods/plant	100-kernel weight (g)	Shelling (%)	Immature kernels (%)	Oil content (%)	Oil yield (q/ha)
Sowing dates									
28 April	25.6	90.4	10.6	20.9	64.0	66.6	12.9	51.7	8.9
18 May	25.7	56.6	7.6	21.4	62.8	62.9	9.8	51.6	8.4
8 June	16.8	38.8	7.4	17.3	56.9	70.3	9.7	51.4	6.1
28 June	15.0	37.3	6.1	18.0	51.6	66.2	9.0	48.7	4.8
CD (P=0.05)	3.3	12.1	1.6	NS	5.3	NS	2.2	0.76	1.6
Varieties									
SG 99	24.4	64.8	7.1	15.8	60.8	67.5	9.4	51.1	8.4
SG 84	19.9	51.8	7.2	20.0	49.2	69.4	10.7	51.2	7.1
M 522	18.0	50.8	9.5	22.4	66.5	62.6	10.9	50.2	5.7
CD (P=0.05)	2.1	3.8	0.74	4.9	3.6	4.6	NS	NS	0.8

Table 2 Pod and oil yields (q/ha) of groundnut varieties as influenced by sowing dates

Sowing dates	Pod yield (kg/ha)			Oil yield (kg/ha)		
	Varieties			Varieties		
	SG 99	SG 84	M 522	SG 99	SG 84	M 522
28 April	30.9	24.1	21.9	11.0	8.8	6.9
18 May	34.2	23.9	19.2	10.9	8.3	5.9
8 June	18.1	15.7	16.7	6.5	5.9	5.7
28 June	14.7	16.0	14.3	5.0	5.3	4.2
CD (P=0.05)		4.1			1.6	

References

- Ahmad, M. 1992. Performance of groundnut (*Arachis hypogaea* L.) varieties as affected by date of sowing in Assam. *Indian Journal of Agronomy*, 37: 382-393.
- Karanjkar, P.N., Jadhav, G.S. and Wakle, P.K. 2004. Eco-physiology of yield expression in groundnut, *Arachis hypogaea* L. genotypes during post-monsoon season. *Journal of Oilseeds Research*, 21: 39-41.
- Padhi, A.K. 1994. Response of groundnut (*Arachis hypogaea* L.) varieties to time of sowing under rainfed conditions. *Journal of Oilseeds Research*, 11: 132-133.

- Padma, V., Madhusudana Rao, D.V. and Subha Rao, I.V. 1991. Response of groundnut cultivars to time of sowing in different seasons. *Journal of Oilseeds Research*, 8: 275-279.
- Patel, L.R., Patel, R.H. and Patel, J.K. 1991. Response of groundnut varieties to different dates of sowing and row spacing. *Journal of Oilseeds Research*, 8: 263-266.
- Patel, S.R., Thakur, D.S. and Pandya, K.S. 1998. Influence of sowing time on the performance of groundnut (*Arachis hypogaea* L.) varieties. *Journal of Oilseeds Research*, 15: 293-296.

Performance of promising Indian mustard entries at different fertility levels under late sown condition

R.S. Baghel, Lallu, Anjani Singh and S.B.L. Srivastava

Oilseed Section, C.S. Azad University of Agriculture and Technology, Kanpur-208 002, UP

(Received: June, 2006; Revised: December, 2008; Accepted: February, 2009)

Abstract

Five promising entries of Indian rapeseed mustard were tried under four fertility levels i.e., 75%, recommended fertilizer (RF), 125% and 150% Rf in the irrigated late sown condition. Study revealed that seed yield increased with increasing fertility level and was recorded highest under 150% RF but was at par with 125% RF. Among genotypes maximum seed yield (1356 kg/ha) was recorded with Kranti.

Keywords: Indian mustard, recommended dose of fertilizer

Fertilizer is the major input through which the mustard productivity can be increased by exploiting varietal potential. Chemical fertilizers have had a substantial impact on yield increments in the recent past and are today an indispensable part of modern agriculture. Keeping in view, the present study was conducted to find out suitable fertility level for promising mustard genotypes.

A field experiment was conducted at the oilseed research farm, Kalyanpur, C.S. Azad University of Agriculture and Technology, Kanpur during *rabi* season of 2007-08. The experiment was laid out in Split Plot Design comprising four fertility levels i.e., 75% RF (80:40 kg N, P and K/ha), 125% and 150% of RF with five promising mustard genotypes i.e., Ashirvad, Kranti, NRCDR 509, NRCHB-101

and Varuna replicated thrice. Crop was sown with 30 cm distance between rows and plant spacing was maintained at 15 cm by manual thinning at 20 days after sowing. The seed yield and yield attributes and 10 mg with harvest index (%) were recorded at the time of harvest.

Seed yield increased with increasing fertility levels and was recorded significantly higher under 150% of RD but was at par (1412 kg/ha) with 125% RF. Test weight of seed also increased with increasing levels of fertility and was recorded maximum with higher fertility levels i.e., 150% RF. Among different genotypes tried, maximum seed yield was recorded in Indian mustard variety, Kranti but was at par with NRCDR 509.

Seed yield of Indian mustard

Genotype	Fertility levels (Seed yield)				Mean (Seed yield)
	75%	RF	125%	150%	
NRCHB-101	9.90	12.42	13.23	12.42	11.99
Varuna	11.01	13.03	13.74	13.64	12.86
Kranti	9.8	14.14	14.95	15.35	13.56
NRCDR-509	10.20	13.64	14.24	14.85	13.23
Ashirvad	9.80	13.23	14.44	14.95	13.11
Mean	10.14	13.29	14.12	14.24	

CD (P=0.05) : Entries = 0.88; Fertility level = 0.52 and Entry x Fertility level = NS

Evaluation of bioefficacy of biopesticides against larvae of mustard saw fly, *Athalia lugens proxima* Klug. under laboratory condition

Wajid Hasan and C.P. Singh

Department of Entomology, G.B. Pant University of Agriculture & Technology, Pantnagar-263 145, Uttarakhand

(Received: November, 2008; Revised: June, 2009; Accepted: July, 2009)

Abstract

LC₅₀ values of *Bacillus thuringiensis*, *Beauveria bassiana* and Nemarin (*Azadiractin*) were evaluated at 24 hrs, 48 hrs, 72 hrs and 96 hrs after treatment against mustard sawfly, *Athalia*.

Keywords: Mustard, sawfly, LC₅₀

The mustard saw fly *Athalia lugens proxima* Klug. (Hymenoptera: Tenthredinidae) is a serious pest to different cruciferous plants in India. The present study was undertaken to investigate the LC₅₀ of biopesticide i.e., Halt (*Bacillus thuringiensis* serovar kurstaki H 3a, 3b, 3c), Biorin (*Beauveria bassiana*) and Nemarin (*Azadiractin*) against 3rd instar larvae of *A. proxima*. The larvae of *A. proxima* were reared on fresh tender leaves of Indian mustard, *Brassica juncea* var. varuna in the laboratory at 20±1°C and 75±5 % R.H with 9:15 (Light: Dark) in B.O.D. incubator. These biopesticides were tested against larvae of *A. proxima* by LRD (Leaf Residue) method (Murugesan and Dhingra, 1998). The leaves of var. varuna were

treated with required concentrations of biopesticides and dried at room temperature and allowed to feed to 3rd instar larvae (Starved for 12 hrs) of *A. proxima* for 24 hrs, thereafter fresh leaves were provided. Three sets of experiment were made for each treatment and mortality counts were made at 24, 48, 72 and 96 hrs after treatment and it was replicated thrice. A control was also run parallel to each sets of experiment to obtain corrected mortality (Abbott, 1925).

The LC₅₀ values were 0.6574%, 6.14 x10⁷ spores/ml and 0.0096% obtained for Halt, Biorin and Nemarin, respectively at 24 hrs after treatment (Table 1). In the second set of experiment, in which observations were taken at 48 hr after treatment, the LC₅₀ values were obtained as 0.4692%, 5.05 x10⁷ and 0.0085% for Halt, Biorin and Nemarin, respectively. While in the third set of experiment mortality count was made at 72 hrs after treatment in which the LC₅₀ values were calculated as 0.3831%, 4.13 x10⁷ and 0.0067% for Halt, Biorin and Nemarin, respectively.

Table 1 Bioefficacy of biopesticides against larvae of mustard saw fly, *Athalia lugens proxima* Klug.

Biopesticide	Heterogeneity	Regression Equation	LC ₅₀	Fiducial Limits		Slop ± S.E.
				Low	Up	
After 24 hours						
Halt (<i>Bacillus thuringiensis</i>)	0.0074	Y= 0.955x+4.795	0.6574	0.385	2294.53	0.955±0.192
Biorin (<i>Beauveria bassiana</i>)	0.0213	Y= 1.501x-7.015	6.14 x10 ⁷	4.40 x10 ⁷	9.81 x10 ¹⁰	1.501±0.118
Nemarin (<i>Azadiractin</i>)	0.0007	Y= 1.241x+7.182	0.0096	0.006	0.073	1.242±0.105
After 48 hours						
Halt (<i>Bacillus thuringiensis</i>)	0.0669	Y= 0.864x-5.022	0.4692	0.296	8.943	0.864±0.140
Biorin (<i>Beauveria bassiana</i>)	0.2794	Y= 1.302x-5.234	5.05 x10 ⁷	3.68 x10 ⁷	6.31 x10 ⁸	1.302±0.092
Nemarin (<i>Azadiractin</i>)	0.0348	Y= 1.097x+7.048	0.0085	0.006	0.095	1.097±0.106
After 72 hours						
Halt (<i>Bacillus thuringiensis</i>)	0.1121	Y= 0.822x+5.181	0.3831	0.233	6.933	0.822±0.129
Biorin (<i>Beauveria bassiana</i>)	0.0268	Y= 1.207x-4.288	4.13 x10 ⁷	2.80 x10 ⁷	1.58 x10 ⁸	1.207±0.775
Nemarin (<i>Azadiractin</i>)	0.2731	Y= 1.044x+7.168	0.0067	0.004	0.016	1.044±0.079
After 96 hours						
Halt (<i>Bacillus thuringiensis</i>)	0.2012	Y= 0.799x+5.454	0.2598	0.096	0.917	1.749±0.111
Biorin (<i>Beauveria bassiana</i>)	0.0493	Y= 1.166x-3.806	3.53x10 ⁷	1.76x10 ⁷	7.80x10 ⁷	1.166±0.075
Nemarin (<i>Azadiractin</i>)	0.6055	Y= 0.992x+7.276	0.0051	0.001	0.011	0.992±0.093

Likewise in the fourth set of experiment mortality count was made at 96 hrs after treatment and the LC_{50} values of Halt, Biorin and Nemark were 0.2598%, 3.53×10^7 and 0.0051%, respectively. The Bioefficacy of *Beauveria bassiana* and neem oil against larvae of mustard sawfly were reported by Pawar and Thombre (1990) and Agrawal and Saroj (2003). It can be concluded that the LC_{50} value was decreased with the increased in duration at 24 hrs of feeding on treated food.

References

- Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. *Journal of Economic Entomology*, **18**: 265-267.
- Agrawal Neerja and Saroj, S.R. 2003. Bio-efficacy of fresh neem oil against larvae of mustard sawfly, *Athalia proxima* Klug. infesting mustard. *Journal of Entomological Research*, **27**(4): 347-351.
- Murugesan, K. and Dhingra, S. 1998. Evolving suitable bioassay technique for base-line data in detecting resistance level in the third instar larvae of *Spodoptera litura* (Fab.) to endosulfan formulated with different solvents. *Journal of Entomological Research*, **22**(3): 223-230.
- Pawar, V.M. and Thombre, U.T. 1990. Biological activity of *Bacillus thuringiensis* (Bt.) formulation against some crop pests. Proceedings and abstracts, Vth International Colloquium on Invertebrate Pathology and Microbial Control, Adelaide, Australia, 20-24 August 1990. pp496.

Eco-friendly management of *Alternaria* blight of Indian mustard, *Brassica juncea* L.

Rajendra Prasad, K.K. Maurya and S.B.L. Srivastava

Oilseed Section, C.S. Azad University of Agriculture & Technology, Kanpur-208 002, UP

(Received: December, 2008; Revised: January, 2009; Accepted: January, 2009)

Abstract

To develop an alternative, economical and eco-friendly method for the management of *Alternaria* blight of mustard, 11 bio-agents, garlic bulb extract and fungicides along with a set of check were evaluated as seed treatment alone and in combination with foliar spray. All the treatments has significantly reduced the disease severity and increased the yield over the check. Seed treatment with carbendazim and foliar spray of Ridomil MZ 72 WP was found most effective to reduce the *Alternaria* blight severity (26.3%) followed by seed treatment with Apron and foliar spray of Ridomil MZ. Maximum seed yield was recorded with the treatment of carbendazim followed by Ridomil MZ 72 WP.

Keywords: *Alternaria* blight, garlic, bioagents, Indian mustard

Cultivation of Indian mustard, *Brassica juncea* (L.) Czern & Coss. is an important and predominant *rabi* oilseed crop in India which occupies an area of 5.9 m.ha yielding 6.43 mt with an average productivity of 1000 kg/ha. *Alternaria* blight caused by *Alternaria brassicae* Sacco is one of the most important disease of mustard inflecting upto 70% seed yield loss. An increasing consciousness about environmental pollution and pesticides contamination of food specially the edible oils, the present study was undertaken to evaluate an alternative, economic and eco-friendly method of the disease management in Indian mustard.

The trial was conducted with 11 different bio-agents, garlic bulb extract and fungicides along with a set of check as seed treatment (ST) alone and in combination with foliar spray (FS) at the oilseed farm of the C.S.A. University of Agriculture and Technology, Kanpur during 2006-07. The experiment was laid out in a Randomized Block Design having 5 x 3 m plot size with three replications. To prepare the garlic bulb extract, 20 g garlic bulbs were crushed in wearing blender. The juice has extracted from the crushed

garlic bulb by adding water in limited quantity and sieve in muslin cloth several times till enough quantity of juice is extracted. The quantity of extract was made 1 l by adding required quantity of water. The extract was prepared afresh on the day for seed treatment and for foliar spray. Bio-agents were collected from G.B. Pant University of Agriculture and Technology, Pantnagar.

All the treatments were found effective in reducing the disease severity and increased the seed yield. Seed treatment with carbendazim and foliar spray of Ridomil MZ 72 WP was found most effective to reduce the *Alternaria* blight severity (26.3%) followed by seed treatment with Apron and foliar spray of Ridomil MZ. Singh and Rai (1982) have also reported that Ridomil MZ (0.2%) gave the best result in controlling *Alternaria* blight of mustard. Seed treatment and foliar spray with garlic bulb extract was also found most effective and recorded 29.7% disease severity. Daya Ram (1997) and Shivpuri *et al.* (1997) have been reported antifungal activity of garlic bulb extract. Maximum seed yield was recorded with the seed treatment with carbendazim followed by Ridomil MZ 0.02% spray for *Alternaria* management. Bio-agents and garlic bulb extract as seed treatment alone and its combination with foliar spray were found statistically at par among themselves. However, seed treated with the bio-agent (*T. harzianum*) recorded the maximum test weight (5.03g) and the maximum plant stand was observed when the seed were treated with the combination of apron + carbendazim.

References

- Daya Ram. 1997. Fungitoxicity of some plant extracts against *Alternaria brassicae*. *Annals of Agriculture and Biological Research*, 2 : 25-26.
- Shivpuri, A., Sharan, O.P. and Hamaria, S.L. (1997). Fungitoxic properties of plant extracts against pathogenic fungi. *Journal of Mycology and Plant Pathology*, 27 : 29-31.
- Singh, D.B. and Rai, B. 1982. Effect of certain agro-chemicals on growth behaviour of *Alternaria brassicae* and *Dreschslera graminea*. *Acta Botanica Indica*, 10 : 4-7.

Effect of salinity on Indian mustard, *Brassica juncea* at seedling stage

Lallu, R.S. Baghel and S.B.L. Srivastava

Oilseed Section, C.S. Azad University of Agriculture and Technology, Kanpur-208 002, UP

(Received: June, 2006; Revised: December, 2008; Accepted: February, 2009)

Abstract

Thirty three genotypes of Indian mustard were tested at seedling stage under three artificially created salinity levels i.e., 2 (control), 6 and 10 dS/m. Finding revealed significant reduction occurred in germination per cent, root and shoot length, speed of germination and dry weight of seedling as salinity levels increased. Mustard genotypes BIO 169-96, RGN 81, SKM 9927, Krishna, RH 9615, RH 0116, Kranti and Urvashi were identified salinity tolerant at seedling stage.

Keywords: Indian mustard, salinity, seedling stage

Out of 7 m.ha of salt affected soils in the country, about 1.2 m.ha is affected with salinity in the state of U.P. alone. The germination and seedling growth of mustard under salinity levels is critical one and thus becomes a limiting factor for production of crop. Under such condition identification of salt tolerant genotypes is of paramount importance for managing salinity. The salt tolerance in mustard varies from variety to variety (Lallu and Dixit, 2001; Chopra and Chopra, 1992). Keeping above in view, the study was conducted to identify genotypes of Indian mustard which have tolerance to salinity at seedling stage.

Table 1 Germination (%), root length (cm), shoot length (cm) as influenced by different levels of salinity in Indian mustard cultivars

Genotypes	Germination %					Root Length (cm)					Shoot length (cm)				
	S ₁	S ₂	S ₃	Mean	% Red	S ₁	S ₂	S ₃	Mean	% Red	S ₁	S ₂	S ₃	Mean	% Red
RGN 73	98	90	72	86.6	26.5	9.1	6.2	5.5	6.9	39.5	11.8	10.2	9.3	10.4	21.1
BIO 772	90	92	74	85.3	17.7	13	7.9	7.2	9.3	44.6	12.5	11.3	9.7	11.1	22.4
BIO 169-96	100	96	78	91.3	22	12.2	10.8	10.7	10.3	12.3	11	10.4	10.2	10.7	7.2
RGN 81	100	88	76	88.0	24	7.3	8.1	6.4	7.4	16.8	10.5	10.1	9.9	10.0	5.7
SKM-9927	98	98	76	90.6	22.4	11.4	9.1	8.9	9.8	21.9	11.7	10.7	8.8	10.4	24.7
Krishna	88	84	68	78.6	22.7	13	12.5	8.6	11.3	33.8	12.9	12	11	11.9	14.7
JGM-02-01	100	92	76	89.3	24	9.4	7.8	4.4	7.2	53.1	11.1	10.6	8.9	10.2	19.8
RM-51	100	90	76	88.6	24	12.4	9.9	3.3	8.2	73.3	12.8	11	7.7	10.5	39.8
YET-17	98	94	74	88.6	24.4	10	7.6	6.9	8.1	31.0	12	10.9	8.7	10.5	27.5
RM-11	100	88	76	88.0	24	10.4	9.4	6.9	8.9	33.6	12.5	11.8	10.8	11.7	13.6
SKM-0158	90	88	66	81.3	26.6	10.1	7.7	6	7.9	40.5	12.9	11.3	10.8	11.6	16.2
RN-510	100	98	76	91.3	24	12.6	7.5	5.1	8.4	59.5	11.4	10.7	10.7	10.9	6.1
RGN-48	100	100	72	90.6	28	9.9	6.6	5.6	7.3	43.4	10.4	10	9.4	9.9	9.6
RH-9615	90	90	70	83.3	22.2	11.4	8.5	8.4	9.4	26.3	12.3	11.3	10.2	11.5	11.3
CS-508-4	92	78	64	74.6	30.4	5.6	5.2	2.6	4.4	53.5	9	6.6	5.9	7.1	34.4
CS-137-28	98	98	76	91.3	20.4	8.9	6.1	3.5	6.1	60.6	8	7.9	7.5	7.8	6.2
SAL-7	96	86	64	82.0	33.3	6.3	5.2	2	4.5	68.2	7.3	7.6	5.4	6.7	26
SAL-9	96	94	54	81.3	43.7	8.6	5.5	4.7	6.2	45.3	8.6	7.9	7.9	8.1	8.1
CS-611-1-3-6	90	76	60	75.3	33.3	7.8	5.5	4	5.7	48.7	8.7	8.7	7.5	8.3	13.7
CS-609-5-3-1	90	80	70	80.0	22.2	7.6	6.6	4.2	6.1	44.7	8.6	7.7	7.2	7.8	16.2
RH-9623	56	34	32	40.6	42.8	6.6	6.7	5.5	6.2	16.6	9.8	9.5	7.6	8.9	22.4
RH-0116	90	90	78	86.0	13.3	12.9	8.9	6.3	9.3	51.1	12.9	11.6	10.8	11.7	16.2
NDRS-2003	92	82	66	80.0	28.2	12.4	7.1	6.7	8.7	45.9	11.8	11.6	9.8	11.0	16.9
NDRS-2002	94	92	58	81.3	38.2	9.9	7.3	7.2	8.1	27.2	11.5	9.5	9.3	10.1	19.1
NDRS-2001	98	96	70	88.0	28.5	8.3	6.9	4.8	6.6	43.1	10.7	10.2	9.9	10.2	7.4
CS-52	96	94	70	86.6	27	10.6	9	8.1	9.2	23.5	10.7	10.3	9.3	10.1	16.5
Varuna	86	84	62	77.3	27.9	12.8	14.8	8.9	12.1	30.4	12.7	11.2	10.6	11.5	16.5
Kranti	82	82	68	77.3	17	7.3	7.3	6	7.7	17.8	11.2	10.7	10.3	10.7	8
Urvashi	42	42	34	39.3	19	5.4	5.4	4.9	5.2	9.2	10.0	9.5	9	8.3	10
RH-8816	98	96	72	88.6	26.5	8	8.4	5.9	7.4	26.2	12.6	11.2	8.8	10.8	30.1
RH-8814	100	98	74	90.6	26	10.5	9	7.4	8.9	29.5	12.3	11.5	10.1	11.5	11.3
RH-8701	96	92	74	87.3	22.9	9.3	6.8	4.7	6.9	49.4	12.7	10.2	10.2	11.1	19.6
NPJ-92	94	92	70	85.3	25.5	8.7	8.9	4.7	7.4	45.9	11.8	10.9	10.8	10.1	8.4
Mean	91.9	87.6	67.8			9.7	7.8	5.8			11.1	10.1	9.1		
CD (P=0.05)															
V				4.9					0.4					0.3	
S				1.4					0.1					0.1	
VxS				8.5					0.7					0.4	

S₁ = Control; S₂ = 6Ec; S₃ = 10 Ec

Table 2 Speed of germination and dry weight of seedling as influenced by different salinity levels of Indian mustard cultivars

Genotypes	Speed of germination					Dry wt. of seedlings (mg) / 5 seedlings					Overall %
	S ₁	S ₂	S ₃	Mean	% Red	S ₁	S ₂	S ₃	Mean	% Red	Reduction
RGN 73	27.2	21.6	21.6	23.4	20.5	24.2	21	17.2	20.8	28.9	27.3
BIO 772	19.6	20.4	16.4	18.8	16.3	47.5	44.2	27.5	39.7	42.1	28.6
BIO 169-96	26.0	20.4	17.2	21.2	33.8	44.3	44	40.2	42.8	9.3	16.9
RGN 81	28.4	26.0	25.6	26.6	9.8	25.5	24	23	23.6	9.8	3.2
SKM-9927	27.2	26.8	24.0	26.0	11.7	36	34	30	33.3	16.7	19.5
Krishna	16.8	17.6	14.0	16.1	16.6	41.2	40	37	39.4	10.2	19.6
JGM-02-01	28.4	27.2	24.8	26.8	12.6	28.3	28	23.3	26.5	17.7	25.4
RM-51	28.0	25.6	24.8	26.1	11.4	37.2	34	31.2	34.1	16.1	32.9
YET-17	25.6	23.7	20.0	23.1	21.8	33.3	32	27	30.7	18.8	24.7
RM-11	27.2	23.6	22.8	24.5	16.1	37.2	35.2	25.2	32.5	32.3	23.9
SKM-0158	23.2	22.0	21.2	22.1	8.6	37	35	28	33.3	24.3	23.2
RN-510	24.4	24.4	22.4	23.7	8.1	32.2	29	24.4	28.5	24.2	24.4
RGN-48	28.4	28.8	26.0	27.7	8.4	28.3	27.2	21.5	25.6	24	22.7
RH-9615	23.6	23.6	19.6	22.2	18.9	35	30.2	30.3	31.8	13.4	18.0
CS-508-4	23.2	21.2	18.0	20.8	22.4	30.2	27	24	27.0	20.5	32.2
CS-137-28	27.2	27.2	26.0	26.8	4.4	31	28	25	28.0	19.4	22.2
SAL-7	23.6	24.4	21.6	23.2	8.4	35.2	32	27.2	28.1	22.7	31.7
SAL-9	27.6	23.2	18.4	23.0	33.3	31.2	27.2	24.3	27.5	22.1	30.5
CS-611-1-3-6	22.8	17.2	13.2	17.7	42.1	33.2	31.1	21.7	28.6	34.6	34.5
CS-609-5-3-1	20.8	22.0	19.6	20.8	5.7	30.2	28.1	24.4	27.5	19.2	21.5
RH-9623	13.6	7.2	4.8	8.5	64.7	34.4	29.2	23.3	28.9	32.3	35.8
RH-0116	26.4	26.4	26.0	26.2	1.5	33.2	32.1	28.2	31.1	15.1	19.1
NDRS-2003	22.4	19.2	17.6	19.7	21.4	34.3	30.3	21.2	28.6	38.2	30.1
NDRS-2002	23.2	22.8	16.8	20.9	27.5	28.2	26	21.2	25.1	24.8	27.4
NDRS-2001	22.8	21.6	20.4	21.6	10.5	34.2	28	21.2	27.8	38	25.5
CS-52	24.0	18.4	14.0	18.8	41.6	32.5	28	24.3	28.2	25.2	26.8
Varuna	21.6	20.4	16.0	19.3	25.9	34	34	30	32.6	11.8	22.5
Kranti	22.8	20.0	17.2	20.0	24.5	24.2	23	22.2	22.9	8.3	15.1
Urvashi	9.2	9.2	6.0	8.1	34.7	27	24.8	24.5	23.9	9.3	16.4
RH-8816	26.0	23.2	19.2	22.8	26.1	32.2	31.5	27.3	30.3	15.2	24.8
RH-8814	22.4	24.0	16.0	21.0	28.5	30	29	24.2	27.7	19.3	22.2
RH-8701	23.6	19.6	14.8	19.3	37.2	30.3	29.1	19.6	26.3	35.3	32.9
NPJ-92	24.8	22.4	20.8	22.6	16.1	42	33	26.2	33.7	37.6	26.7
Mean	23.6	21.8	19.0			32.9	30.5	25.3			
CD (P=0.05)											
V				1.7					0.7		
S				0.5					0.2		
VxS				3.0					1.2		

S₁ = Control; S₂ = 6Ec; S₃ = 10 Ec

An experiment was conducted at the Oilseed Research Unit of C.S. Azad University of Agriculture and Technology, Kanpur under laboratory conditions in Petridishes adopting Completely Randomized Design with 33 mustard genotypes. As given in table, at three artificially created salinity levels i.e., 2, 6 and 10 dS/m. Each treatment was repeated four times during *rabi* 2003-04. Two filter paper circles of 10 cm diameter were placed at the bottom of petridishes and duly moistened with a thin film of salt solution of desired salinity. Twenty five seeds of uniform size, treated with 0.20% HgCl₂ to avoid fungus growth were evenly placed on the filter paper in each petridish. Seed germination was recorded daily up to 12 days after sowing. At the end, five seedlings were randomly taken for recording the root and shoot length.

The speed of germination was calculated as per Mageuive (1962).

In general, reduction in germination percent, root length, shoot length, speed of germination and dry weight of seedlings were recorded with increasing salinity levels in all the genotypes screened (Table 1 and 2). At higher salinity levels genotypes BIO 169-96 and RH0116 showed higher germination (78%), BIO 169-96, SKM 9927, Krishna, RH 9615, CS-52 and Varuna showed higher root length (between 8.1 to 10.7cm) and higher shoot length was recorded in BIO 169-96, Krishna, RM 11, SKM 0158, RN 510, RH 9615, RH 0116, Varuna, Kranti, RH 8814, RH 8701 and NPJ 92 (between 10.0 to 11.00cm) (Table 1). Maximum valued of speed germination (24.0 to 26.0) was recorded in RGN-81, SKM-9927, JGM02-01, RM-51, RGN

Effect of salinity on Indian mustard at seedling stage

48, CS 137-28, RH 0116 and higher dry weight of seedlings (between 30.0 to 40.2 mg) were recorded in BIO 169-96, RM 51, RH 9615 and in Varuna at higher salinity level (10Ec) (Table 2).

The salinity tolerance of different genotypes was assessed by the overall reduction in above recorded parameters and genotypes BIO 169-96, RGN 81, SKM 9927, Krishna, RH 9615, RH 0116, Kranti and Urvashi were identified tolerant to salinity at seedling stage as these showed overall low reduction (<20%) (Table 2).

References

- Chopra, N. and Chopra, N.K. 1992. Salt tolerance in raya (*Brassica napus* var. *glauca*) varieties. *Indian Journal of Agronomy*, **37** : 304-311.
- Lallu and Dixit, R.K. 2001. Effect of salinity on germination and early seedling growth of mustard [*Brassica juncea* (L.) Czern and Coss]. *Journal of Oilseeds Research*, **18** : 250-252.
- Mageuive, T.D. 1962. Speed of germination aid in selection and evaluation for seedling emergence and vigour. *Crop Science*, **2**: 176-177.

Suitability of soybean, *Glycine max* L. varieties for *kharif* rainfed conditions in northern telangana zone

S. Narender Reddy

Regional Agricultural Research Station, Jagtial-505 327, AP

(Received: March, 2006; Revised: June, 2009; Accepted: July, 2009)

Abstract

Soybean seed of most of the varieties remained viable upto 240 days after harvest with germination of more than 70%. However, after 270 days after harvest only MACS 450, JS(SH) 93-97 and J 335 had minimum permissible germination limits.

Keywords: Soybean, germination, seed viability

Soybean, one of the first three major oilseed crops of India is an introduced crop in Northern Telangana Zone of Andhra Pradesh. The area under this crop is being increased many folds particularly in Adilabad, Nizamabad, Karimnagar and Khammam districts due to establishment of processing industries and market facilities. It has become an alternate and remunerative crop to cotton and groundnut crops in major black cotton soils under rainfed situation in the zone. The coverage of this crop in the zone has been increased from 53,886 ha in 2002 to 1,27,077 ha in 2005 *kharif* season. However, the information pertaining to the suitable varieties for the zone was lacking. Keeping this in view, a field experiment was conducted for three consecutive years from 2001 to 2003 at Regional Agricultural Research Station, Jagtial mainly to find out the soybean varieties suitable for *kharif* rainfed conditions.

A field experiment was conducted during 2001 to 2003 in black soils during *kharif* season under rainfed situation at Regional Agricultural Research Station, Jagtial located in Northern Telangana Zone. Sowings were taken up during last week of June in all three seasons. Experiments were laid out in Randomized Block Design with three replications. Applied the recommended dose of nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) i.e., 30 N:60 P₂O₅:40 K₂O:20 S Kg/ha as basal. Pre-emergence weedicide alachlor was sprayed after sowing @ 5 ml/l to control weeds. Need based plant protection measures were taken.

Data on various yield attributing plant characters (plant height, days to 50% flowering, days to maturity, number of pods/plant, 1000 seed weight, number of seeds/pod and grain yield) and weather parameters were recorded during crop growth and harvest. Rainfall, relative humidity, temperature and sunshine hours prevailed during the

crop growth period in three years were presented in Fig. 1 and 2.

The total rainfall received and number of rainy days during crop growth period in 2001, 2002 and 2003 were 493 mm (29 days), 452 mm (24 days) and 976 mm (32 days) respectively. Dry spell of about 20 days prevailed during reproductive phase in all the three seasons. Whereas, in 2002, dry spell occurred even during vegetative phase. During crop growth period maximum sunshine hours were observed in 2002 as compared to 2001 and 2003.

Among the seven varieties studied the mean seed yield ranged from 990 kg/ha to 2319 kg/ha (Table 2). The black seed variety JS(SH) 93-37 recorded highest seed yield of 2319 kg/ha followed by JS 335 (2036 kg/ha) and DSb 1 (1568 kg/ha). Highest seed yield in JS(SH) 93-37 can be attributed to more number of filled pods/plant, number of seeds, test weight (Table 1). Oil content was also highest in JS(SH) 93-37. Similar results were also reported by Barik and Sahoo (1989), Thakur *et al.* (2003) and Paradkar and Deshmukh (2004).

When year wise seed yield data was observed, highest mean seed yield of 1764 Kg/ha was recorded during *kharif* 2002. Among the varieties JS(SH) 93-37 and JS 335 recorded highest seed yield of 2917 and 2832 kg/ha though, the rainfall received during crop growth period in that particular year was only 452 mm as compared to 493 and 976 mm rainfall during 2001 and 2003 respectively.

Moreover, during 2002, the crop was exposed to two dry spells of each about 20 days at vegetative and reproductive stages. The terminal drought prevailed had badly effected the pod filling in LSb 3 and DSb 1 resulting in reduced harvest index and seed yield. Highest yield during 2002 can be attributed to better solar radiation during crop growth period as compared to 2001 and 2003. Hence, this crop can be cultivated successfully under low rainfall situation in Northern Telangana Zone.

Pooled data indicated that plant height (90 cm), total dry matter (6448 kg/ha) and oil content in seeds (19.97%) were highest in JS(SH) 93-37, whereas crop duration was highest in LSb 3 and the harvest index was more in JS 335 (36.8%).

Suitability of soybean varieties for *kharif* rainfed conditions in northern Telangana zone

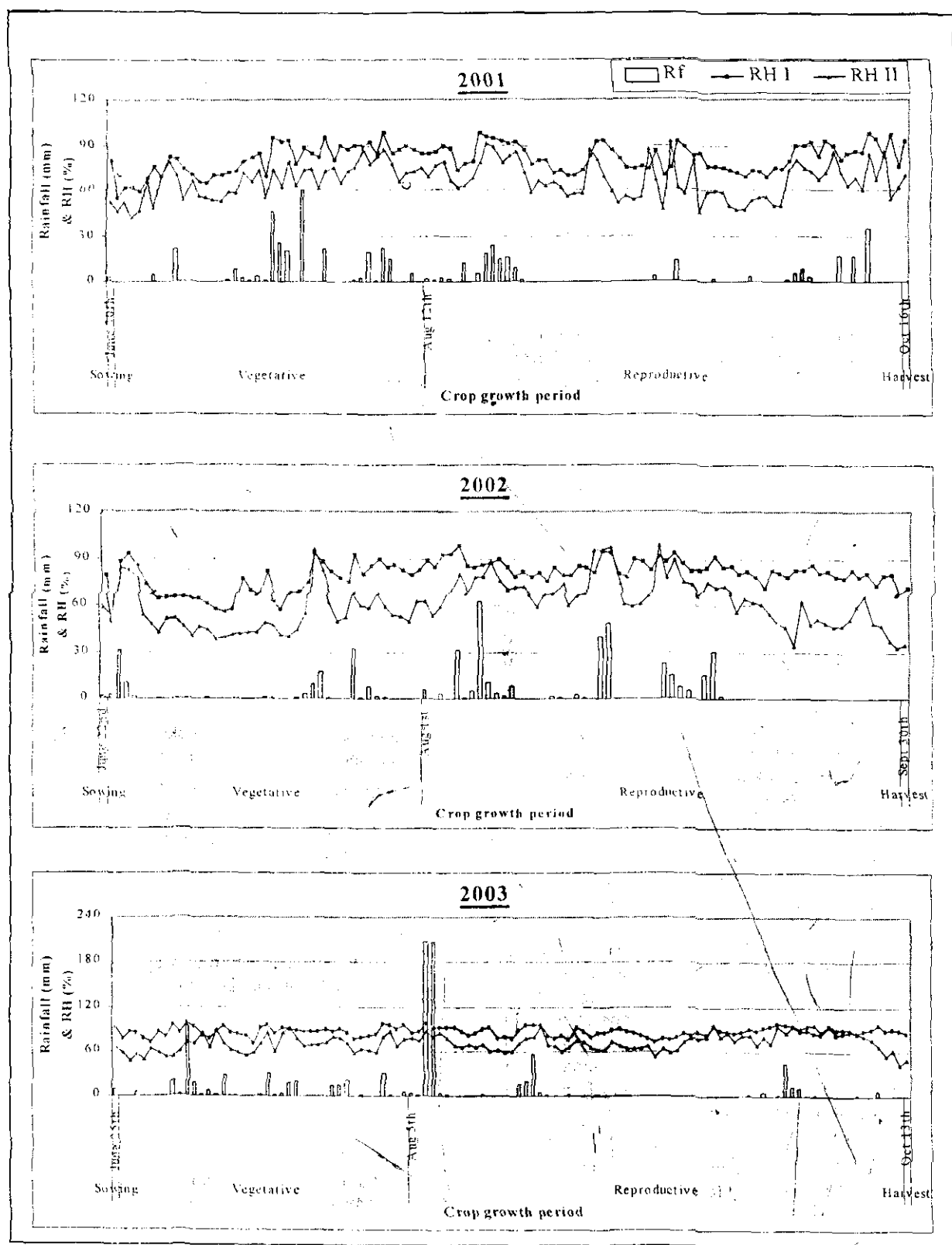


Fig. 1. Rainfall and relative humidity during *kharif* soybean during crop growth period

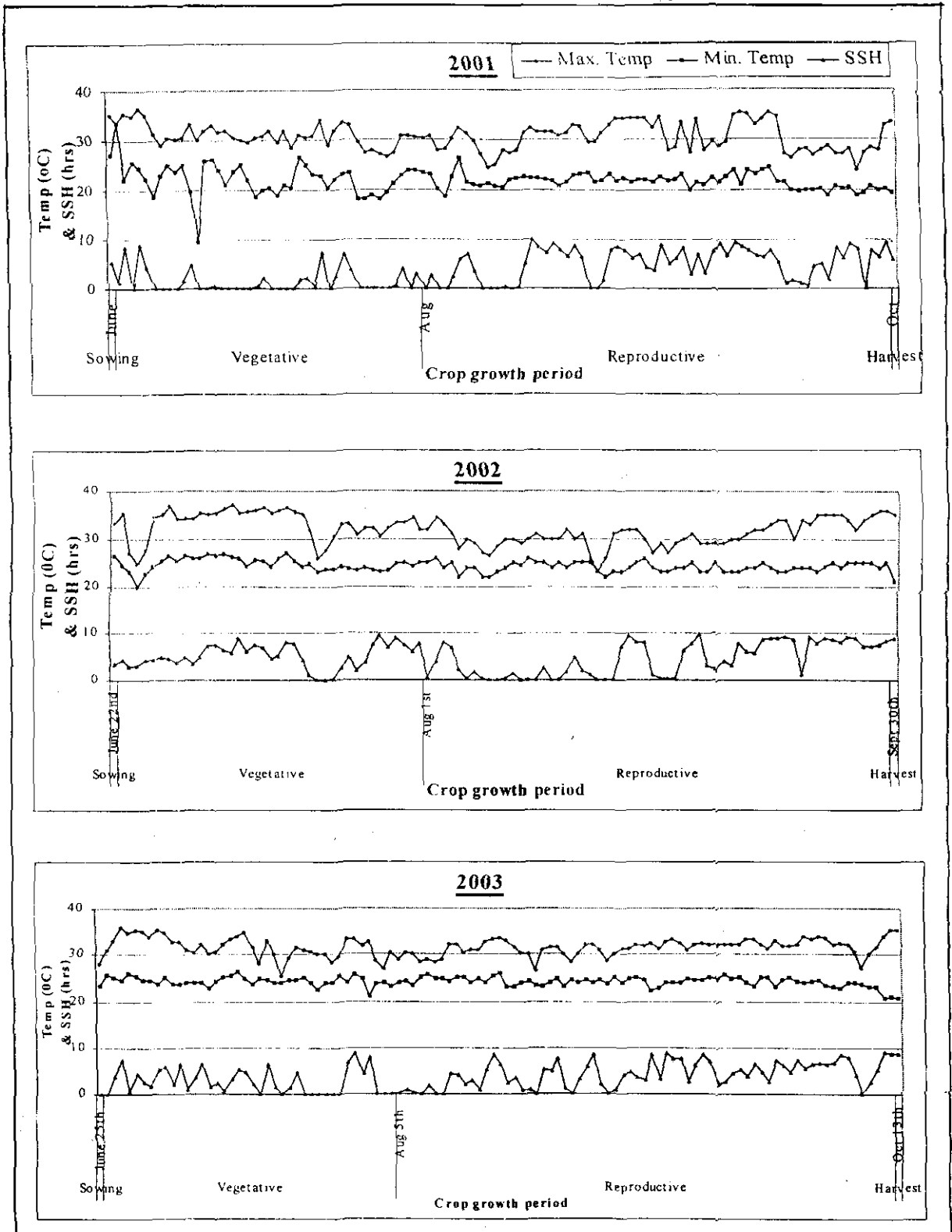


Fig. 2. Temperature and sunshine hours during *kharif* soybean crop during crop growth period

Table 1 Yield attributing characters of soybean varieties under rainfed conditions in *kharif* (Pooled of 3 years, 2001-2003)

Variety	Plant height (Cm)	Days to 50% flowering	Days to maturity	Number of filled pods/plant	Pod filling (%)	Number of seeds/pod	1000 seed weight (g)	Oil content (%)
MACS 450	57	45	102	59	78	2.6	97.5	18.47
PK 1029	40	43	103	53	74	2.5	102.6	19.53
PK 472	41	48	96	54	54	2.3	102.8	18.60
DSb 1	67	45	96	62	78	2.7	84.3	19.73
JS(SH) 93-37	90	44	97	63	90	3.1	121.6	19.97
JS 335	50	42	94	56	90	3.1	113.2	19.40
LSb 3	54	47	106	33	65	2.4	92.0	19.23
CD (P=0.05)	9.30	1.72	3.3	15.9	8.5	0.4	6.83	0.62
CV (%)	14.02	3.31	2.8	25.1	9.5	13.2	5.75	2.78

Table 2 Total drymatter, seed yield and harvest index of soybean varieties under rainfed conditions

Variety	TDM (Kg/ha)				Grain yield (Kg/ha)				Harvest index (%)			
	2001	2002	2003	Pooled	2001	2002	2003	Pooled	2001	2002	2003	Pooled
MACS 450	5432	4777	3097	4435	1635	1448	1105	1396	30.1	30.3	35.7	32.0
PK 1029	4924	3913	3472	4103	1556	1305	1285	1382	31.6	33.3	37.0	34.0
PK 472	2957	4549	3236	3581	961	1500	1259	1240	32.5	33.0	38.9	34.8
DSb 1	5671	6274	5653	5866	1639	1243	1821	1568	28.9	19.8	32.2	27.0
JS(SH) 93-37	6088	7380	5875	6448	2149	2917	1890	2319	35.3	39.5	32.2	35.7
JS 335	4572	6938	4889	5466	1742	2832	1535	2036	38.1	40.8	31.4	36.8
LSb 3	3128	6319	2403	3950	1004	1104	861	990	32.1	17.5	35.8	28.5
CD (P=0.05)	466.8	537.4	837.0	1029.9	207.6	247.9	387.1	423.8	5.04	5.09	4.3	5.57
CV (%)	8.56	9.79	20.9	18.18	8.31	14.17	27.4	23.3	12.47	15.87	11.9	14.49

Table 3 Germination percentage in different varieties after harvest

Variety	30 DAH	60 DAH	90 DAH	120 DAH	150 DAH	180 DAH	210 DAH	240 DAH	270 DAH
MACS 450	94	88	81	78	76	74	72	71	70
PK 1029	85	79	72	67	64	61	61	59	56
PK 472	90	88	83	78	75	73	72	72	69
DSb 1	91	87	84	79	76	74	72	70	69
JS(SH) 93-37	96	92	88	87	84	81	78	75	73
JS 335	93	90	84	82	78	77	75	74	73
LSb 3	82	79	77	73	71	69	71	70	68
CD (P=0.05)	7.77	7.51	8.06	8.07	7.75	7.56	7.49	7.89	7.82
CV (%)	7.40	7.48	8.51	8.92	8.87	8.91	8.97	9.64	9.58

DAH = Days after harvest

In soybean seed viability is a problem. In this study the results of germination test conducted at monthly interval after harvest (Table 3) indicated that up to 240 days after harvest the germination percentage is above seed certification level (70%), where as after 270 days after harvest only in MACS 450, JS(SH) 93-37 and JS 335 minimum permissible germination limit was recorded.

References

Barik, T. and Sahoo, K.C. 1989. Response of soybean to date of sowing and spacing. *Indian Journal of Agronomy*, **34** (4): 464-466.

Paradkar, V.K. and Deshmukh, M.R. 2004. Productivity of soybean, *Glycine max* L. Merrill as influenced by date of sowing in Satpura Plateau Zone of Madhya Pradesh. *Journal of Oilseeds Research*, **21**(2): 351.

Thakur, N.S., Raghuwanshi, R.S. and Sharma, R.S. 2003. Performance of soybean genotypes under different row spacings and seed rates in medium black soils of Satpura Plateau. *Research on Crops*, **4**(3): 313-316.

Short communication

Breeding of sunflower for high seed yield and oil content

S.L. Sawargaonkar, M.K. Ghodke and I.A. Madrap

Dept. of Agril. Botany, Genetics and Plant Breeding, College of Agril., Marathwada Agril. University, Parbhani-431 402, MS

(Received: December, 2008; Revised: January, 2009; Accepted: January, 2009)

Abstract

The 28 F_1 single cross hybrids produced from 8 restorer lines of sunflower depicted significant variability, showing wide variations for seed, yield contributing characters and oil yield.

Keywords: Single cross hybrid, variability, variance, oil content, sunflower

Sunflower (*Helianthus annuus* L.) is grown worldwide, mostly as a source of vegetable oil and proteins. The main objectives of sunflower breeding programmes are the development of productive F_1 hybrids with high seed and oil yield. Sunflower oil yield is determined as the product of seed yield per unit area and the oil percentage in grains. Therefore, consideration of both components is important when breeding for high oil yield.

Cultivated sunflower is primarily grown from single cross hybrid seed. Therefore, study was started with 28 F_1 single cross hybrids produced by crossing in between eight restorer lines in breeding nursery of oilseed research station, Latur during kharif 2006.

The restorer lines selected from Oilseed Research Station, Latur, MAU, Parbhani, Nanded local selection, Dharmapuri local selection and PC Unit, Bengaluru. The sowing was done in four splits with one week interval, in order to obtain the plants for the plants for emasculation and pollination.

The parents were crossed in a diallel fashion to obtain 28 F_1 s (excluding reciprocals) and selfing was followed simultaneously in next generation. The standing crossing techniques described earlier were used for attempting the crosses.

The analysis of variance showed that differences among the treatment in respect of all the characters were significant at both 5% and 1% level. This indicated that wide differences exists among the treatment for yield and contributing characters.

Seed yield/plant ranged from 7.0 to 22.7 g and 9.0 to 43.7g in parental lines and hybrids, respectively. Highest seed yield/plant among the parental lines was recorded in J/6 (22.7 g) followed by DMLT-1Y (18.0 g) and NDR-856 (12.0g). Amongst the crosses J/6 x NDR-1 exhibited highest seed yield/plant (43.2g), which was statistically superior over all other crosses. Range of variation in respect of oil content was from 30.4 to 42.7% and 28.5 to 40.8% for parental line and hybrids, respectively.

Highest oil content among the parents was recorded by 6D-1R (42.7%), while lowest oil content among the parents was recorded by NDR-856 (30.4%). Amongst the crosses the highest oil content in seeds was recorded by cross 6D-1R x DMLT-1Y (40.7%), followed by LR-451 x LR-3322 (38.4), J/6 x NDR-856 (38.3), J/6 x LR-3322 (38.0) and DMLT-1Y x LR-451 (37.5).

Productivity of spring planted sunflower, *Helianthus annuus* L. as influenced by critical inputs and management factors

Virender Sardana

Oilseeds Section, Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana-141 004, Punjab

(Received: June, 2008; Revised: March, 2009; Accepted: April, 2009)

Abstract

Sunflower crop gives better yield when sown in time followed by full package of practices. The productivity of late planted sunflower can be improved by proper weed management and with proper fertilizer application.

Keywords: Spring sunflower, sowing time, recommended fertilizer

Sunflower (*Helianthus annuus* L.) oil is considered premium oil due to higher proportion of unsaturated fats, greater oxidative stability and anti-oxidant properties. Under agro-climatic conditions of Punjab, cultivation of sunflower during spring season (December-January to May-June) has been found best (Sidhu and Kolar, 1996). Cold and frost conditions during these months require longer time for seed germination and crop establishment and many times result in poor germination. To overcome such risks, farmers of this region often plant the crop late in the month of February and even up to early March. Late harvesting of preceding crops such as potato, toria, sugarcane, field peas, etc., and non availability of seed in time also cause delay in planting of sunflower. The productivity of sunflower under delayed planting conditions is adversely affected due to shorter period available for proper growth of different phenophases. In addition to cultivation of short duration hybrid having higher per day productivity, there is need to study the effect of critical inputs on the productivity of short duration hybrid of sunflower under late planting conditions. Hence this investigation was carried out at the Punjab Agricultural University, Ludhiana to assess the influence of critical inputs and management factors on the productivity of sunflower.

The study comprised 10 treatments (Table 1) which were replicated thrice in Randomized Complete Block Design. The short duration sunflower hybrid, PSFH 118 was sown on 24 February 2005 by dibbling two to three seeds/hill on flat beds at recommended spacing of 60 cm between rows and 30 cm between plants within rows. Gross plot size was 4.8m x 4.5m. The sandy loam soil of the experimental field was medium in organic carbon (0.48%), available nitrogen

(348 kg/ha), and rich in available phosphorus (70 kg/ha) and available potassium (405 kg/ha). Fertilizer treatments comprised basal application of 60 kg N and 30 kg P_2O_5 /ha. Weeds were controlled by pre emergence application of pendimethalin @ 0.75 kg/ha using 500 litres of water. In the plant protection treatments, seeds were treated before sowing with thiram @ 2g/kg seed to ward off stem rot. Dursban 20 EC (Chlorpyrifos) @ 5 l/ha was mixed in soil and uniformly applied before sowing for protection against cut worms. Earthing up was first done after thinning and again after two weeks. Total seven irrigations were applied. The crop was harvested at 97 days after sowing.

The highest seed yield (2067 kg/ha) and oil (693 kg/ha) yield were obtained with adoption of recommended agronomic practices (Table 1) which comprised seed treatment with thiram @ 2 g/kg seed, application of 60 kg N, 30 kg P_2O_5 and 30 kg K_2O /ha along with weed control with pre-emergence application of pendimethalin @ 0.75 kg/ha. Missing one or more of these critical inputs or operations caused reduction in seed and oil yield. The field was dominated with *Chenopodium* sp. Non adoption of weed control measures caused maximum reduction in seed (39.4%) and oil (38.6%) yields compared with adoption of all recommended practices. Yield reduction due to weeds was also reported by Suresh and Venkat Reddy (1994). Bhan and Mishra (2002) reported that 30-45 days after sowing is the most critical period of crop weed competition in sunflower.

Similarly cultivation of sunflower without recommended dose of both nitrogen and phosphorus resulted in 75.4% yield whereas, missing only nitrogen application resulted in 88.7% and absence of phosphorus fertilizer resulted in 92.7% seed yield compared to seed yield (2067 kg/ha) obtained with recommended agronomic practices (Table 1). Similar response of nitrogen application to sunflower has been reported (Sarkar *et al.*, 1999, Singh *et al.*, 1999). Mishra *et al.* (1995) obtained higher seed yield with phosphorus application. The plant protection measures had the least influence on sunflower (Table 1). The spring season is often considered free from any major pest or disease outbreak (Sidhu and Kolar, 1996).

Table 1 Influence of critical inputs on yield attributes, seed and oil yield of spring sunflower

Treatments	Plant height (cm)	Head diameter (cm)	100 seed weight (g)	Stem girth (cm)	Seed yield (kg/ha)	Per cent seed yield reduction over full package	Oil content (%)	Oil yield (kg/ha)	Per cent oil yield reduction over full package
Full package	183	16.0	4.5	7.3	2067	-	33.3	693	-
Full package – nitrogen	177	16.0	4.4	7.1	1833	12.8	33.8	620	11.8
Full package – phosphorus	182	14.7	4.1	6.9	1917	7.8	34.9	667	3.9
Full package – nitrogen and phosphorus	165	15.3	3.9	7.7	1558	32.7	33.8	526	31.7
Full package – plant protection	179	15.6	4.1	7.2	1933	6.9	33.0	638	8.6
Full package – weed management	163	14.4	3.9	6.7	1483	39.4	33.5	500	38.6
Full package – fertilizer and weed management	152	13.3	3.5	6.0	1100	87.9	34.4	389	78.1
Full package – fertilizer and plant protection	183	15.3	4.1	7.7	1633	26.6	33.9	553	25.3
Full package – weed management and plant protection	164	14.0	3.6	6.6	1350	53.1	32.9	442	56.8
Full package - fertilizer, weed management and plant protection	154	12.1	3.2	5.6	958	115.8	32.9	314	120.7
CD (P=0.05)	10	2.2	0.6	0.9	265	-	NS	224	-

Absence of both the fertilizers and failure to control weeds reduced the seed yield by 87.9% and oil yield by 78.1% compared to adoption of all recommended practices. Non adoption of fertilizer application, weed control and plant protection measures reduced seed yield by 115.7%, whereas oil yield declined by 120.7%.

Thus productivity of late planted sunflower can be improved by proper weed management and use of recommended dose of fertilizers.

References

- Bhan, V.M. and Mishra, J.S. 2002. Integrated weed management in oilseed based cropping systems. In: *Oilseeds based cropping systems: issues and opportunities*. Gangwar, B., Sharma, S.K. and Yadav, R.L. (ed.). Project Directorate of Cropping Systems Research, Modipuram. pp. 80-91.
- Mishra, A., Dash, P. and Parkaray, R.K. 1995. Yield and nutrient uptake by winter sunflower (*Helianthus annuus* L.) as influenced by nitrogen and phosphorus. *Indian Journal of Agronomy*, **40**: 137-138.
- Sarkar, R.K., Saha, A. and Chakraborty, A. 1999. Analysis of growth and productivity of sunflower (*Helianthus annuus* L.) in relation to crop geometry, nitrogen and sulphur. *Indian Journal of Plant Physiology*, **4**: 28-31.
- Sidhu, M.S. and Kolar, J.S. 1996. *Production technology of sunflower*. Directorate of Extension Education, Punjab Agricultural University, Ludhiana. p. 28.
- Singh, T. Singh, H. and Raj, B. 1999. Effect of genotype, irrigation and fertility on yield, nitrogen recovery and its use efficiency in spring sunflower (*Helianthus annuus*). *Indian Journal of Agronomy*, **44**: 156-159.
- Suresh, G. and Venkat Reddy, N. 1994. Increasing the seed yield and quality of sunflower through weed management. In: *Sustainability in Oilseeds*. Prasad, M V R et al. (ed.). Indian Society of Oilseeds Research, Hyderabad. pp. 372-374.

Effect of weed competition on yield and economics of *rabi* sunflower

A. Malliswara Reddy, G. Prabhakara Reddy and D. Srinivasulu Reddy

Department of Agronomy, Acharya N.G. Ranga Agricultural University, S.V. Agricultural College, Tirupati-517 502, AP,

(Received: June, 2008; Revised: June, 2009; Accepted: July, 2009)

Abstract

The study revealed that in *rabi* sunflower, *Helianthus annuus* L. keeping plots free of weeds upto 40 DAS had shown beneficial effect on seed yield and realising high economic returns.

Keywords: Sunflower, weed competition

Sunflower is a promising oil seed crop introduced to India, during sixties and gained momentum in its commercial cultivation and attained quick popularity as an important oil seed crop. Due to its photo insensitivity, short duration, low water requirement and wide range of adoptability to various agro-climatic situations it can fit well in different cropping systems.

Among different constraints that are limiting the productivity of sunflower, intensive weed competition was found to be one of the major barriers limiting productivity. Yield losses due to weeds alone was up to 55.8% (Tripathi and Vivek, 2001). But, removal weeds throughout crop season may not be economical. Therefore, timely control of weeds is very essential to check the yield losses caused by weeds. Hence, the present investigation was carried out to know the effect of weed competition on yield and economics *rabi* sunflower.

A field experiment was conducted during *rabi*, 2004 at S.V. Agricultural College farm, Tirupati, of ANGRAU. The soil was sandy clay loam in texture, low in organic carbon (0.25%), low in available nitrogen (230 kg/ha) and medium in available phosphorous (23.7 kg/ha) and potassium (204 kg/ha) with a soil pH of 6.9. The experiment was laid out in a Randomized Block Design, with three replications. Fourteen treatments consisted of weed free conditions (WFC) upto 10, 20, 30, 40, 50 and 60 DAS and weed interference (WI) up to 10, 20, 30, 40, 50 and 60 DAS along with weed free and unweeded check.

Sunflower cv. MSFH-17 was sown on November 29, 2004 at 6 kg/ha at a recommended spacing of 45 x 30 cm. The sowing was done by dibbling method. The crop was grown under irrigated conditions total of six irrigations were given during crop growing season. The crop was fertilized with 75 kg N, 90 kg P₂O₅ and 30 kg K₂O/ha. The entire dose of phosphorous and potassium was applied as basal.

Nitrogen was applied in three equal splits i.e., one third as basal, one third at 30 DAS and the remaining one third at 55 DAS. Observations on weed flora and dry matter were recorded from two selected quadrats of 0.5m² in each plot. The major weed flora in the experimental field consisted of broad leaved weeds viz., *Cleome viscosa*, *Commelina benghalensis*, *Enphorbia hirta*, *Celosia argentea*, *Leucas aspera* and *Phyllanthus niruri*; grasses viz., *Cynodon dactylon*, *Datylactenium aegyptium* and *Panicum repens*; one sedge viz., *Cyperus rotundus*. Similar type of species were reported by Krishna Gowda *et al.* (1985) and Suresh and Venkat Reddy (1995) in sunflower.

The weed density was less in early stages of crop growth i.e., upto 20 DAS. During later stages of crop growth period i.e., upto 40 DAS, weed density increased gradually as the slow growing nature of crop provided congenial environment for abundant weed growth during this period. After 60 DAS of crop growing period weed population was suppressed due to smothering of late emerged weeds by crop canopy. These results are in conformity with Wanjari *et al.* (2000). Increased initial weed free conditions led to decreased total weed density (Table 1). Similar results were reported by Tripathi and Vivek (2001).

The highest seed yield was found in weed free check which was at par with WFC up to 60 and 50 DAS. This was mainly due to maintenance of weed free environment during critical stages of crop growth, which would have resulted in better utilization of growth resources and translocating the major portion of accumulated biomass to sink. Oil content of sunflower did not differ significantly due to different weed control treatments as the oil content was a genetical character.

The results are in lined with the findings of Rakesh Kumar *et al.* (1996) and Wanjari *et al.* (2000). The highest gross and net returns were realized with weed free check which was on par with WFC upto 60, 50 and 40 DAS. This was mainly due to high seed yield recorded in these treatments. The benefit-cost ratio was higher with WFC upto 60 or 50 DAS (Table 2). It can be concluded that in *rabi* sunflower keeping plots free of weeds up to 40 DAS had shown beneficial effect on seed yield and realizing high economic returns.

Table 1 Weed density (No. m sq.) as influenced by weed free and weedy conditions in *rabi* sunflower

Treatments	10DAS	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	Harvest
T ₁ - WFC* up to 10 DAS	0.00 (0.71)	26.00 (5.15)	36.66 (6.09)	42.00 (6.51)	46.00 (6.82)	60.00 (7.78)	51.00 (7.17)
T ₂ - WFC up to 20 DAS	0.00 (0.71)	0.00 (0.71)	20.66 (4.60)	35.60 (6.01)	40.60 (6.41)	52.00 (7.22)	49.20 (7.04)
T ₃ - WFC up to 30 DAS	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	20.60 (4.60)	34.60 (5.92)	50.00 (7.25)	41.34 (6.47)
T ₄ - WFC up to 40 DAS	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	24.00 (4.95)	31.40 (5.61)	27.66 (5.31)
T ₅ - WFC up to 50 DAS	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	30.32 (5.55)	24.66 (5.01)
T ₆ - WFC up to 60 DAS	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	21.22 (4.66)
T ₇ - Weed Free Check	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T ₈ - WI** up to 10 DAS	36.66 (6.09)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T ₉ - WI up to 20 DAS	40.00 (6.36)	62.66 (7.95)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T ₁₀ - WI up to 30 DAS	44.00 (6.67)	67.20 (8.23)	78.66 (8.89)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T ₁₁ - WI up to 40 DAS	44.66 (6.72)	68.20 (8.28)	88.00 (9.39)	94.60 (9.75)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T ₁₂ - WI up to 50 DAS	48.00 (6.92)	72.00 (8.51)	88.66 (9.44)	98.00 (9.92)	161.30 (12.72)	0.00 (0.71)	0.00 (0.71)
T ₁₃ - WI up to 60 DAS	48.66 (6.97)	74.00 (8.63)	98.66 (9.96)	103.50 (10.20)	171.00 (13.09)	195.30 (13.99)	0.00 (0.71)
T ₁₄ - Unweeded check	48.66 (6.97)	80.66 (9.01)	110.00 (10.51)	112.00 (10.60)	180.30 (13.74)	197.60 (14.07)	178.67 (13.39)
SEm+	0.588	0.193	0.305	0.215	0.261	0.271	0.222
CD (P=0.05)	1.71	0.56	0.85	0.63	0.76	0.79	0.65

Transformed values in parenthesis. WFC = Weed free condition; WI = Weed interference

Table 2 Seed yield, oil content and economics of sunflower as influenced by weed free and weedy conditions

Treatments	Seed yield (kg/ha)	Oil content (%)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
T ₁ -WFC* up to 10 DAS	1724	34.0	17240	8700	1.02
T ₂ - WFC up to 20 DAS	1772	34.4	17720	8880	1.00
T ₃ - WFC up to 30 DAS	2018	35.0	20180	10740	1.14
T ₄ - WFC up to 40 DAS	2478	34.5	24780	14440	1.40
T ₅ - WFC up to 50 DAS	2568	35.3	25680	14840	1.37
T ₆ - WFC up to 60 DAS	2680	35.8	26800	15260	1.32
T ₇ - Weed Free Check	2745	35.3	27450	15610	1.32
T ₈ - WI** up to 10 DAS	2371	35.1	23710	11970	1.20
T ₉ - WI up to 20 DAS	2296	34.8	22960	11520	1.07
T ₁₀ - WI up to 30 DAS	2012	34.5	20120	9280	0.86
T ₁₁ - WI up to 40 DAS	1780	36.2	17800	7460	0.72
T ₁₂ - WI up to 50 DAS	1724	35.6	17240	7400	0.75
T ₁₃ - WI up to 60 DAS	1692	35.2	16920	7580	0.81
T ₁₄ - Unweeded check	1652	35.4	16520	8580	1.08
SEm+	63.98	0.782	612.413	407.422	0.032
CD (P=0.05)	186	NS	1776	1185	0.09

WFC = Weed free condition; WI = Weed interference

References

- Krishna Gowda, K.T., Muniappa, T.V. and Venkataramu, M.N. 1985. Weed control in sunflower through mechanical, chemical and cultural methods. *Indian Journal of Weed Science*, 17(4): 49-51.
- Rakesh Kumar, Sharma, O.L., Dhaka O.P., Ram, T. and Kumar, R. 1996. Effect of weed control treatments on quality of sunflower (*Helianthus annuus* L). *Annals of Biology*, 12 (2): 227-271.

- Suresh, G. and Venkat Reddy, N. 1995. Integrated weed management in sunflower. *Journal of Research, APAU*, 23(1): 34-35.
- Tripathi, S.S. and Vivek. 2001. Critical period of weed competition in spring sunflower. *Indian Journal of Weed Science*, 33 (3&4): 212-214.
- Wanjari, R.H., Yaduraju, N.T. and Ahuja, K.N. 2001. Critical period of crop weed competition in rainy season sunflower. *Indian Journal of Agronomy*, 46(2): 309-313.

Evaluation of sunflower genotypes for stem borer, *Nupserha* sp. near *vexator* (Pascoe) resistance

B.V. Patil and K.S. Shinde

Oilseeds Research Station, Marathwada Agricultural University, Parbhani-431 402, MS

(Received: April, 2008; Revised: September, 2008; Accepted: February, 2009)

Abstract

Thirteen entries of sunflower were found resistant to the incidence of stem borer, *Nupserha* sp. near *vexator* (Pascoe).

Keywords: Stem borer, sunflower, resistant

In recent years stem borer, *Nupserha* sp. near *vexator* (Pascoe) emerged as a new and regular pest of sunflower in Marathwada region of Maharashtra. Around 228 genotypes were screened during 2002-06 to identify the source of resistance for stem borer in sunflower. Pest incidence varied from 5.0 to 66.0% in the genotypes under investigation during last five years indicating the presence of adequate variability in the material for their repose to stem borer infestation. None of the entry showed zero reaction against stem borer.

Sunflower (*Helianthus annuus* L.) is the fourth important oilseed crop in the world next to soybean, groundnut and rapeseed. In India, sunflower occupied an area of 2.1 m.ha with a production of 1.2 m.t. and a productivity of 566 kg/ha during 2004-05 (Anonymous, 2006). Recently sunflower cultivation in Marathwada region, Maharashtra is threatened by a new pest, stem borer. The stem borer appeared on sunflower at Latur (Marathwada) for the first time in India in 1993. It is a *Nupserha* sp. near *vexator* (Pascoe) a Coleopterous grub belongs to Family: Cerambycidae: Lamiinae. The stem borer incidence in farmer's field in July sown crop was 42-55% while 20-25% incidence was recorded in August sown sunflower during pest survey in Marathwada region. During grain formation stage there is lodging of infested plants. It ultimately resulted in the poor grain feeling and loss in yields to the extent 17.5%. Control of stem borer is difficult because the insect spent its most of life inside plant stems, where it is protected from standard chemical control (Phillip *et al.*, 1996). Hence, the screening work of sunflower genotypes was conducted during last five years to identify the resistant sources against stem borer for further exploitation.

A set of genotypes of Initial Advanced Varietals Trial (IAVT), Initial Hybrid Trial (IHT) and Advanced Hybrid Trial (AHT) from all India coordinated research project on sunflower was received every year during 2002-06 to evaluate the source of resistance for major pests of sunflower. The screening work has been undertaken at

Oilseeds Research Station, Latur, Maharashtra which was identified as a hot spot for stem borer in sunflower. Total 228 genotype lines were screened in field condition during last five years. A set of genotype test lines were sown every year in *kharif* season (July-August) in a single row of 4.2 m length replicated thrice adopting spacing 60 x 30 cm. All the recommended agronomic practices were followed. The observations were recorded at the time of harvesting through stem cutting at the collar region. The percent incidence was worked out on the basis of no. of plants infested in each test line with *N. vexator*. Reactions received from genotypes against *N. vexator* are categorized for ease in evaluation of resistance potential of each test line. The lines showed zero reaction against *N. vexator* is categorized as immune, incidence recorded <10% are resistant (R), < 20% are moderately resistant (MR), < 30% are tolerant (T), >30 are susceptible (S) and >40 are highly susceptible (HS).

The reactions of test lines revealed that out of 55 genotypes screened under field conditions during *kharif*, 2002, only NDSH-357 was found resistant (R) whereas 11 lines were moderately resistant (MR), 20 were tolerant (T), 17 were susceptible (S) and 6 lines showed highly susceptible (HS) reactions. In a succeeding year *kharif*, 2003, 54 lines were tested against *N. vexator* among them 3 lines emerged as R, 9 as MR, 27 recorded T reactions whereas 13 were susceptible. Two lines had more than 40% incidence and thus represented HS category. The incidence of *N. vexator* was high to the extent of 66% (DRSH-103) during *kharif*, 2004. Of the 42 lines, only TNAUSUF-239 exhibited R reaction and three more lines were MR. Tolerant category was represented by 15 lines. High incidence (>40%) recorded in 17 entries. Evaluation report of *kharif*, 2005 indicated that no entry was found R however 4 lines were MR along with check KBSH-44 and 12 reacted as T while 10 genotypes exhibited the S category. Since the average incidence was low during *kharif*, 2006 (HySun-3389, 37.0%) maximum entries out of 34 emerged as an R, MR and T i.e., 8, 17 and 10, respectively. Only two entries crossed the incidence >30% among them DRSF-108 was check. The over all performance of 228 genotypes screened during last five years revealed that no entry showed zero reaction to *N. vexator* however 13 lines were R, 44 were MR, 84 were T, 54 were S where as 33 recorded HS reactions.

Table 1 Screening of sunflower genotypes against stem borer, *N. vexator*

Level of resistance/ Incidence (%)	Season and Year of screening				
	Kharif, 2002	Kharif, 2003	Kharif, 2004	Kharif, 2005	Kharif, 2006
A	B	C	D	E	F
Immune (0 %)	-	-	-	-	-
Resistant ® (<10%)	NDSH-357	NJSFH-145, K-678, S-3741	TNAUSUF-239	-	LSF-300, RSFV-901-1, DRSF-119, DKSH-105, KBSH-56, Bisco-210, NSH-391, ARSH-496
Moderately Resistant (MR) (<20%)	GAUSUF-18, Morden-2-P, LS-15, S-309, NDSH-407, Konark-1, DSH-21, Pro-011, XF-5914, Sunbred-275 & Kaveri-415	LSF-6, DRSF-113 & 110, TAS-82-1/3, Pro-013, NSSH-303, UAS (B) SH-1, Pro-008, S-275.	SSH-6262, 65A41, SF-204	Sunbred Atul, NDSH-596, KPSH-44®, K-583	SS-2038, LSF-I-28, GAUSUF-12, DRSF-118, BISCO-209, DRSF-405, KBSH-55, KSFH-437, CSFH-5195, KBSH-44®, LSFH-05-36, PKVSH-58, PAC-361, KSFH-446, PAC-1091®, MDSFH-404 & K-662
Tolerant (T) (<30%)	TNAUSUF-215, DRSF-112, 110 & 108, LSF-8, PCSP-7, MSSH-96, PSH-30, XF-4132, Nimkar-4126, TWCH-01-02, SCH-01-26, PAC-32032, VSFH-180, PAC-39004, PRO-009, PAC-39007, MSFH-17®, SH-416 & SH-323	TNAUSUF-7®, PCSP-7, LSF-153-I, GAUSUF-12, Morden®, BS-3304, Mahabeej-502, AASFH-18, PAC-1090®, 64A43, MLSFH-93, Sunbred-2077, NDH-421, MSFH-17®, GK-2012, LSFH-01-08, VSFH-18, SSFH-124, SSH-6239, PAC-309, KBSH-44®, PAC-32032, SH-491, GAUSUF-15®, PAC-31007, PRO-011 & XF-5914	Morden®, LSF-11-8, GAUSUF-12, Sunbred-15908, NSFH-702, VSFH-44, KBSH-53, ARSFH-888, PSH-6259, 64A43, Kaveri-6678, KBSH-44®	GAU-15, SS-2038, DRSF-119, DRSF-108, DRSF-306, RSFH-130, CSFH-1001 & 1002, KJSFH-238, DRSF-279 & 104, K-678	Morden®, Sunbred-19012, 64S 99, Sunbred-00997, JK-Chitra, Pro-016, BSFH-4, KHS-2010 & 2030, JKSFH-238
Susceptible (S) (>30%)	DRSF-111, RSFV-5, TNAUSUF-214, DRSF-109, PCSP-5, PRO-008, Sunbred-202, MRSF-1756, Mahabeej-500, JKSH-268, SSFH-1005, NJSH-1215, PBSFH-1136, Monsanto-491, PM-512, KBSH-1®, MPL-77	LSF-16, JKSFH-102, Sel. Shakti, DRSF-102, PBSH-216, LSFH-01-36, MRSF-1056, KBSH-1®, Nimkar-31, BIO-92073, SH-483, SSFH-1005 & XF-4132	DRSF-116, PUSAUDAI, SUPER-90, KBSH-54, Kaveri-3366, ASH-100, DRSF-207, PAC-1091®, XF-4132 & KBSH-1®, ARSH-407, TAS-82	DRSF-113 & 118, LSFH-I-28, LSF-IV-3-I, UAS(B)-05, NSH-23, PAC-10-91®, LSFH-04-83273, Narmada-45, KPSH-1®	HY-Suflower-3389, DRSF-108®
Highly susceptible (HS) (>40%)	Morden®, GAUSUF-15®, MLSFH-90, VSFH-1006, RSFH-27, MLSFH-85	DRSF-114, DRSF-115	DRSF-113, RSFV-901, TNAUSUF-7®, DRSF-108®, LSF-IV-55, GAUSUF-15®, NSH-16, NDSH-608, Surya-444, DRSF-103, US-903, LSFH-1016, MLSFH-93, LSFH-02-18, Sunbred-2077, SSFH-1005 & SH-491	LSF-158-338, TNAUSUF-7®, GAUSUF-12, DRSF-114, LSFH-03-182, Sunbred-2077, NSH-303, MLSFH-93	

References

Anonymous. 2006. *Strategies for Enhancing Sunflower Production in India*. DOR, Hyderabad. p.1.

Management of wilt, *Fusarium oxysporum* f.sp. *ricini* disease in castor through seed treatment in Rajasthan

T.S. Rajpurohit and S.S. Solanki

Agricultural Research Station, Rajasthan Agricultural University, Mandor-342 304, Jodhpur, Rajasthan

(Received: June, 2006; Revised: December, 2008; Accepted: February, 2009)

Abstract

Seed treatment with carbendazim 50 WP @ 2 g/kg seed was effective for the management of wilt disease in castor.

Keywords: Castor, wilt, seed treatment

Castor, *Ricinus communis* L. is one of the most important non-edible and industrial oilseed crop cultivated mainly in India. The crop suffers due to the attack of many seed and soil borne diseases of which *Fusarium* wilt is the major disease of castor. In India, Nanda and Prasad (1974) first reported *Fusarium* wilt from Udaipur and Sirohi districts of Rajasthan state. Castor wilt caused by *Fusarium oxysporum* f.sp. *ricini* is also transmitted through seed. The pathogen was detected in testa, tegument and endosperm of seeds from infected plant to an extent of 2-19% (Raoof *et al.*, 1990). Disease is spreading in all the castor cultivation areas of Gujarat and Rajasthan mainly due to mono cropping of castor. The management of disease can be done through chemical treatment of soil and seed treatment, of which soil application has been reported to be cause hazardous effect in soil and water, death of non-target beneficial flora, uneconomical and unadvisable due to possible resistance development by pathogen (Naik, 2003). The seed borne infection of *Fusarium oxysporum* f.sp. *ricini* from castor seeds can be eradicated by treating the seed with fungicidal seed treatments (Siddaramaiah *et al.*, 1980; Naik, 1994 and

Dange, 2003). In Rajasthan, the disease is spreading in new areas in soil by seeds, hence, the experiment was conducted to find out effective control through seed treatments. A field experiment was conducted in wilt sick soil at Agricultural Research Station, Mandor, Jodhpur during *kharif*, 2003 and 2004 in a Randomized Block Design with three replications. The wilt susceptible castor pistillate line VP-1 was used as the experimental material. The spacing of 60 x 30 cm was maintained with 6 x 3.6 m² net plot size. Six fungicides were tested as seed dresser for the management of wilt disease (Table 1). Observations on number of plants infected with wilt disease and healthy plants on each treatment were recorded upto 60 DAS. Wilt incidence was calculated as per Raoof and Rama Bhadraraju (2005). Two years study revealed that maximum incidence (34.41%) was recorded in untreated control as against the lowest of 10.86% in carbendazim 50 WP @ 2 g/kg seed followed by thiram 0.3% and captan 0.3%. Siddaramaiah *et al.* (1980) reported that seed borne infection of wilt from castor seeds can be controlled by treating the seeds with agallol and thiram @ 3 g/kg seed but in present study, thiram was found less effective than carbendazim seed treatment. Seed treatment with carbendazim has been recommended by Naik (1994) against seed infection of castor wilt which supports present finding. Therefore, seed treatment with carbendazim 50 WP @ 2 g/kg seed is effective in reducing wilt incidence in castor.

Table 1 Management of wilt disease in castor through seed treatment

Treatment	Wilt incidence (%)			Disease control (%)
	Kharif 2003	Kharif 2004	Mean	
Carbendazim 50 WP 0.2%	11.3 (19.59)*	10.43 (18.82)*	10.86	68.43
Thiram 0.3%	15.49 (23.16)	14.86 (22.66)	15.17	55.91
Mancozeb 0.2%	20.09 (26.62)	21.94 (27.93)	21.01	38.94
Captan 0.3%	16.28 (23.80)	14.82 (22.63)	15.55	54.80
Apron 35 SD 0.2%	19.79 (26.39)	19.82 (26.43)	19.80	42.45
Chlorothalonil 0.2%	21.67 (27.69)	24.52 (29.68)	23.09	32.89
Control	36.04 (36.85)	32.79 (34.90)	34.41	-
SEm±	0.88	0.74		
SD (P=0.05)	2.66	2.21		
CV (%)	6.78	5.68		

* Angular transformed values

References

- Dange, S.R.S. 2003. Wilt of castor - An over view. *Journal of Mycology and Plant Pathology*, **33**(3) : 333-339.
- Naik, M.K. 1994. Seed borne nature of fusarium in castor. *Indian Journal of Mycology and Plant Pathology*, **24** : 62-63.
- Naik, M.K. 2003. Challenges and opportunity for research in soil borne plant pathogens with special reference to fusarium species. *Journal of Mycology and Plant Pathology*, **33**(1) : 1-14.
- Nanda, S. and Prasad, N. 1974. Wilt of castor - A new record. *Indian Journal of Mycology and Plant Pathology*, **4** : 103-105.
- Raoof, M.A., Naik, M.K. and Appaji, S. 1990. Current status of castor wilt in Andhra Pradesh. *Plant Disease Research*, **7** : 244.
- Raoof, M.A. and Rama Bhadraraju, M. 2005. Management of castor wilt, *Fusarium oxysporum* f.sp. *ricini* through crop rotation. *Journal of Oilseeds Research*, **22**(2) : 429-430.
- Siddaramaiah, A.L., Desai, S.A. and Hegde, R.K. 1980. Seed mycoflora of castor and its control. *Mysore Journal of Agricultural Sciences*, **14** : 500-502.

Short communication

Assessment of improved technology in castor, *Ricinus communis* L. on farmer's fields

P.M. Vaghasia and R.H. Kavani

Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh, Gujarat

(Received: December, 2006; Revised: January, 2009; Accepted: February, 2009)

Abstract

Five years studies revealed that on an average castor yield in frontline demonstrations was 17% more than farmer's practice. Highest technological gap (3264 kg/ha) was found in variety GCH-6. In each year extension gap was lower than technology gap, so there is need to educate farmers in adoption of improved technology.

Keywords: Castor, *Ricinus communis*, extension gap, technology gap

In India castor is mainly grown in Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka and Orissa states, accounting for about 90% of the area and production. Gujarat ranks the first in area and production with 2.91 lakh ha producing about 5.41 lakh tonnes of seed annually along with an average productivity of 1864 kg/ha (Damodaram and Hegde, 2005). The general productivity level of rainfed castor in all other parts of the country is very low. A multitude of factors such as its cultivation in sub-marginal and marginal lands, uncertainty of rainfall and its erratic distribution, delayed sowings, poor management of the crop with little or no inputs and use of poor quality seed are responsible for low yields under rainfed situations. Keeping in view the significance of transfer of technology, the present investigation attempts to know the yield gaps between FLD and farmers' field, extent of technology adoption and monetary benefits.

The current study was conducted for 5 years i.e., 2001-02 through 2005-06 in the Saurashtra region of Gujarat state. Soils of the region are medium black with pH ranging from 7.5 to 8.9. The farmers selected were mainly of irrigated

farm situation. The cross-sectional data on output of castor, input used per ha have been collected from the frontline demonstrations. In addition to this, data on traditional practices followed by farmers have also been collected. Technology gap, extension gap and technology index were calculated as per standard methods.

The yield enhancement ranged from 14 to 28% (Table 1). By and large, in all the years, yield of demonstration plot was higher as compared to local check, which was due to timely sowing of crop with recommended hybrids and fertilizer management. Technology gap was found higher (3264 kg/ha) in GCH-6 than GCH-4. Prasad *et al.* (1993) reported the similar kind of results in oilseeds and pulse crops. The technology gap remained higher than extension gap during all the five years, which show that there is vast scope to further exploit the potential yield of the crop. Extension gap varied from 334 to 697 kg/ha, indicating there by the need to educate the farmers for adoption of improved technology. Technology index in castor varied from 35 to 54% during all the five years. This indicated that wide gap existed between technology generated and technology adopted at farmer's field level. Similar finding were also reported by Kadian *et al.* (1997).

Economic: The production cost of frontline demonstration plots was a little higher than the farmer's plot in all the years (Table 2). Highest B:C ratio on additional input (18) was recorded in 2002-03 followed by (15) 2001-02. The lowest B:C ratio (10) was recorded during year 2005-06, this may be due to increased in labour and input cost in the year 2005-06 (Table 2). The studies are in line with the findings of Sharma and Kushwah (2001).

Table 1 Production potentials of improved technologies in castor during 2001-02 to 2005-06

Year	Hybrid	No. of FLDs	Area (ha)	Average yield (kg/ha)		Increase in yield (%)	Technological gap (kg/ha)	Extension gap (kg/ha)	Technology index (%)
				I.T.	F.P.				
2001-02	GCH-6	7	2.8	3125	2455	28	2848	697	47
2002-03	GCH-6	10	4.0	2736	2402	14	3264	334	54
2003-04	GCH-6	8	3.2	2917	2499	17	3083	418	51
2004-05	GCH-6	9	3.6	3141	2758	14	2859	383	48
2005-06	GCH-4	9	3.6	3569	3139	14	1931	430	35
Mean	-	-	-	3103	2651	17	-	-	-

Table 2 Economic viability and profitability of FLD (Rs/ha)

Particulars	Years					Mean
	2001-02	2002-03	2003-04	2004-05	2005-06	
Production cost						
Improved Technology	10643	12745	16670	16458	16389	14581
Farmers' Practice	10228	12528	16130	15996	15759	14128
Gross return						
Improved Technology	26643	66701	83078	50250	51707	55675
Farmers' Practice	20571	62739	77155	44125	45403	49998
Net return						
Improved Technology	16000	53956	66408	33792	35318	41095
Farmers' Practice	10343	50211	61025	28129	29644	35870
Increase in net return(%)	55	7	9	20	19	22
B:C ratio on additional input in demonstration	15	18	11	13	10	13

From the forgoing it could be inferred that the technology gap in castor has been always wider than extension gap, suggesting to bridge the same through well organized demonstrations to harvest the potential yields of castor under real farm situation in Gujarat.

References

- Damodaram, T. and Hegde, D.M. 2005. *Oilseeds Situation: A Statistical Compendium*. Directorate of Oilseeds Research, Rajendranagar, Hyderabad, Andhra Pradesh.
- Kadian, K.S., Sharma, Ravinder and Sharma, A.K. 1997. Evaluation of frontline demonstration trials on oilseeds in Kangra Valley of Himachal Pradesh. *Annals of Agricultural Research*, 18(1):40-43.
- Prasad Eswara, Y., Rao Manohar, M. and Vijayabhinandana, B. 1993. Analysis of on-farm trails on and level of technology on oilseeds and pulse crop in Northern Telangana zone of Andhra Pradesh. *Indian Journal of Agricultural Economics*, 48:351-356.
- Sharma, R.P. and Kushwah, S.S. 2001. Evaluation of frontline demonstration trails in Rajgadh district of Madhya Pradesh. *Agricultural Science Digest*, 21(3):183-185.

Impact of frontline demonstrations of improved safflower technologies in northern dry zone of Karnataka

M.M. Nekar, V.S. Kubsad and V. Rudranayak

AICRP (Safflower), Agricultural Research Station, Annigeri-582 201, Karnataka

(Received: May, 2007; Revised: November, 2008; Accepted: February, 2009)

Abstract

Recommended variety A-1 and hybrid, DSH-12 of safflower gave higher seed yield over local checks in northern dry zone of Karnataka.

Keywords: Frontline demonstrations, safflower

Safflower is an important *rabi* oilseed crop in Karnataka grown on receding soil moisture conditions under low inputs management. Acreage under this crop is coming down every year may be due to its spiny nature which leads to difficulty in harvest and processing. India occupies first place in the world of 4.0 lakh ha and production of 2.2 lakh tonnes (Anonymous, 2005-06). Average yield level in Karnataka is around 432 kg/ha (Anonymous, 2005). Lower yield level of this crop may be due to growing with traditional practices. The maximum yield potential of safflower can be realized by adopting suitable agronomic practices like use of promising genotypes, optimum fertilizers dose, timely sowing and maintaining plant density (Sakir and Basalma, 2005), using need-based, timely and proper dose of plant protection chemicals. In order to realize the impact of improved technologies, a series of demonstration were laid out over eight years under ICAR sponsored project of frontline demonstrations. By that farmer can adopt the improved methods of technologies so as to get higher level of quantity and quality of yield. Rest of the farmers encouraged and adopt by observing and watching (Kamboj et al., 2004) the live demonstration of the technology in his neighbor farmer field.

Agricultural Research Station, Annigeri is located in northern dry zone (Zone-III) of Karnataka with deep black soils. The average (31 years) rainfall of the area is 642.5 mm, out of which about 65% of the rainfall was received during *rabi* season. Various frontline demonstrations were laid out during *rabi* season of 1996 and 1999 to 2005 on an area of 0.40 ha. each for improved and farmers under rainfed situation. The demonstrations were taken in and around Annigeri Hubli, Dharwad and Belgaum districts of Karnataka where *rabi* cropping is common. There were 12 intercropping systems (3:1 row proportion), 18 sole safflower with full package, and nine sole safflower with

need-based plant protection chemicals against pest (Aphids and *Helicoverpa*) and diseases (leaf spots) and 10 sole safflower with recommended dose of fertilizers. Improved methods included the cultivation of certified A-1 variety, spineless variety (NARI-6), hybrid (DSH-12-9), recommended dose of fertilizers (40-40-20) NPK kg/ha, seed rate (12.5 kg/ha), seed treatment with fungicide (Captan @ 2g/kg seeds). In local method, the farmers were allowed to follow their traditional cultivation practices. The yields of the crops were recorded from local and improved practices and economics of each of the practices were calculated.

The certified spiny variety, A-1, released during 1949, is high yielder (1200 kg/ha) and oil content (28.7%), seeds are medium and bold in size and appearance.

The NARI-6 variety is spineless and high yielder and requires one or two irrigations. Safflower hybrid DSH-12-9 demonstrated due to its higher yield capabilities.

The intercropping system in safflower was demonstrated due its various advantages like efficient utilization of space, light, moisture and nutrients, additional to this farmer can get the income if any one of the crop may fail.

Safflower with full package v/s farmers practice: This technology was demonstrated to show the farmers the response of full package, viz., seed rate, FYM application, recommended fertilizer doses, timely application of pesticides, etc., in comparison to farmer's practice of safflower cultivation.

Sole safflower with plant protection chemicals (PPC's) v/s local practice : The demonstration was taken to show how the importance of pesticides, their timely application, accurate doses, etc., were important in controlling pests and diseases to maximize the yields.

Sole safflower with RDF v/s farmers practice: The technology was demonstrated to show how the different nutrients are required in specific quantity and timely application for getting high yields in safflower.

Performance of different *rabi* crops: To know the performance and net returns of different *rabi* crops three commonly growing *rabi* crops were demonstrated.

Intercropping of safflower with wheat and bengal gram: The row proportion of 3:1 against sole cropping was tested for six years during 1996 and 2000 to 2004. Higher net returns of Rs. 4400/ha (Table.1) was recorded by wheat + safflower compared to bengal gram + safflower (Rs. 2059/ha) intercropping system due to lower cost of cultivation and higher yield of wheat crop (679 kg/ha) compared to bengal gram (386 kg/ha) although bengalgram fetches higher market price than wheat. Whereas per cent increase in returns compared to farmers practice was higher in bengalgram + safflower (53%) intercropping system compared to wheat + safflower (43%). The higher B:C ratio (1.81) was recorded in wheat + safflower system compared to bengalgram + safflower (1.31).

Production potentials of improved practices of safflower: Safflower is traditionally grown on marginal lands without fertilizers or plant protection chemicals under residual moisture conditions. In the event of delayed sowing after the harvest of early duration leguminous crops in *kharif*, safflower suffers both from moisture availability at a grain filling stage and aphids incidence which drastically reduce the crop yields. The crop is totally neglected in its production where minimum care such as optimum date of sowing, thinning weeding, etc., were not attended leading to severe stress by both biotic and abiotic factors. Therefore a package was worked out under research conditions including all the seed based inputs to realize the maximum production potential of the crop. This technology was carried in farmer's field to assess the degree of effectiveness (Dattatri *et al.*, 2000;

Billore *et al.*, 2004). The sole safflower with full package (Table. 2) recorded the highest net returns (Rs. 1419/ha), B:C ratio of 1.29 and 99% increase in returns over farmer's practice. The farmer's practice recorded the lowest net returns (Rs. 21/ha) and least benefit cost ratio of 1.00. This may be due to use of recommended package compared to local practice. Application of plant protection chemicals (PPC's) increase in yield by 16% and net income by 38% over local practice and higher B:C ratio of 1.35 was recorded in treated plot compared to farmers practice (1.24). This shows use of one or two need based plant protection chemicals practice helps in maximizing yields and income.

The recommended dose of fertilizer plots recorded higher seed yield of 761 kg/ha compared to local practice (644 kg/ha) and increased 15% in grain yield and also recorded higher B:C ratio (1.47) compared to local practice (1.35). Application of recommended dose of fertilizers increased the net return income by 31% over farmers practice.

Recommended A-1 (Table 3) variety recorded higher seed yield (697 kg/ha) over local variety (534 kg/ha) which adds to 23% increased in yields. The A-1 variety recorded higher B:C ratio (1.33) compared to local variety and recorded 90% higher returns (Rs. 1901/ha) over local practice (Rs. 183/ha). Similarly comparison of hybrids with local variety, hybrid DSH-129 recorded 22% higher safflower yields (605 kg/ha) over local variety (470 kg/ha). The hybrid safflower recorded higher B:C ratio of 1.06 over local practice (0.82). This hybrid adds 410% increase in returns over local variety. The higher net returns of hybrid due to higher yield of hybrid.

Table 1 Results of intercropping systems of safflower (mean over 4 years)

Cropping system	No. of demonstrations	Grain yield (kg/ha)			Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	% increase in returns over local practice	B:C ratio
		Intercropping system							
		Main crop	Inter crop	Sole crop					
Wheat + Safflower [3:1RP] v/s sole wheat	6	679	236	669	5420	9820	4400	43	1.81
-	-	-	-	-	5108	7614	2506	-	1.50
Bengalgram+ Safflower [3:1 RP] v/s sole Bengalgram	6	386	266	561	6572	8631	2059	53	1.31
-	-	-	-	-	6364	7325	961	-	1.15

RP = Row proportion

Table 2 Production potentials of improved technologies of safflower (mean over 4 years)

Type of demonstration	No. of demonstrations	Grain yield (kg/ha)	% increase in yield over local practice	Total cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	% increase in returns over local practice	B:C ratio
Sole safflower with full package v/s Farmers' practice	18	520	19	4880	6299	1419	99	1.29
-	-	423	-	4789	4810	21	-	1.00
Sole safflower with PPC v/s Farmers' practice	9	689	16	5688	7654	1966	38	1.35
-	-	581	-	5067	6293	1227	-	1.24
Sole safflower with RDF v/s Farmers' practice	10	761	15	5743	8424	2681	31	1.47
-	-	644	-	5328	7182	1854	-	1.35

PPC = Plant protection chemicals; RDF = Recommended dose of fertilizer

Performance of non-spiny NARI-1 variety compared with local variety and A-1 variety of safflower. NARI-6 recorded lower yield (619 kg/ha) compared to local variety (663 kg/ha), thus reduced by 7% in yields and the local variety recorded higher B:C ratio of 1.74 compared to NARI-6 (1.55) and 33% reduction in net returns by NARI-6 compared to local variety. The variety A-1 recorded higher seed yield of safflower (882 kg/ha) compared to NARI-6 (798 kg/ha) and increased in yields by 11% compared to A-1. The variety A-1 recorded higher B:C ratio (1.54) compared to NARI-6 (1.34). NARI-6 recorded lower yields and net return may be attributed to the non-spiny nature made the crop to susceptibility to pest, disease, birds and natural enemies. The varieties and hybrids were tested against local variety, the recommend variety A -1 and hybrid recorded higher net returns and B:C ratio compared to local variety. However, the NARI-6 performance was poor compared to either recommended A -1 variety or with local cultivar as the returns were lesser than local practices.

Comparative performance of safflower with other rabi crops: In the past, farmers would cultivate safflower variety as a mixed or border crop. Thus the potential of this crop was not realized and its cultivation was

considered to be uneconomical. In order to identify its full potential, safflower was grown in comparison with the other rabi crops, such as wheat and bengal gram with full package. The frontline demonstrations of this crop and the results indicated to ensure the remunerativeness (Table 4) of this crop and the results indicated that sole safflower recorded higher grain yield (1936 kg/ha), net return (Rs. 19695/ha) and B:C ratio (4.60) compared to bengalgram (1028 kg/ha, Rs. 13594/ha and 3.10 respectively) and wheat (1736 kg/ha, Rs. 13,888/ha and 2.31). Safflower recorded higher per cent of net returns (60) compared to bengalgram (42) may be attributed to higher cost of cultivation of bengalgram (Rs. 6483/ha) compared to safflower (Rs. 5473/ha).

Impact of the technology: After realizing the benefit of the improved technologies over the traditional practices 40-50% of the farmers are adopting the cultivation of entire safflower, while 50% of them have adopted the intercropping system in 3:1 row proportion in the safflower growing region. The potential of the safflower crop can still be increased by developing non-spiny, high yielding varieties/hybrids and the value added products such as utilization of safflower stalks and dry florets to improve the net income of the farmers.

Table 3 Production potentials of improved varieties of safflower (mean over 4 years)

Type of demonstration	No. of demonstrations	Grain yield (kg/ha)	% increase in yield over local practice	Total cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	% increase in returns over local practice	B:C ratio
Recommended variety A-1	27	697	23	5777	7678	1901	90	1.33
v/s local variety	-	534	-	5614	5797	183	-	1.03
Non-spiny variety NARI-6	33	619	-7	5472	8463	2991	-33	1.55
v/s local variety	-	663	-	5330	9262	3932	-	1.74
Non-spiny variety NARI-6	2	798	-11	6268	8404	2136	-17	1.34
v/s recommended variety A-1	-	882	-	6023	8289	3266	-	1.54
Hybrid safflower	2	605	22	5579	5890	311	410	1.06
v/s local variety	-	470	-	5453	4500	-953	-	0.82

Table 4 Comparative performance of safflower with other rabi crops (mean over 4 years)

Type of demonstration	No. of demonstrations	Grain yield (kg/ha)	Total cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	% increase in returns over local practice	B:C ratio
Sole safflower	5	1936	5473	25168	19695	60	4.60
Sole wheat	5	1736	6022	13888	7866	-	2.31
Sole bengalgram	5	1028	6483	20077	13594	42	3.10

References

- Anonymous. 2005-06. *Annual Progress Report*. Directorate of Oil seeds Research, Rajendranagar, Hyderabad. pp: 92-93.
- Anonymous. 2005. *Oilseed Situation - A Statistical Compendium, 2005*. Directorate of Oilseed Research, Hyderabad, pp.270.
- Billore, S.D., Joshi, O.P. and Dupraque, B.U. 2004. Impact of frontline demonstrations on augmenting the soybean (*Glycine max* L.) productivity. *Journal of Oilseeds Research*, 21 (2): 352-353.
- Dattatri, K., Sudhakar, N., Reddy, K.M. and Reddy, G.R. 2000. Performance of rabi sesamum under front line demonstrations in Andhra Pradesh. *Indian Journal of Dryland Agricultural Research and Development*, 15(2): 163-165.
- Kamboj, B.R., Yadav, D.B. and Rajbir-Garg. 2004. Assessment of technology gap and productivity gain through frontline demonstrations in toria (*Brassica campestris* var. Toria) at farmer's field. *Haryana Journal of Agronomy*, 20(1/2): 49-52.
- Sakir, S. and Basalma, D. 2005. The effect of sowing time on yield and yield components of some safflower (*Carthamus tinctorius* L.) cultivars and lines. *Proceedings of Sixth International Safflower Conference*, pp.147-153.

Induction of chlorophyll, plant types, floral and leaf mutations using gamma rays and EMS in niger, *Guzotia abyssinica* Cass.

Premjyoti C. Patil, S. Gangaprasad and R.L. Ravikumar and P.M. Salimath

Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad, Karnataka

(Received: May, 2007; Revised: January, 2009; Accepted: February, 2009)

Abstract

The studies suggested that the combination of both gamma rays (30 kR) and EMS (0.6%) may be used to isolate most productive recombinants with diseased plant type in niger.

Keywords: Niger, *Guzotia abyssinica*, chlorophyll, EMS
Niger (*Guzotia abyssinica* Cass) is an important traditional oilseed crop of India with an area 1 lakh ha with a production of 3.9 lakh tonnes and productivity of 320 kg/ha. Though many improved varieties are developed in niger, but all of them representing the same plant type. Traditional varieties when grown in slightly fertile soils or when provided better management practices they tend to become indeterminate, multi-branched growth habit with large number of small capitula, excessive vegetative growth and late maturity. Any further improvement in existing yield levels of niger has to come necessarily from restructuring of plant type in a way that they become more responsive to better management practices as happened in other crops: sunflower, soybean and castor. Mutation breeding has immense scope for genetic enhancement of various qualitative and quantitative characters besides widening the genetic base. In the present study, an attempt has been made to ascertain the extent of genetic variability that can be generated by employing both physical and chemical mutagens in two genotypes viz., N-71 and IGP-76.

Two varieties of niger N-71 released by University of Agricultural Sciences, Bangalore and IGP-76 released at national level were selected for mutagenic treatment. The two mutagens viz., Gamma rays (^{60}Co) and Ethyl Methane Sulphonate (EMS) were used in the study. The dry seeds were exposed to five dose of gamma rays (^{60}Co) 24, 26, 28, 30, 32 kilo rads (kr). EMS concentrations used for treating the seeds were 0.3, 0.5 and 0.6% for eight hours. Prior to EMS treatment, the seeds were pre-soaked in distilled water for fourteen hours to initiate physiological activities in their embryo. The EMS solution was prepared in distilled water and the seeds were soaked in freshly prepared solutions of the mutagen for eight hours at room temperature. The treated seeds were washed thoroughly in running water and were used for sowing immediately.

Treated seeds were sown on July 2005 (*kharif*) with spacing of 30 cm between rows and 10 cm between seeds. The untreated seeds served as control. All treated populations consisting of 400 plants along with control were raised.

Germination: The germination percentage decreased with increase in the dose of the treatment. Among EMS treatments, lowest germination (52.1%) was at 0.6% in N-71. Arslan *et al.* (2001) reported in sunflower that radiation induced meiotic abnormalities and the percentage frequencies of abnormalities increased generally with increasing dose of radiation.

Survival: Both gamma irradiation and EMS treatments were effective in reducing the survival in both the genotypes. Both N-71 and IGP 76 had lowest (50.0%) survival when treated with 0.6% EMS.

Pollen fertility: Pollen fertility is also affected due to mutagenic treatment. Pollen fertility was lowest (42.6%) in N-71 when treated with gamma irradiation at 32 kR. According to Arslan *et al.* (2001) in sunflower reported that, pollen fertility decreased due to meiotic abnormalities in both meiotic-I and meiotic-II, which was induced by the mutagens.

LD₅₀ for germination, survival and pollen fertility: The LD₅₀ values for germination, survival and pollen fertility were obtained based on Probit analysis. This indicated the LD₅₀ in case of gamma rays was in between 30-33 kR and in case of EMS it was in between 0.5 to 0.7 irrespective of genotypes. This is in agreement with the findings of Maloo and Agarwal (1995) in niger.

Morphological mutants: The frequencies of different morphological mutant observed are presented in Table 1.0

Chlorophyll mutants: Four types of chlorophyll mutants (maculata, xantha, chlorina, striata), were observed. Chlorophyll mutations (19%) were more when seeds treated by 30 kR

Leaf mutations: Two types of leaf mutants were identified, as bilobed and abnormal leaves. Maximum frequency of leaf mutants (30%) were induced by 0.6% EMS. Christov (1996) isolated new mutant forms in sunflower, which were

having different shape of leaves and these were inherited in further generations.

Plant type: Two kinds of plant type mutants were observed viz., basal branching and zig-zag stems. Gamma irradiation at 30 kr was able to induce maximum (5%) of plant type mutants. All such mutants were isolated by Veena (1997) in safflower.

Floral mutations: Two types of floral mutants were observed viz., *Fused calyx* and *joint capitula*. Maximum

frequency of floral mutants (8%) were noticed in the population treated by 0.6% EMS. Such floral mutants were observed by Christov (1996), Jambhulkar and Joshua (1999) in sunflower. Gamma rays at 30 kr and 0.6% EMS were able to induce mutations in niger. The combination of both gamma rays (30 kr) and EMS (0.6%) may be utilized to isolate most productive recombinants with desired plant type in niger.

Table 1 Frequencies of different morphological mutants observed in niger

Mutagen with dosage	Chlorophyll mutants (%)				Leaf shape mutants (%)		Plant type mutants (%)		Floral mutants	
	Maculata	Xantha	Chlorina	Striata	Bilobed	Abnormal shape	Zig-zag	Basal branching	Fused calyx	Joint capitula
Gamma 24 kr	-	-	-	-	-	-	-	-	-	-
Gamma 26 kr	-	-	-	-	-	-	-	-	-	-
Gamma 28 kr	-	1	3	1	2	-	2	1	-	2
Gamma 30 kr	1	1	2	-	-	3	2	1	-	-
Gamma 32 kr	1	-	-	2	-	5	3	2	-	1
EMS 0.3 %	3	1	1	8	7	11	1	-	-	-
EMS 0.5 %	7	-	2	4	9	14	3	1	4	-
EMS 0.6 %	9	1	3	6	13	17	3	1	7	-

References

- Arslan, O., Bal, S., Mirici, S. and Yenice, N. 2001. Meiotic studies in the M_2 generation of *Helianthus annuus* L. variety EK 121 after gamma irradiation. *Helia*, **14**(36): 33-38.
- Christov, M. 1996. A new sunflower mutant form. *Helia*, **19**(24): 39-46.
- Jambhulkar, S.J. and Joshua, D.C. 1999. Induction of plant injury, chimera, chlorophyll and morphological

mutations in sunflower using gamma rays. *Helia*, **22**(31): 63-74.

- Maloo, S.R. and Agarwal, P.K. 1995. Mutagenic effectiveness of EMS, MMS and gamma rays in niger. *Annals of Arid Zone*, **34**(4): 297-299.
- Veena, K.R. 1997. Character association studies in safflower and the effect of mutagens on F_0 seeds in altering character association. M.Sc.(Agri.) Thesis, University of Agricultural Sciences, Dharwad.

OBITUARY



Dr. Basappa Narasimha Reddy (Dr. B.N. Reddy),
Principal Scientist (Agronomy) passed away on March 22, 2009 after a brief illness. Born on July 3, 1952, Dr. B.N. Reddy joined ICAR service on January 10, 1978 as Scientist at DOR and rendered over 30 years of valuable service. Dr. Reddy also functioned as IMC Member of DOR and DRR, Hyderabad. Dr. Reddy was Life Member of ISOR and also acted as General Secretary, ISOR for two terms i.e., 1994-1995 and 2002-2003. The Indian Society of Oilseeds Research convey their heartfelt condolences to the bereaved family.

GUIDELINES TO THE CONTRIBUTORS

The contributions in the form of full papers and short communications, based on original research relating to basic and applied aspects of oilseed crops in the disciplines of Genetics and Plant Breeding, Biotechnology, Agronomy, Entomology, Plant Pathology, Crop Physiology, Soil Sciences, Chemistry, Biochemistry, Economics and Extension including post-harvest technology will be considered for publication in the **Journal of Oilseeds Research** only from members of the ISOR. The reviews on current topics and recent books will also be published. The articles submitted for publication must not contain data older than 5 years on the date of receipt of the article in the society office. The period shall be reckoned from the following January and July after the completion of the field experimentation in *kharif* and *rabi* seasons, respectively.

Manuscripts, in triplicate, neatly typed in double space on one side of the white paper (A4 size) can be submitted through the Registered Post to the **Chief Editor, Journal of Oilseeds Research, Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, Andhra Pradesh (India)**. The revised manuscript must accompany a CD (only CD is allowed) having article typed and saved in MS Word. Chief Editor can be contacted at e-mail: harvirn@gmail.com

The **Title** of the paper should be concise but self explanatory. A short running title should also be given. It should be followed by a list of authors (names and addresses). The manuscript of paper should clearly define aims and objectives of the study and include the relevant review of literature. **Material and methods** should be clear and to the point. In case of well known methods, only the reference will suffice. **Results and discussion** should preferably be combined to avoid repetition. Results should be written concisely. The data should be given only in metric system. Tables should be numbered in arabic numerals, typed on separate sheets with brief and self-explanatory titles. The data given in tables should not be repeated in figures. This should be followed by **Acknowledgements**, if any. The **References** should be arranged alphabetically by the name of the first author and then, if required, by the second and the third author and so on. The names of the journals must be full and in italics according to 'World List of Scientific Periodicals'. The number of references should be kept at minimum possible. These may be cited as below:

- Paper** : Vani, K.P. and Bheemaiah, G. 2004. Alley cropping and green leaf manures – effective means of integrated nutrient management for sustained returns of rainfed castor, *Ricinus communis* L. *Journal of Oilseeds Research*, **21**(1):73-77.
- Book** : Trenbath, T. 1986. Resource use by intercrops. In *Multiple Cropping Systems* (ed. Charles A. Francis). Macmillan Publishing Company, New York.
- Chapter** : Hanumantha Rao, C. and Chakrabarthy, S.K. 1997. Castor. In *Efficient management of dryland crops: Oilseeds* pp.257-272 (eds. R.P. Singh, P.S. Reddy and V. Kiresur) Indian Society of Oilseeds Research, Hyderabad.
- Thesis** : Satyanarayana, K.V. 2000. Genetic analysis of elite inbred lines using L x T design and modified TTC model in sunflower (*Helianthus annuus* L.). M.Sc. (Ag.) Thesis, Acharya N.G. Ranga Agricultural University, Hyderabad.

The citation of reference in the text should be as Prasad and Nath (1985) or (Prasad and Nath, 1985), depending upon the composition of the sentence. Two or more than two references cited jointly should be arranged alphabetically in ascending order of years of publication and distinguished from each other by semi-colon. More than two authors should be referred to by using *et al.* with the name of the first author. Complete scientific name of crop/organism with its authority must be given on its first mention.

Illustrations: Figures and photographs should be submitted in duplicate along with typewritten titles on separate sheet. Photographs should be on high quality glazed paper with good contrasts. The figures and photographs should fit in A4 size paper and must be included in the softcopy CD submitted along with the revised article.

Certificate that the papers submitted to the **Journal of Oilseeds Research** have not been submitted to any other journal for publication. The responsibility for duplication in publishing, a full paper or part of it in any other journal, lies entirely with the author(s). A certificate from Head of Department along with signature of all the authors indicating the years of work done and their consent to publish in Journal of Oilseeds Research should be sent along with the article.

The Editorial Board assumes no responsibility for the views and statements of the authors published in the Journal.

----> For style of papers, consult the recent issue <----

Note: CD containing the manuscript is a must along with revised article.

