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Genetic Analysis for Seed Cotton Yield and its Components in *Gossypium hirsutum*

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ABSTRACT : The generation means analysis of data of an intra *hirsutum* cross CAK-32 A x DHY-286-1-R revealed predominance of dominance and epistatic interactions in the genetic control of seed cotton yield, yield components and quality characters. Duplicate type of gene action was involved in the expression of all the characters, except days to maturity, seed cotton yield and sympodia where complementary type of gene action was involved. Bolls/plant and seed cotton yield exhibited high inbreeding depression while days to flowering, days to maturity, monopodia, plant height and micronaire value exhibited regulative inbreeding with F_2 mean higher than F_1.

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Triallel Analysis for Ginning Out Turn in Cotton (*Gossypium hirsutum* L.)

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ABSTRACT : Sixty, three-way cross hybrids produced by crossing six upland genotypes of cotton were tested in a randomized block design. The mean data on ginning out turn were analysed as per triallel analysis model. The character showed predominantly epistatic genetic variance. The magnitude of dominance x dominance type of epistasis was maximum as compared to additive gene effect. All the three-way cross hybrids showed invariable order effect for this character. The triplet in the order of (MCU 5 x TCH 1002) x MCU 7 had significant three line specific effect with high *per se* performance. When this order was changed as (MCU 5x MCU 7) x TCH 1002 and (MCU 7 x TCH 1002) x MCU 5, the t_{ijk} effect in these triplets was non-significant and negative in direction. Hence the order effect has to be decided well before attempting the multiple crosses. The parents *viz.,* TCH 1002 and SVPR 1 were observed as good general combiners being a grand parent. Whereas, parent Sharada was considered to be a good general combiner as immediate parent in three-way crosses for ginning out turn.

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Genotype-Environment Interaction Studies of Yield and Yield Components in Upland Cotton

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ABSTRACT : Forty-five genetically diverse genotypes of upland cotton were grown during *kharif* 1999 at Ludhiana, Kheri and Abohar with three dates of sowing. The genotypes were evaluated for seed cotton yield per plant, number of bolls per plant boll weight, seed index, days to flower initiation, number of monopods per plant, number of sympods per plant and plant height. Pooled analysis of variance revealed significant genotype environment interactions for all the traits studied. Similarly, heterogeneity between regression was significant for all the traits. Further, significant genotype-location interactions were observed for all the traits when the analysis was performed over dates of sowing for each location. Heterogeneity between regression mean squares were significant for seed cotton yield per plant and number of bolls per plant for all the three dates of sowing; for seed index and plant height at mid-April and first week of May sowing.

Significant genotype-dates interactions were also observed for all the traits. But the heterogeneity between regression was significant only for seed index at Ludhiana; for boll weight, days to flower initiation and plant height at Abohar.

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Estimates of Additive, Dominance and Epistatic Variation for Yield and its Component Characters in Upland Cotton (*Gossypium hirsutum* L.).

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ABSTRACT : To estimate additive, dominance and epistatic components of genetic variation for seed cotton yield and its component characters, 34 progenies of upland cotton produced by crossing 17 genotypes with two testers in a Simplified Triple Test Cross fashion along with their parents were evaluated in a randomized complete block disign with three replications. The analysis of variance for the test of epistasis revealed the presence of epistasis for all characters except for number of monopods and boll setting percentage. Both additive and dominance genetic components were significant for all the characters studied. Partial degree of dominance was observed for plant height, number of fruiting points, boll weight and harvest index, which indicated the predominance of additive genetic component for these characters. The dominance component was more preponderant for number of monopods, number of sympods, number of bolls, boll setting percentage, average internodal length, seed cotton yield and days to maturity where degree of dominance was in over-dominance range. The directional element of dominance 'F' was non-significant for all the characters indicating ambi-directional dominance.

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Stability of Hybrids and their Parents for Yield and Yield Component Characters in American Cotton (*Gossypium hirsutum* L.)

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ABSTRACT : The stability of 55 genotypes of American cotton (*G. hirsutum* L.) comprising of 10 parents and their 45 hybrids produced in a diallel fashion (without reciprocals) were evaluated in four different environments for yield and yield component characters. The partitioning of G x E interactions indicated that a substantial portion of the G x E interactions was linear for number of symoida per plant, number of bolls per plant, boll weight, seed index, lint index and seed cotton yield. Both linear and non-linear components were equally important for days to 50% flowering, number of monopodia per plant and number of seeds per boll. The study of stability parameters revealed that the hybrids NA 1325 x ARB 8824 and CWROK x ICMF 82 were found stable over environment with high mean seed cotton yield, regression near unity and non-significant deviations.

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Effect of Plant Population on Growth and Yield of Cotton Hybrids Under Drip Irrigation With Mechanical Cultivation

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ABSTRACT : A field experiment was carried out during *kharif* season of 1998-99 to 2000-2001. Plant population and cotton hybrids were tested in split plot design with four replications under drip irrigation. The results indicated that all the hybrids recorded similar seed cotton yield (PKV Hy 4 (14.11 q/ha), PKV Hy 2 (13.71 q/ha) and NHH 44 (12.99 q/ha). In respect of spacing, 96x75 cm recorded maximum seed cotton yield (14.94 q/ha) which was *at par* with 96x50 cm (14.60 q/ha) and significantly more by 20.3 and 20.0 per cent than the closer (96x25 cm) and wider spacing (96x100 cm), respectively. Maximum water use efficency (kg/ha/mm) was recorded in hybrid PKV hy 4 (1.08) and spacing at 96x75 cm (1.22). C : B ratio was recorded highest in hybrids PKV Hy 4, followed by PKV Hy 2 and lowest in NHH-44. Closer spacing recorded minimum C : B ratio at 96x25 cm (1:1.21) and highest at 96x75 cm (1:1.57).

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Effect of Dates of Planting and Defoliant on Yield and Quality of Cotton (*Gossypium hirsutum* L.)

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ABSTRACT : A field experiment was conducted to study the effect of dates of planting and defoliant on yield and quality of American cotton (*Gossypium hirsutum* L.) during *kharif* 1994 and 1995. The crop sown on April 20 produced significantly higher seed cotton yield as compared to the crop sown on May 15 and June 10. A significant improvement in quality characters *viz.*, span length, bundle strength, maturity coefficient, seed index and oil content was observed in early planting dates of April 20 and May 15 as compared to June 10 planted crop. The seeds obtained from June 10 planted crop showed significantly less seed index than prior planting dates. Time of defoliant (thidiazuron) application did not influence the seed cotton yield but different levels of defoliant showed significant effect on seed cotton yield. Application of thidiazuron @ 75 g/ha produced significantly higher seed cotton yield over control but was at par with higher levels of thidiazuron. Different levels of thidiazuron enhanced crop maturity by 14 to 18 days. Defoliant application did not show any adverse effect on the quality characters such as span length, bundle strength, fibre fineness, maturity coefficient, seed germination percentage, ginning out turn, seed index, lint index and oil content.

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Effect of Detopping and Foliar Sprays of Plant Growth Hormones and Nutrients on Growth and Yield of Rainfed Cotton

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ABSTRACT : From three years (1999-2000 to 2001-2002) orperiments at Cotton Research Unit, Dr. Panuabrao Deshkukh Krishi Vidyapeeth, Akola, it was found that detopping in *hirsutum* cotton was not advantageous in terms of growth and seed cotton yield. Foliar spraying of 20 ppm NAA (at flowering and boll development stage) and sequential spraying of 2 per cent urea at flowering and 2 per cent DAP at boll development stage recorded 12.3 and 13.6 per cent higher seed cotton yield over control (no spray), respectively.

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Effect of Growth Regulators, Sulphur Fertilization and Crop Geometry on Producing Squars, Flowers, Bolls and Their Abscission in Cotton

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ABSTRACT : A field experiment was conducted during 1996 and 1997 at Agricultrual Research Station, Rajasthan Agricultural University, Sriganganagar. More squares, flowers, no. of picked bolls, total no. of bolls/plant and boll setting (%) were recorded during both the years with the application of growth regulators, sulphur fertilization and square planting pattern of cotton, while dropped bolls/plant, shedded squares/plant, no. of shedded flowers/plant and per cent dropped flowers/plant significantly decreased with growth regulators, sulphur fertilization and in square planting pattern of crop geometry. Boll weight, weight of cotton seed and seed cotton/plant also increased with the application of growth regulators and sulphur fertilization. Square planting pattern also gave greater boll weight, weight of cotton and seed cotton/plant as compared to rectangular planting pattern of 90 x 22.5 cm^2 and 67.5 x 30 cm^2 of crop geometry.

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Effect of Water Salinity of Different Electrical Conductivity on Physical Characteristics of Cotton fibre

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ABSTRACT : Varying water-salnity (electical conductivity) treatments *viz.* 0, 2, 4, 6............16 dS/m were given to ascertain their effect on the fibre characterstics and yield parameters of *desi* hybrid cotton AAH 1 in pot experiments during the year 2001 and 2002. The cotton seed were sown in pots irrigated with saline water of different electrical conductivities (EC). In treatment of EC 16 dS/m, the seed did not germinate while in treatment of EC 14 dS/m there was no boll formation. The yield and physical properties of cotton fibre raised with water-salinity of EC 0, 2, 4..........12 dS/m were analysed. The parameters such as 2.5 per cent length, mean length, effective length, yield, seed index and lint index were increased up to EC 4 dS/m and therafter gradually decreased. The seed-cotton yield increased by 42, 36 and 5 per cent with water-salinity of EC 4, 6 and 8 dS/m respectively and it declined 36 per cent at salinity 12 dS/m over the control. There was significant reduction in linear density and maturity parameters of fibre with increasing water-salinity. The bundle strength at 0.0, 3.2 and 6.4 mm gauge increased up to EC 8 dS/m and beyond that declined. At treatment of EC dS/m, the FQI was significantly large and thereafter it followed the declining trend. From the analysis of data, it may be concluded that cotton AAH 1 performs well up to the water-salinity level of EC dS/m with improvement in physical characteristics of fibre and seed-cotton yield in comparison to control and higher water-salinity levels.

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Nutrients Uptake in Cotton as Affected by Growth Regulators, Sulphur Application and Crop Geometry

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ABSTRACT : A field experiment on cotton was conducted at Agricultural Research Station, Rajasthan Agricultural University, Sriganganagar for two consecutive years (1996-97). Three levels of each of gowth regulators, sulphur fertilization and crop geometry, consisting of 27 treatment combinations, constituted the experiment. Growth regulators *viz.* NAA and triacontanol and sulphur fertilization increased significantly the nutrients uptake of N, P, K, Ca, Mg and Fe. All these nutirents uptake had positive correlation with dry matter production with the application of growth regulators ans sulphur fertilization. Square planting of 45 x 45cm^2 recorded higher nutrients uptake over rectangular planting pattern (67.5 x 30cm^2 and 90 x 22.5cm^2).

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Arthropod Predatory Fauna and its Population Dynamics in Cotton in Haryana

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ABSTRACT : Field studies conducted in cotton (var. HS-6) in Hisar, Haryana revealed the presence of sixteen species of arthropod predators. Spiders constituted the major group of predators with seven species belonging to four families. The species were *Oxyopes shweta* Tikader, *Oxyopes pandae* Tikader, *Phidippus punjabensis* Tikader, *Cheiracanthium sadanai* Tikader, *Neoscona theis* Walckenaer, *Neoscona mukerjei* Tikader and *Thomisus* sp. Second major group consisted of coccinellids with three species, namely, *Coccinella septempunctata* Linnaeus, *Cheilomenes sexmaculata* (Fabricius) and *Scymnus nubilis* (Mulsant). Other predators recorded were *Paederus fuscipes* Curtis, *Chrysoperla carnea* (Stephens), *Geocoris ochropterus* Fisher, *Nabius* sp., *Ammophila* sp. and *Syrphus* sp. The population of arthropod predators exhibited a significant positive numerical relationship with the population of sucking insect-pests such as leafhopper, whitefly and aphid (r = 0.54 to 0.95). Population of arthropod predators and sucking insect-pests was positively correlated with maximum temperature (r = 0.46 to 0.62). The importance of conserving and augmenting these predators is stressed.

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Evaluation of Some Seed Treatments and Soil Applications against Cotton Stem Weevil *Pempherulus affinis* Fst.

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ABSTRACT : Stem weevil, *Perpherulus affinis* Fst. is an endemic pest of cotton in the Southern India. Studies were conducted at Cotton Research Station, Srivillputtur, to evaluate some of the seed treatment and soil application techniques against this pest. Results of the two years' trials revealed that basal application of neem cake @ 150 kg/ha + drenching 1 per cent oil suspension at 25 days after sowing and basal application of carbofuran 30 kg/ha + drenching chlorpyrifos 25EC @ 500g ai/ha at 25 DAS recorded 55.99 and 46.91 per cent reduction in stem weevil damage, respectively over control.

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Bio-efficacy of Imidacloprid against *Bemisia tabaci* Gennadius and *Thrips tabaci* Lindeman on Cotton

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ABSTRACT : Bio-efficacy of foliar application of imidacloprid 17.8% SL was evaluated at 80-150 ml/ha during 2000-2001 against whitefly (*Bemisia tabaci* Gennadius) and thrips (*Thrips tabaci* Lindeman) on cotton. No control of whitefly was obtained at the tested doses after 1, 3 or 7 days of the spray. The aleyrodid population in the insecticide sprayed plots was generally higher than the control plots. On the other hand, imidacloprid at 100-150 ml/ha provided satisfactory control of thrips for a longer duration than dimethoate.

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Succeession of Pest Complex and their Natural Enemies on Cotton (*Gossypisum* spp.) in Madhya Pradesh

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ABSTRACT : Twenty speices of pests infested upland cotton crop in an overlapping manner. Nine speices of natural enemics damaged various stages of pests during 1999-2002 in Madhya Pradesh. Only five species *viz. Amrasca biguttula biguttula, Aphis gossypii, Earias* spp., *Helicoverpa armigera* and *Pectinophora gossypiella* attained the status of major pests. Three species namely *Plusia acuta, Phusia orchalcia* and *Pempherulus affinis* were categorized as stray pests during the crop growth while twelve species attacked the crop as minor pests. In the case of natural enemies, *Coccinella septempunctata, Menochilus sexamaculatus, Chrysoperla carnea, Syrphus serarius, Platygomphus dolobratus* and *Cantheconidea furcellata* were found to feed on the pests attacking cotton. *Trichogramma chilonis, Ecphorosis preditincutus, Bracon gelechiae, Apanteles flavipes* and *Apanteles colomani* were found to parasitise the host with very less population.

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Studies on Incidence of Bollworms on Cotton (*Gossypium arboreum*) in South Western Haryana

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ABSTRACT : Studies conducted on bollworms infestation on cotton in south-western Haryana revealed that American cotton (*Gossypium hirsutum*) variety HS-6 was more susceptible to bollworms in comparison to *desi* cotton (*G. arboreum*). Bollworms infestation in shed fruiting bodies renged between 10.15 and 26.65 per cent, being maximum in HS 6, and minimum in HD 324, a *desi* cotton genotype. Among the *desi* genotypes, HD 324, HD 107, AAH 3 and HD 123 recorded lower infestation than others and were on a par with each other. On intact fruiting bodies, the bollworms infestation was higher in HS 6 than *desi* cotton genotypes. The highest infestation was in HD 357, followed by HD 371, HD 123, HD 107, HD 324 AND AAH 1. In open bolls, the infestation on boll basis ranged between 12.95 and 32.80 per cent, being maximum in HS 6. The *desi* genotypes recorded significantly lower infestation. Yield-wise, HD 123 was the best followed by AAH 3, HD 107, HD 357 and HD 371. Overall performance of AAH 3, HD 324, HD 123 and HD 107 was better than other genotypes.

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Efficacy of Newer Formulations of Insecticides against Bollworms of Cotton

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ABSTRACT : Efficacy of a readymix formulation (endosulfan 35 EC + cypermethrin 5 EC) and a tablet formulation (deltamethrin 25% Tablet) was tested during 2000-2001 against spotted bollworms (*Earias insulana* Boisd. and *Earias vittella* Fab.) and pink bollworm [*Pectinophora gossypiella* (Saunders)] attacking cotton in Haryana. On the basis of combined per cent incidence of bollworms in opened bolls at harvest it was observed that readymix formulation of endosulfan and cypermethrin was as good as cypermethrin (62.5 g a.i./ha) or fenvalerate (100 g a.i./ha) and significanlty better than endosulfan (700 g a.i./ha) in controlling bollworms. Endosulfan + cypermethrin at higher doses (700+100 or 875+125 g a.i./ha) was significantly suerior to its lower dose (350+50 g a.i./ha). Similarly, deltamethrin 25% Tablet at 10, 12.5 or 15 g a.i./ha offered significantly better control of bollworms than endosulfan. At the higher dose of 15 g a.i./ha deltamethrin proved superior to fenvalerate.

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Fusarium Wilt : Genetics and Breeding for Resistance-A Review

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Desi cottons (*G. arboreum* and *G. herbaceum*) are grown on large area (3.2 m. ha.). The country produces about 156 lakh bales of *desi* cotton grown on 2.59 lakh hectares, whereas, Maharashtra produces about 36.50 lakh bales grown on area of 32.54 lakh hectares with the productivity of 191 kg of lint per hectare becasue of many advantages such as insect resistance, drought resistance, highly superior fibre quality and needs comparatively less inputs. However, the wilt casused by *Fusarium* is the most limiting factor in *desi* cotton production causing a loss of 5 to 60% (Dastur, *et al*. 1960). Due to the seed and soil borne nature of the pathogen disease control remains the foremost challenge. This disease does not attack the *hirsutum* varieties grown in India, but is reported in some other countries. The disease was first reported (Atkinson, 1892) near Montgomery, Alabama, USA. Wilt in cotton is caused by *Fusarium vasinfectum*, (Atkinson, 1892; Kulkarni, 1928). In India, the disease was first reported by Evans in 1908 at Nagpur Experimental Farm and then by

Kulkarni from the then Bombay presidency (Kulkarni, 1934). The causal fungus, though a facultative saprophyte, is highly specialized in its parasitic relations. The results of the past investigations have led all the workers to conclude that the only practical way of controlling this disease was through the development of wilt resistant strains (Ajrekar and Bal, 1921; Kottur, 1924; Rosen 1928; Fahmy 1931-1934; Anderson, 1930; Kulkarni, 1934; Hutchinson *et al*., 1937; Uppal 1937).

Disease symptoms and pathogen : The cotton plants are affected at all stages of the growth. The affected young cotton seedlings shows yellowing and browning of the cotyledons and formation of a brown ring on the petiole which results into wilt and death of the seedlings. However, in older plants yellowing starts at the basal region of older leaves, which ends with branches and whole plant. By split opening the affected plant at basal portion, brown stained vascular system occurs. In the early stages of attack there is a yellowing of the vessels and surrounding tissue. Later on this colour may change to brown and occasionally to dark brown (Fig. 1). Many of such coloured vessels contain the hyphae of a fungus which at times completely fill them. Fungus hyphae may be found in vessels apparently normal (Fig. 2, 3, 4, 5) and many affected vessels are filled with dark gummy masses (Fig. 2) (Kulkarni, 1928).

The pathogen : At present six races of *Fusarium oxysporium* f. sp. *vasinfectum* are reported and among these race 4 was reported in India (Armstrong, 1960).

Morphology : The hypae are hyaline, septate, inter and intracllular, producing microconidia on lateral phialides. These may be grouped on short branches, and are one or two celled, usually ellipsoidal, 5-12 x 2-3.5 µm sickle shaped, hyaline mostly 3 septate but sometimes 4 to 5 septate, measuring about 40-50 x 3-4.5 µm in size (Singh, 1983). Chlamydospores are terminal or intercalary thick walled, more or less spherical. No sexual stage has been reported so far (Booth and Waterston, 1964).

Perpetuation, dissemination, physiology and disease development : *Fusarium* is soilborne facultative parasite surviving in the soil up to a death of one meter or more below the soil surface but infestation is most severe in the first 40 centimeters (Singh, 1983). Short period of favorable conditions may lead to multiplication of the chlamydospore population (Cook and Synder, 1965). The disease can be spread by infected seed, water and even by transport of infested soil (Elliott, 1923; Wickens, 1964; Booth, 1971; Ebbels, 1975).

Physiology and disease development : *Fusaric* acid, a 'toxin' is closely associated with symptoms of *Fusarium* wilt in cotton, and this is pyridine-carboxylic acid (5-n-butyl-pyridine-2-carboxylic acid) (Kalyanasundaram, 1955; Lakshminarayana and Subramanian, 1955). It is estimated that 17 ppm *Fusaric* acid by weight in 2 to 3 week old infected cotton seedlings (Kalyansundaram and Venkata Ram, 1956). *Fusaric* acid affects the plants water balance by changing the semi permeable properties of the plasma membrane in leaf cells. Though, it decreases the photosynthesis it does not cause other physiological changes in infected plants such as increased respiration and staining of the xylem (Krishnamani and Lakshmanan, 1976). The contents of peroxidase and polypholoxidase was higher in resistant and susceptible cultivars and the contents increased in response to infection in both the cultivars (Sharma *et al*., 1984). A correlation between symptom development and production of polygalacturonase *in vitro* was indicated by Lakshminarasimhan and Kalyansundaram, 1979; and Suresh *et al*., 1984. Sankaranarayanan and Kumar, (1985) described characteristics of host specific endotoxin. According to Kulkarni and Mundkur (1928) the primary factors leading to the death of cotton plants is a liquid compound or compounds, which is not destroyed by boiling and removed by filtration through porcelain filters and not even by heating the filtrates in an autoclave at 110°C to 115°C. The nature of the substance has not been determined, but lactic and oxalic acids are definitely excluded and nitrites do not appear. Sharma *et al.* (1988) observed that more pathogenic isolates produced less mycelium and fewer spores. Incidence of *Fusarium* on seedlings correlated positively with root disease index, hypocotyls disease index and total soil N/ha, and negatively with soil pH (Roy and Bourland, 1982). Pre-inoculation of cotton plants with a low level of virulent strain of *Fusarium* protected them against subsequent inoculation with a high dosage of the same virulent strain. (Muruganandham and Kalyansundaram, 1979). Balasubramanian and Kalyansundaram (1979) observed a correlation between disease incidence and vascular colonization but no such correlation applied to either vascular browning or occlusion of vessels. An avirulent strain showed poor growth and caused very little vascular browing (Kumar and Subramanian, 1977). Kumar *et al*. (1986) discussed method to eliminate autofluorescence of host tissues and soil.

Screening : *G. arboreum* cultivars were comparatively less resistant than those of *G. herbaceum* (Khetmalas, *et al.,* 1989). According to Sharma *et al*. (1984) *G. arboreum* LD 212, LD 224, LD 231, LD 252, LD 254 and LD 258 were resistant.

Effect of temperature, fertilizer : The Khandesh strains of *Fusarium* has slightly higher temperature relations for the development of wilt than the Broach and Dharwad strains (Uppla, 1937). Further, Uppal (1937) and Kottur (1933-34) stated that the level of activity of *Fusarium* depends on the degree of soil-infestation by the pathogen, optimum soil temperature, air temperature and soil moisture. Kulkarni (1934) concluded that temperatures of 25°C and below favoured wilt and higher temperature retarded it. Sharma and Bedi (1990) reported that the incidence of *Fusarium* was significantly less in May sown crops than those sown in April. These results were linked with the effects of temperature, rainfall and relative humidity on disease development during the season. Kalyanansundaram (1954-55) suggested that energy giving substances might be utilized in the resistant plants for the formation of toxic substances, which inhibit the development of the pathogen in vascular system. *Fusarium* incidence was less in plots with calcium ammonium nitrate as fertilizer than with urea and ammonium sulfate (Sharma and Bedi, 1989).

Genetics and resistance breeding : A technique of breeding for *Fusarium* wilt resistacne in *G. arboreum* was developed which was well known as "Poona Technique" (Uppal, 1938). According to this wilt resistance in cotton is not due to single gene but may be controlled by cumulative genes. Immunoelectrophoretic separation of the antigen of isolates exhibits selective virulence and the serological grouping could be correlated with their selective virulence (Laxshminarasimhan and Kalayansundaram, 1976). Resistance to *Fusarium* wilt was dominant to susceptibility and GCA was greater than SCA (Singh *et al*., 1984) *Fusarium* wilt was apparently controlled by more than one gene (Ma, 1985). Wilt resistance in *G. arboreum* and *G. herbaceum* is controlled by two dominant complementary genes, A and B and a third one c with a dominant inhibitory action (Kelkar *et al*., 1947). Plants with a longer period of incubation have higher percentage of immune progenies than mother plants of shorter incubation period. The shifting type of immunity might behave as true immune. Under extreme conditions of infection segregation of resistant plants suggest accumulative nature of the inheritance of resistance (Fahmy, 1931, 34). Backcross of the hybrid to the resistant parent appears to be fairly reliable method of obtaining material of better resistance than the straight cross (Ramiah and Paranjape, 1947). Almost all Asiatic cottons are highly susceptible to *Fusarium*. Some commercial varieties, though susceptible, contain some degree of resistance and on selection yield resistant strains. Such varieties, if grown on wilt infected soils, show rapid improvement owing to early elimination of susceptible individuals (Kottur and Maralihalli, 1934). In *G. arboreum* crosses, three complementary factors were involved in wilt resistance (Uppal *et al*., 1940). The only practical way of controlling this disease was through the development of wilt resitant strains (Ajrekar and Bal, 1921; Kottur, 1924; Kulkarni, 1934; Hutchinson *et al*., 1937 and Uppal, 1937). Extensive data suggests that probable number of determines responsible for wilt resistance have been published in past (Wade, 1929; Walker, 1930; Fahmy, 1931-34; Burnham, 1932; Blank and Walker, 1933; Mc Rae and Shaw, 1933 and Uppal, 1939- 1939-42). Hutchinson, 1937, discussed the Fahmy's work. Fahmy started with the hypothesis that the inheritance of resistance to wilt was controlled by single factor-pair and ended by assuming multiple factor inheritance.

G. hirsutum x *G. arboreum* x *G. thurberi* hybrids were suseptible to wilt (HR-1 and HR-2 type) (Demol and Nicolas, 1960). F_2 hybrid of *G. hirsutum* x *G. arboreum* x *G. herbaceum* x *G. thurberi* with wilt resistance S-460 gave rise to S-4534, which exceeded 108 F in wilt resistance (Arutjunava, 1968). Resistance to *Fusarium* wilt was recorded in hybrids (*G. thurberi* x *G. anomalum* x *G. bickii* x *G. sturtii*) with (*G. hirsutum* x *G. arboreum*) by Kohel and Bell in 1999.

Control : Sharma and Bedi (1986) recommended seed treatment with Bavistin (Carbendazim) followed by Agallol (Methoxyethyl mercury chloride) at 0.1% treatment. Chauhan *et al*. (1988) concluded that seed treatment or soil application of carbendazim followed by carboxin gave good disease control against pre and post-emergence seedling mortality due to wilt. Arjunrao (1971) reported that an addition of actionomycetes in soil reduced wilt incidence. Preinoculation of cotton plants with low levels of virulent strains of wilt pathogen protected them against subsequent inoculation with the same virulent strain (Murugandham and Kalyanasundaram, 1979). Culture of *Fusarium oxysporium* sp.*vasinfectum* was appreciably inhibited by 2 soil isolates of *B. subtilis* (Podile *et al*., 1985).

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Management of Fusarial wilt of *arboreum* cotton in Punjab

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ABSTRACT : Eleven fungicides and two species of *Trichoderma,* namely, *T. harzianum* and *T. viridae* were evaluated for the control of wilt caused by *Fusarium oxysporum* f. sp. *vasinfectum* in LD 230 variety. Data were recorded for per cent germination and wilting upto flowering stage. Chemical treatments were applied as seed as well as soil treatment in wilt sick pots. Wilt sick pots were prepard by adding mass inoculum of *Fusarium oxysporum* f. sp. *vasinfectum*. In case of *Trichoderma* species the seeds were coated with the conidial suspension of *Trichoderma spp.*, having a concentration 8 x 10^6 per ml and were air dried overnight. All the chemicals, except Monceren, were found to increase germination and checked wilting at flowering stage. Emisan-6 (73.3%) and Benlate (70.0%) were found to be most effective, followed by Kitazin (66.7%) and Bavistin (65%). Wilt incidence was also found to be low with *T. harzianum* and *T. viridae* i.e. 42.8% and 40.8 per cent when applied as seed treatment. The wilt incidence was recorded with *T. harzianum* (42.6%) *T. viridae* (40.2%) and Emisan-6 (64.1%) when applied as soil treatment.

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Effect of Biocontrol Agents and Fungicidal Seed Treatments on Incidence of Root Rot and Yield of Seed Cotton and its Economics

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ABSTRACT : A field experiment was conducted to assess the efficacy of biocontrol agents *viz., Trichoderma harzianum, Trichoderma viride* both @ 5 g/kg seed and *Pseudomonas fluorescence* @ 10 g/kg seed and fungicides *viz.,* thirum, captan and carbendazim each @ 3 g/kg seed as seed trreatments against root rot (*Rhizoctonia bataticola*) disease of cotton for three successive crop seasons. Seed treatment with all the biocontrol agents and fungicides significantly reduced root rot incidence and also significantly increased yield of seed cotton (except carbendazim). However, on the basis of efficacy against the disease, yield performance, net profit and cost benefit ratio, *Trichoderma viride* was the best followed by *Trichoderma harzianum*.

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Biological Control of Alternaria Leaf Blight of Cotton caused by *Alternaria macrospora*

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ABSTRACT : An experiment was conducted on biological control of Alternaria leaf blight during the year 1998, 1999 and 2000. *Trichoderma viride* (antagonist) was observed as the best bioagent for control of this foliar disease. *Alternaria* leaf blight (PDI-22.07%) in field condition followed by *Aspergillus niger*. However, cotton crop sprayed with copper oxychloride fungicide also played significantly role in the control of disease. The crop sprayed with these antagonistic and fungicide was yielding higher as compared to unsprayed crop. The highest seed cotton yield (1831 kg/ha) was observed in the treatment with streptocycline + copper oxychloride, followed by *T. viride* (1639 kg/ha). However, the results due to spraying of *Trichoderma viride* and fungicide were *at par* indicating the effectiveness of *T. viride* in control of Alternaria leaf blight.

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Integrated Management of Root Rot of Cotton caused by *Rhizoctonia solani* Kühn under Screen House Conditions

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ABSTRACT : Out of four insecticides tested as seed treatment, thiomethoxam (4.3 g/kg seed) exhibited 38.09 per cent disease control in seedlings, followed by imidacloprid (5g/kg seed) (31.68%) in cotton cv. HS-6. Among six fungicides tested as seed treatment, carboxin (2g/kg seed) 64.51 per cent disease control, followed by carbendazim (2g/kg seed) (60.55%) against root rot. Soil application of *Trichoderma viride* biomass (500g/kg soil) proved most effective which gave 72.08 per cent disease control, followed by *Gliocladium virens* which exhibited 64.94 per cent disease control. Soil application of pendimethalin (2 1/ha) showed maximum protection of seedlings (40.60%), followed by trifluralin (2 1/ha) which exhibited 31.41 per cent disease control. Seed treatment with thiomethoxam + carboxin and soil applications of *T. viride* + soil treatment with pendimethalin protected seedlings by 87.87 per cent under screen house conditions. An integrated approach in the management of root rot of cotton is suggested.

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Study of Heterosis in Single and three-way Corsses in Upland Cotton (*Gossypium hirsutum* L.)

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Cotton is an important industrial crop of India contributing to about 85 per cent of raw materials to textile industry. It is also an important commodity for export in the form of raw cotton, cotton yarn and other value added textile goods. Hence, the development of high yielding hybrids of cotton has become necessary to fulfil the domestic and export need. Although the single cross hybrid *viz*., Varalaxmi, DCH 32, NHH 44, Savitha, NHB 12, TCHB 213 and DHH 11 are popular and occupy a significant area, these suffer due to certain inherent drawbacks, especially under stress conditions *viz*., summer irrigated and rainfed conditions. None of the hybrid was found to be promising than varieties under summer irrigated conditions. Hence developing three-way cross hybrids has been thought of as a viable alternative for these stress area. The present investigation was carried out to study the comparative performance of three-way cross hybirds and single cross hybrids for heterosis in upland cotton.

Six upland cotton genotypes (*G. hirsutum*) *viz*., MCU 5, MCU 7, TCH 1002, SVPR 1, Sharada and JR 36 were crossed in all-possible combinations to effect 15 direct crosses. A portion of seeds from fifteen single crosses was reserved and the rest was, in turn, crossed with 6 parents in all triallel fashion to get 60 three-way cross hybrids (Rawlings and Cockerham, 1962). Thus six parents, 15 single cross hybirds and 60 three-way cross hybrids were evaluated in a randomized block design with three replications during summer 1999 at Cotton Research Station, Srivilliputtur. A spacing of 90 cm between the rows and 45 cm between plants within a row was maintained. The yield components *viz*., bolls per plant, boll weight and seed cotton yield per plant were recorded on ten randomly selected plants in each plot in all the replications. The expression of heterosis was assessed by taking into consideration the increase over mid parent (P1+P2/2) for single crosses and (P1+P2+P3/3) for three-way crosses. Similarly, heterobeltiosis was also calculated by considering the value of superior parent. The significance of relative heterosis (di) and heterobeltiosis (dii) was tested by using the 't' test suggested by Wynne *et. al.* (1970).

The mean phenotypic expression was observed to be maximum in single cross hybrids for bolls/plant (23.77), boll weight (3.27) and seed cotton yield/plant (80.48 g), as compared to the three-way cross (TWC) hybrids for bolls/plant (22.70), boll weight (3.22 g) and seed cotton yield/plant (73.79 g). The highest value for seed cotton yield/plant was recorded in single cross hybrid *viz*., MCU 5 x TCH 1002 (121.57 g) but the highest value for bolls/plant of 34.93 and boll weight of 4.03 g was recorded in TWC hybrids (MCU 5 x SVPR 1) x JR 36 and (SVPR 1 x JR 36) x MCU 5, respectively. The variation between the lowest and the highest phenotypic expression was observed to be maximum in single cross hybrids than TWC hybrids in respect of boll weight (1.44 g) and the seed cotton/plant (70.17 g). Maximum variation for boll/plant (20.6) was found in TWC hybrids. The analysis of variance revealed significant variance due to parents and hybrids for all the three characters studied indicating adequate genetic diversity (Table 1). Both single cross and TWC hybrids showed significant values for all the three characters. The highly significant parent vs. crosses interactions for bolls per plant and seed cotton yield per plant indicated the presence of high degree of heteroisis for this trait. The non-significant interaction (parents vs. crosses) observed for boll weight indicated low degree of heterosis between parents for boll weight. Similarly no significant interaction due to single vs. TWC hybrids for boll weight revealed the absence of significant difference for boll between the two kinds of hybrids.

Extent of heterosis in single cross hybrids : Among the 15 direct single cross hybrids, five hybrids *viz*., MCU 5 x TCH 1002, SVPR 1 x Sharada, SVPR 1 x JR 36, MCU 5 x Sharada and MCU 5 x MCU 7 exhibited high relative heterosis for seed cotton yield, boll number and boll weight (Table 2). The highest heterotic percentage (155.3) for seed cotton yield was observed in SVPR 1 x JR 36. Turner (1953) reported that the high heterosis percentage could be obtained from crosses of two low yielding (poor) inbreds but absolute yield of such hybrid was lower than the adopted varieties. He further emphasized that the number of bolls was far more important than boll weight.

Extent of heterosis in three-way hybrids : The extent of heterosis both over mid-parent (relative heterosis) and better parent (heterobeltiosis) in the three-way cross hybrids indicated that the number of crosses with significant heterotic effect was higher in seed cotton yield/plant and number of bolls/plant. The relative heterosis and heterobeltiosis values ranged from -5.4 to 193.3 per cent, and -28.9 to 151.1 per cent, respectively for number of bolls/plant and -13.1 to 26.77 per cent and -17.8 to 118.8 per cent, respectively for seed cotton yield/plant. The three-way cross hybrid (MCU.5 x SVPR 1) x JR 36 exhibited maximum relative heterosis and heterobeltiosis for boll number and seed cotton yield/plant. The other promising three-way cross hybrids which showed significant heterotic effect for the yield components *viz*., boll number/plant, boll weight and seed cotton yield/plant were (MCU 5 x MCU 7) x Sharada, (MCU 7 x Sharada) x MCU.5, (MCU 7 x Sharada) x SVPR 1, (TCH 1002 x JR 36) x Sharada, (SVPR 1 x Sharada) x TCH 1002 and (SVPR 1 x JR 36) x

MCU 5 (Table 2). Shroff *et al*. (1983) reported that three-way cross hybrids produced by using cytoplasmic male sterile lines exhibited significant heterosis for number of bolls/plant, boll weight and seed cotton yield/plant which is in agreement with the present finding. Ansingkar *et al*. (1992) also observed significant heterosis for seed cotton yield/plant in three-way hybrids of Asiatic cotton (*G. arboreum*).

Single crosses verses three-way crosses : Comparison between TWC and SC for their heterotic expression towards boll number, boll weight and seed cotton yield/plant revealed the superiority of single crosses for their heterotic expression. Most of the parents, which produced high magnitude of heterosis in single crosses, recorded highest percentage in three-way corsses also. In the three-way cross hybrids the triplet combinations *viz*., (MCU 5 x SVPR 1) x JR 36, (MCU 7 x Sharada) x MCU 5, (MCU 7 x Sharada) x SVPR 1 and (TCH 1002 x JR 36) x Sharada have exhibited singificant relative heterosis and high *per se* performance for seed cotton yield and its contributing characters. Hence these combinations could be utilized for heterosis breeding in improving seed cotton yield. However, in some combinations the change of order reduced the heterotic expression. Based on these results it can be concluded that in case of inability to exploit high degree of heterosis in SC hybrids, TWC hybrids would be a viable alternative as the additional line involved in their synthesis would offer ample scope of incorporating resistant genes for biotic and abiotic stresses.

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Inter-relationships among Seed Oil Traits in Upland Cotton (*Gossypium hirsutum*)

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Cotton is primarily cultivated as a fibre crop. It is also a very important source of edible oil. In the past, breeding efforts have been limited mainly to the improvement of lint yield and fibre properties and little attention has been paid to the genetic improvement of cotonseed oil. There are a few reports about the correlation of cottonseed oil with yield and yield components (Dani, 1984, 1985, Bhale *et al*., 1989). The present investigation was undertaken to determine the components of seed oil content in upland cotton through correlation and path analysis.

The experimental material comprised and 41 phenotypically diverse genotypes of upland cotton (*Gossypium hirsutum*). These lines were grown during 2001-02 at the Central Insitute for Cotton Research, Nagpur in non-replicated trial. Recommended agronomic practices and plant protection measures were adopted to raise a good crop. Each genotype had 2 rows of 10 dibbles spaced at 60x45 cm. The composite cottonseed sample obtained from ten randomly selected plants of each line was evaluated for seed index, kernel index, hull index, seed oil per cent, kernel oil per cent and hull oil per cent. The oil estimation in seed, kernel and hull was done by Nuclear Magnetic Resonance (NMR) technique. The inter-relationships among these six seed oil traits were estimated by usual procedure. The path analysis was done considering kernel oil per cent as a dependent variable. (Dewey and Lu, 1959).

A wide range of variability was observed for various traits among 41 germplasm lines as is evident from range and phenotypic coefficients of variation (PCV) (Table 1). The seed oil per cent varied from 12.40 to 25.20 per cent and its PCV was 11.58 per cent. Interstingly, the kernel oil per cent recorded lowest PCV (7.35%) and a range of 25.20-37.20 per cent despite a wide range of variation observed for seed oil per cent and kernel index. Unexpectedly, hull oil per cent recorded highest PCV (30.67%) and its range was 0.90 to 3.60 per cent. Bhale *et al*. (1989) also recorded a wide range of variation among cotton germplasm lines for seed index and seed oil per cent. Character association analysis (Table 2) exhibited that seed oil percentage was positively correlated with seed index (0.205), kernel index (0.189), kernel oil per cent (0.192), hull index (0.111) and was negatively correlated with hull oil per cent (0.047), but all these correlations were negligible to moderate in magnitude and were statistically non significant. Positive correlation between seed index and seed oil per cent in upland cotton has also been reported in earlier studies by Dani (1984, 1985). On the other hand, kernel oil per cent, which constitutes the extractable part of cottonseed oil (scientific processing) had significant positive correlation with seed index (0.633), kernel index (0.489) and hull index (0.534) and was positively correlated with seed oil per cent (0.192), *albeit* non significant statistically. However, kernel oil per cent exhibited no relationship with hull oil per cent in the present study.

Kernel index understandably had a near perfect positive correlation with seed index (0.910) and also interestingly a positive correlation with hull index (0.175) although low in magnitude. The breeding strategy for cottonseed oil improvement so far has been to increase kernel content and to reduce hull content in cottonseed.

Path analysis (Table 3) clearly showed that seed index which exhibited a high positive correlation with kernel oil per cent (0.633) also had the maximum negative direct effect (-14.245) towards it. The high correlation of seed index with kernel oil was due to high indirect effects of seed index towards kernel oil per cent *via* kernel index (11.275) and hull index (3.680). Dani (1985) also reported negative direct effect of seed oil per cent on seed index in his studies on character association in cotton. The high positive correlation of kernel index with kernel oil per cent (0.489) was mainly due to its high direct positive effect (12.387) towards kernel oil content. The positive and significant association of hull index with kernel oil per cent (0.534) was due to direct positive effect (6.492) of hull index and its indirect positive effect (2.166) *via* kernel index. This trend suggests a need for restricted simultaneous selection model to be followed i.e. restrictions are to be imposed to nullify the undesirable indirect effect of seed index while making selections for increased kernel and hull to improve kernel oil per cent.

The magnitude of residual (0.4916) observed in the present study further suggested that three could have been a few more unexplored factors affecting kernel oil per cent that needed to be taken account of. It is concluded that kernel index and hull index are the major component of kernel oil per cent which should be given due weightage while making selection for high kernel oil percentage in upland cotton.

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Heterosis and Genetic Component Analysis in Crosses of White Linted Genotypes with Coloured Linted Genotypes in *Gossypium hirsutum* Cotton

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India is the pioneer country in the development of high yielding hybrids of cotton using the converntional hand emasculation and pollination pechniques of hybrid seed production. In order to study the differences in the magnitude of heterosis in intraspecific hybrids of white linted and coloured linted types for yield and its components, a comparative study was attempted and the genetic parameters including heritability and genetic advance were estimated in such hybrids.

Three divergent white female cultivars *viz*, HS-6, F 505 and LRK 516 were crossed with ten divergent pollen parents. Of these five genotypes were brown linted (CSC 83-1, CSC 83-3, CSC 1358, LC 1-1 and CSC 1390) and five were greenish brown linted (SA140A, SA 140B, SA-3, SA-5 and CSC 84-2). Twenty six hybrids were raised during *kharif* 1997-98 along with two check varieties, HS-6 and F 846, and hybrid 'Om Shankar' in randomized block design with three replications at CICR, Regional Station, Sirsa, Haryana. The hybrids were grown at a spacing of 67.5 cm x 60 cm, and varieties at 67.5 cm x 30 cm. At random, 5 plants of hybrids and varieties were taken for recording observation. The genotypic and phenotypic coefficients of variations, heritability, genetic gain investigation, and heterosis over standard checks and hybrid were estimated.

Analysis of variance for all the characters showed significant differences among the genotypes (Table 1). The data on phenotypic and genotypic coefficient of variation were found to be high for all the traits studied, depicting the possibility of improvement of these traits by fruther selection in segregating progenies.

The magnitude of the PCV was greater than GCV for all the characters. However, the GCV/PCV ratio showed narrow differences between GCV and PCV indicating less influence of environment on these traits (Table 2). The hertiability estimates were highest for ginning out turn (87.32%), followed by boll number/plant (78.68%), boll weight (77.92%), seed cotton yield/plant (70.43%) and plant height (69.80%). The high heritability for yield and these component traits indicated that these characters were determined by major proportion of genetic effects. Hence, genetic improvement of these traits by adopting mass selection was attainable. Krishna Doss and Kadambavansudaram (1993) and Nadarajan and Sreerangaswamy (1990) also reported similar results in white linted cotton. High genetic advance together with high heritability and GCV was observed for seed cotton yield/plant, boll number, ginning per cent and plant height, indicating the presence of additive gene action in the inheritance of these characters.

The use of heterosis in coloured linted cotton, so far is very limited as compared to white linted *hirsutum* and *hirsutum* x *barbadense* hybrids. This is because of limited and restricted utilization of colour cotton types. Sundaramurthy *et al*. (1994) reported that hybrids made between naturally coloured linted and white linted *hirsutum* strains were found to be superior for quality traits as compared to naturally existing pigmented cotton strains. Similarly, the hybrids combinations *viz*.; Vikram x LC-1-1, MCU 5 x 1-1, CNH 36 x LC 1-1and Vikram x Parbhani american were better than white cultivar LRA 5166 in yield and ginning out turn (Pavasia and Shukla, 1997).

In the present study, many hybrids showed the existence of considerable heterosis for seed cotton yield and component characters over the two check varieties and the hybrid 'Om Shankar'. The magnitude of heterosis varied from cross to cross and check to check. For seed cotton yield/plant, nine hybrids gave positive heterosis over the two-check varieties and check hybrid. The highest heterosis of 248.4, 270.8 and 133.5 per cent was recorded over HS-6, F 846 and 'Om Shankar', respectively for the brown linted cross LRK-516 x CSC 83-3. Other brown linted crosses *viz*. F 505 x CSC 83-1, HS-6 x CSC 83-1 and LRK 516 x CSC 83-1 showed significant heterosis for seed cotton yield. It was noticed that the crosses with high heterosis for seed cotton yield also had high heterosis for boll weight and boll number, the major yield contributing characters. This observation was in agreement with earlier reports suggesting that increase in boll number was largly responsible for yield but only with an increased boll weight (Tuteja *et al*., 1993, Jain, 1995 and Ahuja and Tuteja, 2000). For boll number, the range of heterosis over check HS-6, F 846 and Om Shankar was 59.2 to 40.8, -59.2 to 40.8 and -67.8 to 11.2 per cent respectively (Table 1). However, there was no consistent relationship between heterosis for boll number and seed cotton yield per plant except for the crosses *viz*., F 505 x CSC 1358, HS-6 x CSC 83-1 and HS-6 x CSC 83-3 which exhibited positive heterosis for both the characters. The results, therefore, suggest that high yield does not necessarily depend on the high heterotic behaviour of the combination of all the yield components. Pavasia *et al*. (1999) and Ahuja and Tuteja (2000) have reported almost identical results.

The character ginning out turn is primarily governed by additive gene action and hence resulting in low geterosis (Pavasia and Shukla, 1997). The heterosis ranged from -15.8 to 16.7, -22.9 to 6.8 and -23.43 to 11.71 per cent over HS-6, F 846 and Om Shankar, respectively. For this trait hybrid HS-6 x CSC 83-1 showed 16.7, 6.8 and 11.7 per cent heterosis over HS-6, F 846 and Om Shankar, respectively. For mean fibre length the heterosis ranged between -16.9 to 28.3, 20.9 to 11.8, -16.13 to 12.09 over two check varieties (HS-6 and F 846) and the hybrid Om Shankar, respectively. For mean fibre length of greenish brown linted cross LRK 516 x SA-140B gave 5.7, 3.4 and 9.6 per cent heterosis over HS-6, F 846 and hybrid Om Shankar, respectively. Greenish brown linted hybrids showed the highest mean fibre length of 27.8 mm. The heterosis for seed index ranged from -5.81 to 15.1, -8.1 to 11.6 and 6.3 to 28.0 per cent over the three checks. High yielding hybrids KRK 516 x CSC 83-3 and LRK 576 x CSC 83-1 also exhibited high positive heterosis for seed index over all the three checks. This results confirms the reports of Govil and Singh (1979) and Bhatade (1981) in white linted *desi* cotton.

The study therefore, suggested that the brown linted cross combinations *viz*. LRK 516 x CSC 83-3, F 505 x CSC 83-1 and HS-6 x CSC 83-1, which have shown the highest heterosis for seed cotton yield and its component traits could be exploited for commercial cultivation. But the cultivation of coloured cotton may be taken up in selected areas as growing of coloured cotton in the vicinity of white cotton is likely to contaminate the latter upsetting the seed production and cotton production process. Contamination may result from outcrossing in the field and from post-harvest operations like transportation spinning etc. Therefore, isolation at all stages of cultivation, harvesting and post-harvest operations is considered to be most crucial to prevent contamination between coloured and white linted cottons (Ranganadha Charyulu, 1996 and Basu, 1996).

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A long staple intra *hirsutum* cotton Hybrid PKV Hy-4 (CAHH-8) (Based on Cytoplasmic Male Sterility)

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Cotton is an important cash crop grown in about eighty countries all over the world. India is the pioneer country in the world for successful exploitation of heterosis (hybrid vigour) in cotton on commercial scale. Cotton assumes place of pride in Indian economy, as it is one of the most important cash crops in India and plays a dominant role in the industrial and agricultural economy of the country. India is one of the major producers of cotton in the world with the largest acreage which is almost one fourth of world area. The production share is, however, only 13.5 per cent ranking 3^{rd}. In the year 1999-2000 the area under cotton was about 86.46 lakh ha with annual cotton production of approximately 156 lakh bales with average productivity of 307 kg lint/ha. *Gossypium hirsutum* L. is the principle cultivated cotton and accounts for about 90 per cent of the world cotton production. In Maharashtra cotton was grown on an area of 32.54 lakh ha, the largest among cotton growing states in the country with about 36.50 lakh bales of production of having productivity of 191 kg/ha. (Anonymous, 2000).

At present, most of the hybrids grown in this region are of category of medium to super medium staple giving 20^s to 30^s counts (PKV Hy-2, PKV Hy-3, NHH-44 etc.). The long staple giving 40^s to 50^s counts are H-4 and H-6. However, the area under these hybrids is very low and now H-4 s nearly out of cultivation. There is a pressing demand from the spinning mills and the Maharashtra State Cotton Growers Marketing Federation for long staple cotton giving 40^s and 50^s counts. Such demand is not fulfilled from Maharashtra, and cotton is being purchased from other states. This hybrid CAHH-8 will be most suitable for fulfilling these requirements as it is *at par* with H-4 and H-6 in fibre properties.

Yield performance of PKV Hy-4 : To evaluate this hybrid for its adoptability and superiority it was tested at various locations *viz*., Akola, Achalpur, Yavatmal, Kutki, Buldana, Nagpur, Jalgaon, Nanded, Indore etc. during the period between 1990-91 to 1995-96 (Table 1). The mean yield of six years data over different locations indicated its wider adaptability as it has given 21.8, 50.4 and 6.7 per cent more yield than PKV Hy-3, H-4 and H-6, respectively. The hybrid CAHH-8 was also tested in AICCIP trials in Central Zone under rainfed condition during 1991-92 to 1995-96. The mean data of five years indicated its superiority over the check PKV Hy-3 by 18.52 per cent increase in yield. It was also tested in adaptive trials through T and V and in Front Line Demonstrations. The results of adaptive trials confirmed its superiority over PKV Hy-3. It showed 5.15 per cent increase in adaptive trials through T & V and 12.27 per cent increase in Front Line Demonstrations (Table 2). From the data of agronomical trials CAHH-8 (PKV Hy-4) was found to be superior than PKV Hy-3 in respect of seed cotton yield, when planted at 120 x 90 cm under irrigated and 60 x 60 cm under rainfed conditions with supplimentation of 100 : 50 : 50 kg NPK under irrigated and 50 : 25 : 25 kg NPK/ha under rainfed condition, respectively

Fibre quality : PKV Hy-4 has superior long staple of 30.2 mm. In case of spinning performance this hybrid was superior in CSP value at 40^s and 50^s count than PKV Hy-3 and H-6 with good micronaire value and fineness (Table 3).

Considering overall good performance of PKV Hy-4, it was released and notified for large-scale cultivation in cotton growing tracts of Maharashtra region.

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Stability of Seed Cotton Yield and it's Components in Upland Cotton (*Gossypium hirsutum*)

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The productivity of cotton is fluctuating over a wide range of environments. Selection of widely adapted genotypes may be significant for improvement in cotton. Boll weight and boll number are the most important components of seed cotton yield. Therefore, the present study was undertaken to identify genotypes/hybrids with stable performance for yield, boll number and boll weight in *Gossypium hirsutum*.

The experimental material comprised of 44 upland cotton hybrids, 15 parents and one standard check (i.e. HHH-81). The experiment was conducted at three locations during *kharif* 2000-2001 at research farms of Hisar, Sirsa and Bawal in a randomized block design replicated thrice at every location. All the recommended package of practices were followed to raise a good crop. The data were recorded for yield, boll number and boll weight on five competitive plants selected randomly and subjected to stability analysis.

Genotype x environment mean sum of squares were tested against pooled deviation. Genotype x environment component was significant for seed cotton yield and boll weight which indicated differential response of the variety and environment. For seed cotton yield, eight genotypes had both bi and S^2 di values simultaneously significant indicating the presence of high magnitude of genotype x environment interactions (Table 1). The significance of S^2 di indicated the presence of non-linear portion of G x E interaction for 46 genotypes. The two genotypes B59x H1117 and J34xG67 showed non significant values of bi and S^2 di meaning thereby free from G x E interaction. Patel *et al*. (1999) and Yadav *et al*. (2001) also reported similar results in cotton.

The genotype IAN579-1xRS810, IAN579-1 x RB 464 and B 59x RS875 had stable boll number up to some extent exhibiting above average means. Most of the genotypes showed significant values for either bi or S^2 di indicating the presence of G x E interaction. For boll weight the hybrid IAN579-1xG67, B59x H1180, B59xG67, B59xH1117, J34xG67, GreggxJ2P7 and GreggxH1180 had higher mean values, bi<1 indicating their suitability to poor environments whereas, the hybrids IAN579-1 xRB464, IAN579-1xH1117, B59xJ2P7, B59xS.D., B59xRS810, B59xHS6, J34xCNH1012, GreggxRS875 and GreggxH1117 were suitable for richer environment as they were having higher value with bi>1. Patel and Pethani (1995) also reported similar results while studying 60 crosses and 19 parents of Asiatic cotton in three environments.

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Selection of Parents for Heterosis Breeding in Upland Cotton *Gossypium hirsutum* L.

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The genetic improvement of any crop will depend upon the choice of parents and scope of exploiting heterosis. Combining ability helps the breeder in selecting the desirable parents and crosses for exploitation in breeding programme. Present investigation was, therefore, carried out in half diallel crosses among well adapted varieties/genotypes to obtain information on combining ability effect vis a vis formulating an efficent breeding programme for getting higher seed cotton yield.

Eleven promising varieties/strains of diverse geographic origin of American cotton (*G. hirsutum*) *viz*. Jhorar, RS-875, HS-6, LRA-5166, RS-810, RST-9, H-1098, RS-2013, LH-1556, PIL-8 and K-34004 were chosen. A diallel set of 55 crosses excluding reciprocals was attempted during 1999-2000. The 66 genotypes (55 Fls+11 parents) were grown during the *kharif* of 2000-01 in a randomized block design with three replications at Central Institute for Cotton Research, Regional Station, Sirsa. Each entry was grown in two rows of 5.40 m length each spaced at 67.5 cm and 60 cm between rows and plants, respectively. Observations were recorded on seven characters *viz*. plant height, seed cotton yield, number of monopods, number of sympods, boll number, boll weight and ginning out turn. Ginning percentage was estimated in 100g sample of seed cotton yield obtained from each plot. Statistical analysis for combining ability was worked out by using method II and Model I of Griffing (1956).

The analysis of variance revealed highly significant differences among all the characters under investigation, indicating considerable genetic diversity among the parents selected. Combining ability analysis revealed that variances both due to general combining ability (gca) and specific combining ability (sca) were highly significant for all the characters except the latter for ginning out turn. (Table 1). However, the magnitude of gca variance was much larger than that of sca variance for all the traits, indicating the preponderance of additive genetic variance over the non-additive variance for the characters studied. Similar findings have been reported by Jagtap and Kholi (1993), Pavasia *et. al*. (1999) and Ahuja and Tuteja (2000).

General combing ability : The ultimate choice of parents in a breeding programme is generally based *per se* on the performance of parents and their Fls. The comparative performance of different parents in relation to gca effects (Table 2) revealed that among parents LH-1556 was found to be best general combiner for plant height, number of sympods, boll number, boll weight, ginning out turn and seed cotton yield, HS-6 for plant height, seed cotton yield number of monopods and boll weight, PIL-8 for plant height and number of sympods, and K-34007 for plant height, seed cotton yield, number of monopods, sympods and boll number per plant. In general, LH-1556 and K-34007 may be used in future for hybrid breeding programme.

Specific combining ability : Desirable specific combining ability of the crosses involving such parents seems to be mainly due to sca effects (Patel *et al*., 1997). These combinations may be excepted due to combination of favourable alleles contributed by their parents. However, the combining ability of parents may be considered as a reliable guide for prediction of yield potential of a hybrid. Verma *et al* (1991) and Ahuja and Tuteja (2000) also suggested that crosses between two high gereral combiners were not always best for the sca effects.

Nine hybrids showed significant positive sca effects for plant height, 17 for seed cotton yield, 12 for number of monopods, 10 for number of sympods, 6 for boll number and 2 for boll weight. However, for ginning out turn none of the cross combinations showed significant positive sca effect. The cross combinations Jhorar x RST-9 exhibited higher mean performance for seed cotton yield. Similarly, RST-9 x K34007 and Jhorar x RS-2013 exhibited higher significant sca effects for boll number; PIL-8 x K34007 and RS-875 x K 34007 for number of sympods, RS-875 x HS-6 and H-1098 x LRA-5166 for boll weight. The crosses exhibiting significant sca effects for yield and its component traits comprised of good and poor general combiners, however, one of the parents had good *per se* performance. It is expected that desirable transgressive segregates may be obtained if one of the parents in a hybrid is good combiner and additive gene action is present in good combiners. Complementary epistatic effects within F_1 act in the same direction so as to maximize desirable plant attributes (Ahuja & Tuteja, 2000). Therefore, the selection of parents for a crossing programme on the basis of phenotypic performance may not prove useful. So a modified selection type which involved recurrent selection may be successfully used for carrying over and conserving the breeding material for its desirable characters like seed cotton yield.

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NH-545 – a new High Yielding Variety of American Cotton for Marathwada Region of Maharashtra State

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Cotton is an important cash crop and is grown on an area of 6.5 lakh hectares in Marathwada region of Maharashtra state. Mostly, *intra-hirsutum* hybrid varieties are grown under rainfed condition which is subjected to erratic and uneven distributions of rainfall. Productivity of cotton is low (88 kg lint/ha) (Anonymus 2001-2002) and there is fluctuation in yield from year to year. One of the reasons of low productivity is growing of hybrid varieties on marginal lands and low input conditions on significant area. Full scale recommended production technologies are not adopted in the large chunk of rainfed cotton area, hence cultivatros are not able to harvest higher cotton yield. Therefore, there is a necessity of developing alternative *hirsutum/arboreum* varieties having early maturity, high yielding potential with stability in performance and resistance to pests and diseases that are suitable for growing under resource constraint situation and on marginal lands.

Concerted efforts made in this direction at Cotton Research Station, Nanded have led to development of two cotton varieties of *G. hirsutum viz*. NH 452 and NH 545. NH 452 was released during 1994-95 and has covered significant cotton area in Marathwada and vidrabha region. Farmers have been benefited from this variety due to its early maturity and resistance to biotic and abiotic stresses. NH 545 is an another variety having high yielding potential, stability in performance and moderate resistance to sucking pests and bollworms. This variety was released by state seeds sub committee of Maharashtra State during 2002 for large scale cultivation in Marathwada region.

Yield performance : Cotton variety, NH 545 was compared with NH 452 in regional trials conducted during 1994-95 to 2000-01. On the basis of average of 33 trials, it recorded 24.3 per cent higher seed cotton yield over NH 452 (Table 1). When compared with hybrid NHH 44 in 15 trials conducted over 4 seasons NH 545 recorded 12.1 and 25.4 per cent increase in seed cotton and lint yield, respectively under rainfed condition (Table 2). NH 545 was tested in All India Co-ordinated trials conducted in central Zone for five seasons i.e. from 1996-97 to 2000-01. Based on average of 34 trials, it recorded 69.5 per cent increase in seed cotton yield over zonal check, LRA5166 thereby indicating wider adaptability and stability in performace (Table 3). In adaptive trials conducted during 1999-2000 and 2000-01 on 26 farmers fields, NH 545 recorded 20 per cent higher yield over NHH 452 and *at par* yield with hybrid NHH 44 in 21 F. L. D.^{s} conducted during 2001-02 in Marathwada region.

Fibre quality : Full spinning test of NH 545 was carried out at C. I. R. C. O. T. Mumbai and it was found suitable for spinning to 30^{s} counts (Table 4). In micro-spinning test conducted on lint sample of 2001-02 season, NH 545 was found suitable for spinning to 40^{s} count (Table 4a). Thus, it may help fulfil bulk requirement of mills of lint with superior medium staple category.

Reaction to pests and diseases : As regards field reaction to sucking pests, NH 545 was found moderately resistant to jassid, aphid, thrips and whitefly. It was almost similar to NH 452 and superior to NHH 44 with regard to infestation of jassid and thrips (Table 5). NH 545 was found tolerant to bollworms and showed overall less infestation as compared to NH 452 and NHH 44 (Table 6). NH 545 was found moderately resistant to bacterial blight, a major disease and its field reaction was almost similar to other two varieties (Table 7). It also recorded low incidence of parawilt, grey mildew and anthracnose diseases under field conditions.

NH 545, being a stable genotype, seed production was easy and economical. Due to less cost of cultivation and higher yield as compared to hybrid, farmers may obtain higher net economic returns by growing NH 545.

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Inheritance Studies of Quantitative and Fibre Characters in Inter specific Cross of cotton

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Study of nature and magnitude of gene effects governing inheritance of the quantitative and fibre characters is of prime importance in formulating effective and efficient breeding methods used for cotton improvement programme. In the present study an attempt was made to estimate gene effects operative for control of quantitative and fibre characters by using generation mean of a *Gossypium hirsutum x G. barbadence* cross.

The material for the present study comprised of a inter specific cross of *G. hirsutum* and *G. barbadence* (i.e. RHC-001 x RHCb-001), parents, F_2, BC_1 and BC_2 populations. The material was grown in randomised block design with two replications during summer, 2001 season under irrigated condition at Cotton Improvement Project, M.P.K.V., Rahuri. The parents and F_1s were grown in a single row, the F_2s in six rows and back crosses in four rows each having 7.2 m length. The spacing was 90 cm between rows and 90 cm within a row. Five competitive plants from each parent and F_1 , 20 plants from F_2 and 15 plants from BC_1 and BC_2 in each of the replication were selected randomly for recording observations on days to 50 per cent flowering, days to first boll bursting, days to maturity, plant height (cm), bolls/plant, monopodia/plant, sympodia/plant, boll weight (g), seed index, lint index, ginning per cent, seed cotton yield (g), 2.5 span length (mm), micronaire, bundle strength (3.2), fibre quality index, uniformity ratio and extensibility percentage. Simple scaling test A, B, and C of Mather (1949) and joint scaling test of Cavalli (1952) were used to detect the presence of epistasis. Six parameter model given by Hayman (1958) to obtain estimate of m, d, h, i, j and l parameters was used.

Mean and standard errors are given in Table 1. Mean of F_1 exceeded that of better parent for plant height, boll weight, seed index, seed cotton yield, 2.5 span length, bundle strength, fibre quality index and extensibility percentage, indicating over dominance for these traits. Whereas, for rest of the characters the mean of the F_1 either tended towards mid parental value or parental value, indicating partial dominance. The F_2 means were smaller than F_1 mean in the cross for all the characters except days to 50 per cent flowering, days to first boll bursting, days to maturity and plant height indicating interaction of dominance and/or epistatic nature. For the characters *viz*; days to 50 per cent flowering, days to first boll bursting, days to maturity and plant height the F_2 mean tended towards F_1 mean which might be due to linkage or complementary factors or both.

The scaling test (Table 2) indicated that either A, B or C significantly deviated from zero for all the characters, indicating the presence of epistatic interactions. Joint scaling test also resulted into high chi-square value, indicating inadeauacy of three parameter model. Both scaling and joint scaling tests revealed the presence of epistasis in all characters. Six parameter model was fitted for separating epistasis. The estimate of gene effects presented in Table 3 revealed that dominance effect was more pronounced and in desirable direction for the inheritance of days to 50 per cent flowering and maturity. Among the interactions, additive x additive (i) was important. Opposite sign of h and l parameters indicated duplicate type of epistasis for these characters. Negative sign of significant effects indicated that the genes for earliness were dominant over the genes for lateness. Whereas, for days to first boll bursting additive and dominance x dominance effects were predominant.

Both additive and dominance gene effects (d) and (h) were of prime importance for plant height, but the contribution of dominace was greater than additive gene effect. Among the epistasis, dominance x dominance (1) was significant and positive. Opposite sign of h and l indicated duplicate type of epistasis. Bolls/plant and monopodia were both under the control of additive and dominance effects, however dominance effect was greater than additive effect. Among the interactions, additive x additive (i) was relatively more important component by virtue of its higher magnitude and desirable direction. Opposite sign of h and l indicated duplicate type of epistasis for monopodia. Additive effect was negative and significant for sympodia. Among interaction, dominace x dominace (l) was relatively more important being significantly higher in magnitude and in desirable direction. Positive sign of both h and l components indicated the presence of complementary epistasis for sympodia. Considering the magnitude and direction, dominace component (h), additive x additive (i) , additive x dominance (j) and dominance x dominance (l) were relatively important in the inheritance of boll weight. Positive sign of both h and l components indicated the presence of complementary epistasis.

Dominance effect was more pronounced and in desirable direction for the inheritance of seed and lint index. Among the interactions, additive x dominance (j) in case of seed index and i and j in case of lint index were important. Opposite sign of h and l parameters indicated duplicate type of epistasis for lint index. Additive as well as dominace effects were important for inheritance of ginning percentage and seed cotton yield/plant, dominance being more in magnitude. The fixable component additive x additive (i) was the most important interaction component being significant and in desirable direction. This suggested that selection for ginning per cent and seed cotton yield/plant were more fruitful if selection was delayed till dominance component was reduced due to selfing. Positive sign of both h and l components indicated the presence of complementary epistasis for both characters. Considering the magnitude and direction, dominace component (h), additive x additive (i), were relatively important in the inheritance of 2.5 span length, mocronaire, fibre quality index and extensibility percentage. Opposite sign of h and l parameters indicated duplicate type of epistasis for these characters. Both additive (d) and dominance (h) gene effects were significant but negative for bundle strength and uniformity ratio. Among the epistasis, dominance x dominance (i) was significant and positive for these traits. Duplicate type of epistasis played an important role as the sign of h and l were negative.

It is important in breeding programme that the choice of parents should be based on the type of gene action controlling seed yield and its components. The earlier reports of Ahmed and Mehra (2000), Atta *et al*. (1982), Dhillon and Singh (1980), Kapoor (1998) and Thombre *et al*. (1987) showed varying degree of additive and dominance gene effects for yield and its components similar to the present study. However, the magnitude of dominance effect was higher than additive effect for all the characters except days to first boll bursting, bundle strength and uniformity ratio indicating the possibility of heterosis breeding for improvement of these traits by selection in transgressive segregants. The epistatic effects, dominance x dominance (l) was predominant for first boll brusting, plant height, bolls/plant, sympodia, bundle strength and uniformity ratio while, both additive x additive and dominance x dominance were important for days to 50 per cent flowering, days to maturity, bolls/plant, monopodia, sympodia, boll weight, span length, micronaire, bundle strength, fibre quality index, uniformity ratio and extensibility percentage.

Most of the characters showed significant epistatic gene effects coupled with duplicate epistasis for almost all the characters, except bolls/plant, sympodia, boll weight, seed index, ginning per cent and seed cotton yield. It indicated that through effective selection, transgressive segregants could be obtained in subsequent generations. For bringing simultaneous imporvement in yield and its components, the epistatic effects suggest multiple crosses followed by inter-mating among desirable segregants.

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Variability, Heritability and Genetic Advance Studies in Cotton (*Gossypium hirsutum* L.)

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The average productivity of cotton is low in India as compared to other cotton growing nations of the world. Success of any crop improvement programme depends on the nature and magnitude of genetic variability existing in breeding material with which plant breeder is working. Effectiveness of selection directly depends on the amount of heritability and genetic advance in per cent of mean for that character. Hence, an insight into the magnitude of variability per cent in available associations of american cotton is of utmost importance to a plant breeder for starting a judicious breeding programme. Therefore, in the present investigation an attempt has been made to assess the variability in core collection of cotton.

The experimental material consisted of 38 dirverse accessions of american cotton. These accession were evaluated at Agricultural Research Station-Sri ganganagar during *kharif* 2001 in randomized block design replicated twice keeping row-to-row and plant-to-plant distances of 67.5 x 60cm, respectively. Recommended packages of practices were followed to raise the crop. The characters included in the investigation were: plant height (cm), number of monopodia/plant, number of sympodia/plant, number of bolls/plant, average boll weight (g) and seed cotton yield/plant (g). The data were recorded on five randomly selected plants in each replication. The genotypic coefficient of variation, phenotypic coefficient of variation, heritability in broad sense and genetic advance were estimated as per procedure cited by Singh and Choudhary (1979).

The estimates of genotypic coefficient of variation and phenotypic coefficient of variation were the highest for monopodia/plant (35.04 and 35.22), followed by number of sympodia/plant (30.25 and 30.29), number of bolls/plant (26.82 and 26.92), seed cotton yield/plant (25.56 and 26.98), average boll weight (13.59 and 13.88) and plant height (10.31 and 10.60), respectively. The variation in the values of genotypic coefficient of variation and phenotypic cofficient was narrow for all the traits studied which indicated less influence of environment in the expression of these traits. These observations indicated ample scope for improvement of above traits through breeding. The heritability estimates are the better indicators of heritable preportion of variation. The high heritability indicates the effectiveness of selection based on phenotype but, does not necessarily mean a high genetic gain for a perticular character (Swarup and Chougule, 1962). Hence, consideration of both, heritability and genetic advance is more important for predicting effective selection than heritability alone. In relation to this, almost all the traits exhibited high heritability accompanied with useful genetic gain. However, number of monopodia/plant exhibited the highest heritability coupled with highest genetic advance (99.00 and 71.81 per cent), followed by number of sympodia/plant (99.70 % and 62.23 %), number of bolls/plant (99.30% and 55.04%), seed cotton yield/plant (89.70% and 49.88%), average boll weight (95.90% and 27.42%) and plant height (94.60% and 20.66%), respectively. High heritability accompanied with high genetic gain indicated that these traits are under the control of additive gene action and directional selection for these traits in the generally diverse material could be effective for desired genetic improvement. These results are in agreement with the results of Kowsalya and Raveendran (1996), Ahuja and Tuteja (2001) and Girase and Mehetre (2002).

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A New Genetic Male Sterile Line in American Cotton : HGMS-1

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Conventional hybrid seed production in cotton is not feasible in north zone because of high cost. The main reasons for high cost are :

i) Short duration of flowering period in North zone (40-50 days) in comparison to central and south zone.

ii) Boll setting period coincides with cloudy weather i.e. less number of sunny days during monsoon period.

iii) High wages of labour.

The conventional hybrids developed earlier (HHH 81, Fateh, Maru Vikas, Om Shankar and LHH 144 in *hirsutum* and LDH-11 in *arboreum* cotton) could not gain much acreage due to high cost of hybrid seed production in north zone.

The hybrid seed production of cotton is feasible if suitable male sterile line is available. Moreover, for the successful development of hybrid an agronomic base of female line, preferably a male sterile line, as one of the parent of hybrid is desirable. With the development of male sterile line, the cost of hybrid seed production can be reduced drastically by eliminating the cost of emasculation and increasing the percentage of boll setting. Keeping in view the above objectives, a new male sterile line in *hirsutum* cotton has been developed at CCS HAU, Hisar. This new GMS named as HGMS-1 has been developed by involving B-59, an old GMS line and H 777, a commercial variety of Haryana state.

HD 266 – Male parent of Hybrid AAH-1

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Asiatic cotton, *Gossypium arboreum* L.race *bengalense* is cultivated in North zone and used for domestic and surgical purposes because of its coarseness. The trend of cultivation of hybrid cotton is increasing with the development of hybrid AAH-1 in North zone. The popularity of this hybrid among the farmers and seed growers is increasing because of its characters like earliness, good boll weight and number, and high yield in addition to easy hybrid seed production as the farmer can produce their own hybrid seed. The combination of these important characters is obtainted because of the male parent, HD266 is being used in the development of the hybrid AHH-1. The main characteristics of this male parent are given below :

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Growth, Yield and Quality of Cotton Cultivars as Influenced by Sowing Time and Mepiquat Chloride application

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Sowing time is the most important factor influencing growth and yield of cotton as it influences the duration of vegetative and reproductive stage of the crop. The early sown crop attains excessive vegetative growth that has a detrimental effect on fruiting behaviour of the crop while stunted growth is observed under late sown crop causing a drastic reduction in seed cotton yield. Manipulation of growth and development through exogenous application of mepiquat chloride play an important role in maintaining proper source-sink relationship under such situations (Briggs, 1980). Keeping this in view the present experiment was conducted to study the effect of various sowing dates and time of application of mepiquat chloride (MC) on growth, yield and quality of two American cotton cultivars.

The present experiment was conducted at Agronomy Farm, Punjab Agricultural University, Ludhiana during *kharif* , 2000. The experimental soil was loamy sand in texture with normal EC (0.27 ds.m), low in organic carbon (0.20%) and normal in reaction (pH 8.1). The soil was low in available nitrogen (213 kg N/ha). The experiment was laid out in split plot design with three replications. Combinations of two American cotton cultivars *viz*. F 846 and LH 1556 and four sowing dates *viz*. March 15, April 5 and 25 and May 15 were taken as main plot treatments. The subplot treatments comprised of single spray of MC 250 at ppm 80 DAS (days after sowing), double spray of MC 125 ppm at 60 and 80 DAS and an untreated control.

There was no significant difference between the two cultivars for the growth characteristics like plant height, LAI (leaf area index), dry matter accumulation (DMA), monopods/plant and sympods/plant. However, cultivar F846 recorded significantly higher flowers/plant and seed cotton yield than LH 1556 (Table 1). Cultivar F 846 was earlier in maturity than LH 1556. The two cultivars did not differ significantly for quality characters like seed index, lint index and ginning out turn (Table 2). The growth, yield and quality attributes of a particular cultivar are controlled by its genetic build up. The variation in the two cultivars for different growth, yield and quality attributes is because of their respective genetic build up. Plant height was reduced significantly with delay in sowing time (Table 1). The March 15 sown crop recorded 15.4, 31.9 and 54.4 per cent higher plant height than the crop sown on April 5, and 25 and May 15, respectively due to shortening of vegetative growth period in later sowing dates. The crop sown on March 15 and April 5 took 119 and 107 days for flower initiation as compared to 90 and 81 days taken by later sowing dates of April 25 and May 15, respectively. Other growth attributes like DMA and LAI were also reduced significantly with delay in sowing dates and at maturity March 15 sown crop recorded 22.4 per cent higher DMA than the crop sown on May 15. The higher DMA and LAI in earlier sowing dates of March 15 and April 5 were due to higher crop growth rate (CGR) of 10.05 and 9.1 g/m^2 day as compared to CGR of 8.0 and 7.45 g/m^2 day respectively for later sowing dates of April 25 and May 15 during grand growth period (60-120 DAS) of the crop. The length of growing season and heat units (calculated as the average of maximum and minimum temperatures minus 10°C) were primarily responsible for these responses. The value for these were computed as follows : March 15 sowing 220 days and 414.7 heat unit; April 5 sowing 206 days and 3913.7 heat units; April 25 sowing-190 days and 3534.3 heat units and May 15 sowing-171 days and 3112.3 heat units. These results are in conformity with the findings of Bilbro and Ray (1973) and Cathey and Meredith (1988). Number of monopodial and sympodial branches/plant were also significantly reduced with delay in sowing date from March 15 to May 15 (Table 1).

Crop planted on later sowing dates (April 25 and May 15) was inferior in flowers produced per plant, open bolls/plant, opening percentage, mean boll weight and ultimately in seed cotton yield as compared to earlier sowing dates of March 15 and April 5 (Table 2). Low yield realization in later sowings was primarily due to shortening of vegetative and reproductive phase. Also in later sowing dates, boll maturation took place under poor environmental conditions, particularly of night temperatures below 18°C and sunshine hours less than 9 hours/day, resulting in poor boll opening percentage and lower boll weight, thereby, reducing the seed cotton yield. However earliness index increased with delay in sowing from March 15 to May 15 due to shortening of growing season. The earlier sowing dates of March, 15 and April, 5 were also superior in quality characters like seed index and lint index as compared to later sowing dates of April, 25 and May 15 (Table 2). However sowing dates did not influence ginning out turn. Both treatments of MC significanlty reduced the plant height over control (Table 1). At maturity, double spray of MC 125 ppm at 60+80 DAS or single spray of MC 250 ppm at 50 DAS recorded 14.5 and 5.4 per cent less plant height than control, respectively. The height reduction with MC application is due to inhibition of gibberllin biosynthesis by MC, thus reducing cell elongation within the plant (Fletcher and Kirkwood, 1982). Similarly, MC 125 ppm at 60+80 DAS or MC 250 ppm at 80 DAS recorded 9.5 and 3.5 per cent lower DMA than control, which is due to inhibitory effect of MC on growth and development of the plant (Cothran *et al*., 1990). Application of MC 125 ppm at 60+80 DAS or MC 250 ppm at 80 DAS caused 9.6 and 6.5 per cent reduction in LAI over control because if its role in inhibition of leaf expansion (Erwin *et al*, 1979). However, MC application did not influence number of monopodial branches per plant but MC 250 ppm at 80 DAS significantly increased sympods/plant over control.

MC application of 250 ppm at 80 DAS or MC 125 ppm at 60+80 DAS significantly increased open bolls/plant by 8.9 and 4.3 per cent over control respectively (Table 1). It is attributed to the better partitioning of metabolites towards fruiting bodies due to growth retardation by MC (Wallace *et al*. 1993). Application of MC treatments failed to significantly influence boll opening percentage and boll weight. Single spray of MC 250 ppm at 80 DAS significantly improved seed cotton yield by 11.7 per cent over control due to reduced vegetative growth and diversion of assimilates towards fruiting bodies. Quality characters like GOT, seed index and lind index were not significantly affected by mepiquat chloride treatments (Table 2).

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Effect of Different Spacing and Mepiquat Chloride on Cotton (*Gossypium hirsutum* L.) Productivity

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Punjab, a leader in cotton production till recent time has trailed behind other states in average productivity since 1998. Sub optiomal plant population results in poor seed cotton yield and consequently less number of pickable bolls per unit area. On the other hand, high plant densities promote dense vegetative growth, resulting in shading of lower portions of the canopy which may contribute to increased fruit shedding and poor pest control (York, 1983). Alteration of plant canopy to allow more light penetration might help to reduce shedding of squares and young bolls. Reductions in plant height and leaf area can be obtained with the application of growth retardant namely mepiquat chloride (MC). Keeping these points in view, the present study was conducted to find out the effect of various spacing combinations and MC on growth and yield of cotton.

A field experiment on American cotton cultivar LH 1556 was conducted during *kharif* 2000 at Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana. The experiment was laid out in split plot design with combinations of two inter-row spacings (70 and 100 cm) and four intra-row spacings (20, 30, 40 and 50 cm) in main plots and two treatments of mepiquat chloride *viz*. single spray of 250 ppm at 80 DAS (days after sowing) and sequential spray of 125 ppm each at 60 and 80 DAS along with control as sub-plot treatments. The soil of the experiment field was loamy sand in texture, low in available N (209 kg/ha), medium in available P (19.8 kg/ha) and exchangeable K (250 kg/ha), normal in reaction (pH=8.0) and soluble salts (0.27 ds/m). The recommended package of practices was followed to raise the crop, except for the treatments under study.

Maximum plant height (131.5 cm) was recorded at closest spacing of 70x20 cm and it was statistically *at par* with spacings of 100 x 20 cm and 100 x 30 cm (Table 1). Different spacings had a non-significant effect on number of monopods/plant. Maximum number of sympods/plant was recorded by the widest spacing combination of 100 x 50 cm, which was statisticaly *at par* with all other spacing combinations of the crop sown at rows spaced 100 cm apart but significantly more than the different spacing combinations of the crop sown in 70 cm wider rows. The lesser sympods/plant under closer spacings was due to delay in formation of first sympodial branch causing excessive vegetative growth of the crop (Buxton *et al.,* 1977). Similarly maximum number of pickable bolls/plant was produced by the crop sown at the widest spacing of 100 x 50 cm. The closer spacings were inferior in pickable bolls/plant because of abortion of fruiting froms on lower sympods due to the shading of lower portions of the canopy. Different spacing combinations failed to exert any significantly influence on the boll weight. However, maximum seed cotton yield (23.7 q/ha) was picked from the crop sown at the spacing of 70 x 30 cm which was statistically *at par* with all other spacing involving 70 cm wider rows but significantly higher than the spacing combinations involving rows that were spaced 100 cm apart. It was due to higher plant population resulting in higher productivity per unit area under closer rows spacings.

Foliar application of MC caused a significant reduction in plant height than control. Application of MC 250 ppm at 80 DAS or MC 125 ppm each at 60 and 80 DAS resulted in 11.2 and 8.1 per cent reduction in plant height than control (130.8 cm), respectively. This is due to the fact that MC acts as antigibberellin and thus inhibits the biosynthesis of gibberellic acid, a growth promoter known to increase the cell elongation (Fletcher and Kirkwood, 1982). Application of MC either as a single spray or double spray did not exert any significant influence on the number of monopods/plant. Foliar application of MC 250 ppm significantly increased the number of sympods/plant by 11.0 per cent over control whereas its sequential application at reduced rates (125 ppm) reduced the sympods/plant by 11.0 per cent. Similarly, foliar application of MC 250 ppm increased the number of bolls picked/plant from control by 42.8 per cent and sequential application of 125 ppm each at 60 and 80 DAS reduced the number of bolls per plant by 19.0 per cent from control (17.3). However, boll weight was not influenced with the application of MC. Application of MC 250 ppm at 80 DAS resulted in seed cotton yield of 21.6 q/ha which was 13.7 per cent more than control, while its application of 125 ppm each at 60 and 80 DAS resulted in a reduction of 9.5 per cent in seed cotton yield from control.

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Performance of *hirsutum* Cotton under Different Intra Row Spacing

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Plant population is one of the practices for efficient utilization of available production factors. In wider spacing there is reduction in yield due to less plants per unit area where as in dense spacing there is reduction in yield due to competition within plants. So there must be equalibrium at which the increase in production due to increase in plant density must compensate reduction in production of individual plant. The determination of optimum plant spacing is an important factor for increasing the yield per unit area. Keeping this in view, the present investigations were undertaken to study the performance of some promising varieties of cotton in relation to different plant spacing.

The experiment was conducted at Research Farm of PAU, Regional Station, Faridkot during *kharif* 2001. The soil of experimental field was sandy loam having pH 8.21, organic carbon 0.21%, available phosphorous 14 kg/ha and potassium 227 kg/ha. The experiment was laid out in split plot design with three replications. The treatments comprising of five varieties (LH 1556, F 1378, F 1861, F 1946 and F 1914) in main plot and two intra row spacings (67.5 x 30 cm and 67.5 x 45 cm) in sub plots. The crop was sown during second fortnight of April by using dibbling method. Recommended doses of nutrients (N : 75 kg/ha and P_2O_5: 30 kg/ha) were applied. All other recommended production and protection practices were uniformly applied. The rain received during the crop season was 241mm.

The results given in Table 1 revealed that the plant height and boll weight were found to differ non-significantly among all varieties. Significantly higher seed cotton yield, yield/plant and number of bolls/plant were observed in variety F 1946 which was *at par* with F 1861. These two varieties were significantly better than F 1914, LH 1556 and F 1378. The increase in seed cotton yield of F 1946 was 4.8, 14.8, 17.0 and 20.0 per cent over F 1861, F 1914, F 1378 and LH 1556, respectively.

Significant higher number of bolls/plant was observed with a spacing of 67.5 x 45cm as compared to a spacing of 67.5 x 30cm, however, the differences between the two intra row spacing in respect of other characters and yield were non significant. Similar trend was observed by Narkhede *et. al*. (2000). Although there was increase in yield/plant in case of spacing 67.5 x 45cm but due to less number of plants per unit area, it was *at par* with spacing at 67.5 x 30cm. All the interactions between spacing and varieties were non significant. This was in conformity with finding of Rao and Setty (2000).

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A Promising Strain of *Trichogramma chilonis* Ishii for Use in Biological Control Programme Against *Helicoverpa armigera* (Hübner)

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Species and/or strains of *Trichogramma* collected from the local hosts or areas are the first choice for using them in a biological control programme. *Trichogramma chilonis* Ishii is the most frequently encountered species in the Indian sub-continent and south-east Asia (Nagarkatti and Nagaraja, 1977). In Haryana, *T. chilonis* has been reported to occur in different agroecosystems (Ram *et al*., 1998). Its inundative releases against cotton bollworms in cotton crop were also found promising in controlling these pests in Haryana (Ram *et al*., 1997). In a recent study it was found that *T. chilonis* caused heavy egg parasitisation of *Acherontia styx* Westwood, a pest of sesame, and there was an increased parasitisation of *Helicoverpa armigera* (Hübner) eggs by this parasitoid on cotton intercropped with sesame (Ram *et al*., 2002). In view of the above observations it was considered worthwhile to study some desirable biological attributes of this strain in the laboratory so as to explore the possibility of using it in the biological control programme against *H. armigera*.

The parasitoid adults were obtained by collecting the parasitised eggs of *A. styx* from sesame intercropped with cotton and rearing them in the laboratory at 27±2°C. The adults were provided with freshly laid eggs of *Corcyra cephalonica* Stainton for parasitistion. Honey streak on paper pieces was provided as food for adults. Observations were recorded on different attributes, namely, fecundity, female longevity, adult emergence, sex ratio, tolerance to low temperature etc. For studying fecundity and female longevity newly emerged and mated females were isolated and confined in glass vials. These were provided daily with about 80 eggs of *C. cephalonica* till death. The female longevity was recorded from emergence of the female till death. Number of eggs parasitised by each female during its life time were counted and the total fecundity was computed. Adult emergence and sex-ratio (per cent females in the progeny) were recorded by counting total number of males and females emerging from 590 parasitised eggs.

To study the effect of storage of parasitised eggs at low temperature on the emergence of the parasitoid, 100 five-day old parasitised eggs were kept in a refrigerator at 10±1°C temperature and 75±5 per cent relative humidity for 15, 22, 29, 36 and 43 days keeping four replications. The eggs were taken out from the refrigerator at the above intervals and were kept under observation at room temperature to note adult emergence. The data were converted into percentage and transformed into angular values. These were subjected to analysis of variance using Complete Randomized Design.

Data presented in Table 1 indicated that on an average a female lived for 18.1 days (range 5-27 days) and parasitised 141.2 egg hosts (range 50-233 egg hosts). First day fecundity was 29.2 egg hosts parasitised per female (range 8-40 egg hosts). The adult emergence was 91.9 per cent and the progeny consisted of 86.9 per cent females.

Storing five day old parasitised eggs at 10±1°C and 75±5 per cent relative humidity for 15, 22, 29, 36 and 43 days in the refrigerator did not indicate any adverse effect on adult emergence (Table 2). Earlier studies indicated that *T. chilonis* could be safely stored in the refrigerator for 22-29 days (Khosa and Brar, 2001; Singh *et al*., 2001). The differences in the extent of adult emergence from the parasitised eggs stored at low temperature in the present studies and those reported earlier could be due to differences in storage conditions especially relative humidity and also the strain of the parasitoid.

In view of the fact that fecundity, adult longevity and sex ratio are the key biological parameters of a strain favouring its probable field performance, the present strain had a good score in this regard. Hence, this strain holds good promise for further evaluation against *H. armigera* under field conditions.

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Studies on Seasonal Abundance of Cotton Pink Bollworm, *Pectinophora gossypiella* (Saunders) using Sex Pheromone Delta Traps and Influence of Weather Parameters on Trap Catches

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Among a dozen pests which are mainly responsible for most of the losses in seed cotton yield, the bollworms *viz*., spotted bollworm, American bollworm and pink bollworm are the most important because they damage mainly the reproductive parts of cotton plant. Among them pink bollworm (PBW) *Pencinophora gossypiella* (Saunders) (Lepidoptera : Gelechiidae), is considered as a mojor pest in many parts of the world including India. It is reported to cause severe boll damage (Korat, 1991; Sangareddy and Patil 1977) in northern Karnataka. Monitoring of pests by pheromone traps gives necessary information for need based application of pesticides. Therefore, an attempt was made to know the seasonal activity of this pest using sex pheromone delta traps.

The present investigations were undertaken at Regional Research Station, Raichur-584 101, Karnataka during 2000-2001. Delta pheromone traps baited with gossyplure were used for trapping pink bollworm male moths. Three such traps were installed in different cotton blocks at 200 m apart during 2000-2001 crop season. Trap catches were recorded twice a week and were averaged as per International Standard Week (ISW). To maintain trap efficiency lure was changed after every 15 days and moths trapped were removed after counting.

Temperature (maximum and minimum), relative humidity (morning and afternoon) and rainfall data were collected from the meteorological unit of Regional Research Station, Raichur. Correlation analysis was carried out to know the influence of weather parameters on pheromone trap catches of pink bollworm moths. Weekly observation on field infestation in flowers (rosetted flowers), and green bolls was recorded and computed to per cent basis and correlated with the pheromone trap catches.

Monitoring of PBW moth activity with delta sex pheromone traps revealed that the pest remained active throughout the year (Table 1) with maximum initial activity in the month of September though the crop had not reached reproductive stage indicating "sucidal emergence" as reported by Sangappa *et al*. (1985), Sangareddy and Patil (1997) and Panchabhave *et al*. (1999). Later, higher moth activity was noticed from 2nd week of November and continued till last week of March. From March onwards the trap catches declined gradually. During the observation period from 14th standard week (first week of April 2000) to 22nd standard week (fourth week of May 2001) it was found that six peak pheromone trap catches were recorded: on 30th (fourth week of July), 35th (fourth week of August), 48th (fourth week of November) 50th (second week of December), 1st (first week of January) and 10 (first week of March) standard week. These observations are in close agreement with those of Sangappa *et al.* (1985), Korat (1991), Sangareddy and Patil (1997) and Panchabhavi *et al*. (1999) from Karnataka. The moth catches ranged from 2 to 173 per week with highest trap catches in second week of December (50th standard week).

Present investigations revealed that the effect of maximum and minimum temperature (°C) was negatively and significantly correlated with trap catches, while positive but non-significant correlation was established between morning and afternoon relative humidity. Total rainfall was negatively correlated but number of rainy days in that particular period was positively and significantly correlated (Table 2). These findings are in close agreement with the reports of Sangappa *et al*. (1985), Gupta *et al*. (1990), Korat (1991) and Sangareddy and Patil (1997). The infestation of PBW followed the trap catches in the present study *i.e*., after one week of emergence positive and significant correlation was noticed between the trap catches and incidence on flowers. Similarly two and three week after moth emergence incidence on green bolls and open bolls was positively related with moth catch. Current findings are in line with the reports of Sangareddy and Patil (1997) and Buchelose *et al*. (1999).

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Studies on Management of Cotton Pink Bollworm, *Pectinophora gossypiella* (Saunders)

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Key words : Cotton, pink bollworm, management tactics

Pink bollworm, *Pectinophora gessypiella* (Saunders) (Lepidoptera: Gelechiidae) is a serious pest of cotton in the country. A wide range of planting dates extends the reproductive period of the crop and thus helps in the multiplication of the pest. Narayanan (1962) claimed 75-100 per cent damage by this pest if unchecked. Sangareddy and Patil (1997) from Karnataka reported the incidence ranging from 6 to 8.40 per cent on locule basis, where only insecticidal sprays were undertaken. The present investigation were conducted to know the cost effectiveness of different management tactics against cotton pink bollworm (PBW).

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Response of American Cotton Genotypes to Leaf Curl Virus Infection under Natural Epiphytotic Conditions

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Among the many factors responsible for decrease in area, production and productivity of cotton in Punjab, cotton leaf curl virus (CLCuV) is a major limiting factor. Cotton leaf curl disease (CLCuD) was first reported on american cotton in Abohar area of Punjab (*Kapur et al.*, 1994). The disease had appeared in serious form on almost all cultivars of *G. hirsutum* in Punjab during 1997. Now cotton leaf curl virus has become the most important disease problem in northern cotton zone of the country. Cotton leaf curl disease is caused by a *gemini* virus of genus *Begomovirus* and transmitted by cotton whitefly (*Bemisia tabaci*). Damaging potential of CLCuD on seed cotton yield and quality of lint on variety HS-6 has been reported upto 81.4 per cent in maximum disease grade. In Pakistan, it is occuring and causing heavy production losses almost every year since 1987 (Hameed *et al*., 1994). Some long term and short term strategies (Narula *et al.*, 1999) have been worked out for effective management of this disease. However development of resistant hybrid/variety is most effective. The present study was undertaken to identify the resistance genotypes against CLCuV with better yield potential.

A total of 88 american cotton genotypes were evaluated in a randomized block design against cotton leaf curl virus under natural epiphytotic conditions at P.A.U. Regional Research Station, Bathinda during *kharif* 1998-99. A rating scale of 0-4 grade was used for recording observations on disease severity and data on disease incidence were recorded on the presence/absence of disease symptoms. The initiation of disease is characterised by small vein thickening (SVT) type symptoms on young upper leaves of plants. The disease is further characterised by upward curling of leaves. Later, formation of cup shaped or leaf laminar outgrowth called enations appear on the underside of leaves. In severe cases and in plants affected in early age, reduction of internodal length leading to stunting and reduced flowering/fruiting is observed. On the basis of percentage disease incidence, genotypes were categorized as highly resistant, moderately resistant, susceptible and highly susceptible.

Out of 88 genotypes evaluated, seven *viz*. LHH144, LRA5166, RS2013, F1794, PIL8, PIL43 and P12-1 were found free from cotton leaf curl virus disease incidence which were termed as highly resistant (Table 1). However, disease severity in rest of 81 genotypes ranged from 0.19 (LH1556) to 33.2 (Lakhewali) per cent

(Table 2). Out of these genotypes, 47 genotypes showed disease incidence of <5 per cent where disease severity ranged between 0.19 to 2.16 per cent and were termed as resistant. Out of these 5 genotypes *viz*. H1185, Pusa325, LH1556, Anjali and LH1896 showed<1 per cent disease incidence and severity with maximum disease grade of 1 or 2. So it can be said that these genotypes possess good degree of resistance. Cotton leaf curl incidence of <1.5 per cent in genotypes Anjali and LH1556 was earlier reported by Singh and Yadav (1999). Eighteen genotypes were found moderately resistant with 5 to 10 per cent infection with disease severity range of 2.00 to 3.73 per cent. Among all these genotypes, a total of 16 genotypes showed susceptible reaction to CLCuV from which, six genotypes were susceptible with disease infection of 10 to 20 per cent whereas ten were highly susceptible with more than 20 per cent infection. In these genotypes the severity of the disease was so high (5.36 to 33.2%) that more than 60 per cent genotypes were found to be highly susceptible to CLCuV i.e. all the plants were diseased showing bunchy top symptoms and maximum disease grade. The disease appeared in serious form on almost all cultivars *viz*. RST-9, HS-6, F-1378, LH-900, F-846, F-1054, F-505 and underscriptive cultivars *viz*. Jhurar, PL-104 and Lakhewali. Kapoor *et al.* (1994) also reported that F-846 and undescriptive *viz.* Jhurar, PL-104 and Lakhewali were highly susceptible to this disease. In adjoining state of Rajasthan at Sriganganagar, high CLCuV incidence was reported on Pakistani narma, F-846, RST-9 and LH-900. Singh *et al.* (1994) also screened several cotton genotypes against CLCuD in screen house conditions and revealed high incidence of disease on Jhurar, F-846, LH-900 and RST-9. Thus cultivation of varieties *viz.* F505, F1054, LH-900 and undescriptive cultivars *viz*. Jhurar, PL-104, Lakhewali and Sikander Raja P-36 should be discouraged as these were found to be highly susceptible to this disease in this study and most of the earlier studies. The result highlighted that elite genotypes, which possessed good resistance and can be used in the development of agronomically good varieties/hybrids of american cotton.

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Biological control of root rot of cotton caused by *Rhizoctonia solani*

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Rhizoctonia solani is a destructive plant pathogen having unlimited host range. Though various attempts have been made to control this disease by the applications of chemical and cultural methods (Mathur *et al*., 1971) but the success has been limited. Isolates of *Trichoderma* spp. have been found hyperparasites on *R. solani* and it has potential to control *R. solani* under controlled conditions (Yadav *et al.*, 2000). The present attempts were made to screen the rhizosphere mycoflora of diseased and healthy cotton plants to find out their antagonistic behavior against *R. solani*.

Soil samples collected from each location were mixed, homogenized and dried for two hrs and one gram of this soil was subjected to serial dilutions. Fungi obtained were cultured on Potato Dextrose Agar (PDA) medium and maintained on specific media for further characterization.

Screening of bioagents for their antagonistic ability :

Under laboratory conditions : Antagonistic ability of the selected micro-organisms in dual culture with *R. solani* was compared. Five mm mycelial disc were cut from the margin of three days old culture of *R. solani* and test organisms (antagonists) with the help of sterilized cork borer and placed four cm apart on PDA and incubated at 28±2°C. Periodical observations on the growth of the organisms were recorded.

Under screen house conditions : Isolates of *T. harzianum, T. viride, G. virens* and *Aspergillus* sp. were cultured on wheat bran saw dust (WBSD) medium (Mukhopadhyay and Chandra, 1986). The preparations of each bioagent were added @ 500 mg/kg soil in sterilized soil inoculated previously with *R. solani* in pots.

After five days of soil inoculation with antagonists, pots were sown with ten delinted cotton seeds (cv. HS-6) along with control (without antagonist) with three replications. After germination, observation on root rot incidence was recorded up to 30 days.

Data presented in Table 1 reveals that isolate of *Aspergillus* sp. exhibited minimum growth inhibition (48.15%) as compared to other isolates. The maximum growth inhibition (89.26%) was recorded from *T. viride*, followed by *G. virens* (82.60%). *Trichoderma harzianum* isolate was also found effective antagonist which showed 76.11 per cent growth inhibition of *R. solani*. *Trichoderma viride, G. virens* and *T. harzianum* exhibited antagonistic potential by completely over growing the colony of *R. solani*. These observations get positive support of several workers (Sivan *et al.*, 1984 and Yadav *et al.*, 2000) who recorded the antagonistic activity of *Trichoderma harzianum* against *R. solani*.

As revealed by data presented in Table 2, the isolate *T. viride* gave maximum protection of disease (72.08%), followed by *G. virens* (64.94%). While *Aspergillus* sp. and *T. harzianum* exhibited 45.88 and 57.08 per cent disease control, respectively. This observation gets positive support of the work done by Tu (1981) particularly in respect of isolate of *G. virens* against *R. solani*.

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n vitro Evaluation of Chemicals and Bioagents against *Alternaria macrospora* Zimm. Causing Leaf Spot of Cotton

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Among the major factors responisble for lower yields, diseases play an important role in reducing the yield of seed cotton and deteriorating the quality of lint (*Jakhar et al*. 1977). Alternaria leaf blight caused by *Alternaria macrospora* Zimm. of cotton is widespread and often causes serious economic losses to the tune of 40 per cent and becomes more serious in the high humid condition. The pathological analysis of the infected leaves and other plant parts (bolls, stem etc.) often showed the presence of the pathogens in complex. Work done at different places on control revealed that fungicides were effective in disease control, whereas the possibility of *Trichoderma* spp. has also been explored *in vitro* keeping in view the seriousness of disease.

Five fungicides *viz*., Thiram, Captan, Blitox-50, Dithane M-45, Ziram were used at 0.25 per cent concentration. The biocontrol agent *viz*., *Trichoderma viride, T. longiforum, T. harzianum, T. coningii,* and *T. hamatum* were tested for their antagonistic properties by "Direct Bit placement method" (Brodbent *et al.* 1971). The quadruplicate PDA plates were inoculated with 5 mm diameter bit of 7 days old growth of test organism at one corner of plate and subsequently inoculated with 5 mm diameter bit of 7 days old growth of the fungus at opposite corner of the plates keeping 15mm distance from periphery. The inoculation of pathogen alone in the centre served as control. The plates were incubated at 29 ± 1°C for 7 days. After seven days of incubation the growth of fungus was measured in each plates and the per cent growth inhibition of intersecting colonies was calculated.

Poisoned food technique was followed to evaluate the fungicides. A basal medium Potato Dextrose Agar (PDA) was prepared and 100 ml quantity was poured in 250 ml Erlenmeyer flask and sterilized after sufficient cooling. To each flask measured quantity of different fungicides as per the recommended concentration was added. Flasks were then shaken thoroughly to ensure the even distribution of fungicides. The contents of each flasks were poured in each sterilized quanruplicate plate for each of fungicides. These plates were inoculated with 5 mm bit of *A. macrospora* of 8 days old culture grown on potato dextrose agar at the centre of each plate. These were incubated at 29 ± 1°C for 8 days. Plates with potato dextrose agar medium without fungicides served as control. Observations on colony diameter and sporulation were recorded 8 days after inoculation. Radial growth was measured and results were expressed as per cent inhibition of mycelial growth over control.

It was revealed from the data that all the speices of *Trichoderma* were inhibitory to test fungus (Table 1). *T. viride* was effective in controlling the growth to the extent of 75 per cent followed by *T. koningii* (69.16%), *T. harzianum* (67.50%), *T. hamatum* (61.66%) and *T. longiforum* (16.66%). Thus *T. viride* was the best antagonist. These results were more or less similar to the results reported by Chattanavar *et al*. (1988), Lokesh and Hiremath (1988).

The efficacy of different chemicals *in vitro* was studied and was observed that Thiram, Captan, Copper oxychloride (blitox) Dithane M-45 and Ziram at 0.25 per cent concentation were effective in inhibiting the growth and sporulation. The results obtained during study were in agreement with the results of Bhaskaran and Shanmugam (1973) and Padule and Shinde (1989).

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Cotton Development Programme by Government of India in KBK districts of Orissa

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The undivided districts of Koraput, Bolangir and Kalahandi (popularly known as KBK districts) form one such region of Orissa where incidence of poverty is the highest in the State. In fact, this region with about 68.8 per cent of its rural people below poverty line is perhaps the poorest region in the country. Several other parts of western Orissa are also socially and economically depressed. These regions are also frequently visited by natural calamities like severe drought, floods etc. Heavy incidence and persistence of poverty in these regions has been a cause of concern for the state government as well as Government of India. However, ad-hoc approaches adopted in the past to develop these regions did not yield the desired results. Therefore, in consultation with the Government of India, state government has adopted a special area development approach for these regions with a view to focus attention on them and to accelerate development.

The state is non-traditional state in the production of cotton. The present status of the crop production and productivity is *at par* with national average inspite of adversities like rain fed situation, small and fragmented holding, biotic and abiotic stress, resource constrants and non-regulated market system. The favourable agro-climatic condition has greatly contributed to the quality and productivity of cotton in the state. This resulted in sharp increase in the area under cotton in the state.

The area production and yield during the 1980-81, 1998-99 and 1999-2000 and 2000-01 in the state are as under:

Year	Area (000 ha)	Production (000 bales)	Yield (kg/ha)
1980-81	4	4	170
1998-99	29	53	311
1999-2000	38	61	273
2000-2001	40	65	276

The area coverage during 2001-02 is expected to about 63000 ha and it may reach 75000 by the year 2003-04. The cotton in the state is mostly confined to the western dry region i. e. KBK districts now re-organised into eight districts i. e. Koraput, Bolangir, Kalahandi, Nawapara, Sonepur, Malkangiri, Rayagada, Nawrangpur. The cotton in this region is almost 70% of the state total. The KBK districts are most sutiable for cotton cultivation. In fact the cotton produced in the recent years in these districts is of high quality. These districts have mostly black soils, which make cotton cultivation more profitable and therefore this crop has great potential in the area. Annually the rainfall of these areas is between 1296 mm to 1522 mm. The cotton belt of state received about 85-90% of the rainfall from May to October with average 63 rainy days (Sahoo, 2001). It is expected that by the end of 10th Plan, area may cross even one lakh ha.

The district wise potential area (Sahoo, 2001) is given below:

Name of the District	Potential area for cotton (ha)
Nowarangpur	35000
Royagada	36000
Koraput	10000
Kalkangiri	10000
Kalahandi	36000
Nuapada	10000
Bolangir	36000
Sonepur	7000

The major constraints faced in cotton cultivation in the area are as under:
Inadequate seed supply.
Lack of water for irrigation.
Congenial condition for disease pest spread.
Need for transfer of technology as the crop is new to area.
Marketing of produce.

In view of potential of the crop, the Government of India and the State Government since 8th Plan have encouraged the farmers for the cultivation of cotton through the Centrally Sponsored Scheme for Intensive Cotton Development Programme (ICDP-Cotton). The information on physical and financial targets set for KBK districts during 1998-99 to 2001-02 for the components; Demonstration, Distribution of Certified seed, IPM Demonstration, Plant Protection Equipments, Distribution of Sprinkler Sets and Framers training are given in Table-1. The expenditure on most the activities was shared by GOI and State Government on 75:25 basis. The assistance provided by Government of India is briefly given in Table-2. As there is still potential to increase the area in the state, the ICDP-Cotton may be continued during the 10th Plan as well. Therefore, various activities are being proposed under the ICDP-Cotton for KBK districts during 2002-03. The expenditure on most of the activities has been proposed to be shared by GOI and State Government on 90:10 basis. The assistance proposed is briefly as under:

* Supply of breeder seed : full cost.
* Production of foundation and certified seed limited to Rs. 50/kg and Rs. 15/kg respectively. The seed distribution will be @ Rs. 20/kg.
* Farmers field school @ Rs. 20,000/each; Seed treatment with insecticides @ Rs. 40/kg; Pheromone/light traps @ Rs. 300/ha.; Bio-agents @ Rs. 900/ha.
* Supply of sprayers @ Rs. 800 for manual, Rs. 2000 for power and 10,000 for tractor operative.
* Sprinklers @ Rs. 10,000-15,000 per ha, drip Rs. 25,000-30,000 per ha.
* Demonstration @ Rs. 2000-2 lakh, training Rs. 10,000- one lakh.
* Contingencies etc.

The physical and financial targets suggested for various activites of the ICDP cotton during 2002-03, for KBK districts is given in Table-3. The total amount required would be Rs. 153.85 lakhs consisting of Rs. 138.45 lakh as Central share and Rs. 15.40 lakh as State share. With the evident of Technology Mission on Cotton, Orissa State as whole and KBK districts in particular will be benefitted through four Mini-Missions. Spade work done by Government of Orissa will get boost through TMC in improvement of area, production, productivity and quality of cotton. Already a centre has been established under AICCIP project, ICAR for generating location specific technologies at OUAT, Umerkot w.e.f., January, 2000 under MM-I. Under MM-II of TMC technology dissemination will be done by the State Government with the financial assistance provided by Government of India Three market yards have already been sanctioned for development under MM-III. More market yards would be developed during 10th Plan of TMC. Although only one ginning factory has approached for modernisation under TMC, it is hoped that remaing factories also will avail assistance and new factories will come up under TMC (Basu, 2001).

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Resource Productivity, Resource Use Efficiency and Factor Share in Irrigated NHH-44 Cotton Production

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Cotton is India's principal crop which has been providing livelihood to several million farmers and several million people in trade, processing and textile industry as well as edible oil industry. Maharashtra is the largest cotton producing state which is contributing 34.80 per cent the the country's area under cotton (8.53 million hectares). However, out of 2.96 million hectares under cotton in the state, only 0.09 million hectares are under irrigated condition that is about 3 per cent. It is a fact that per hectare productivity of seed cotton can be increased by growing coton crop under irrigated condition. In order to increase the cotton production, the scarce resources like land, labour and capital must be employed with consideration of their marginal productivities. It is also needed to know the highest monetary return per unit of input in the cotton production. Keeping in view the above aspects, the study of resource productivity, resource use efficiency and factor share in irrigated NHH-44 cotton porduction was undertaken.

Selection of farms : Irrigated NHH-44 cotton farms were selected from Marathwada region of Maharashtra through multistage sampling design as follows. In the first stage, Parbhani district was purposely selected because of its predominance in area of cotton. In the second stage, Parbhani tehsil was also purposely selected because of its superiority in area of cotton under irrigated condition. In the third stage, 8 villages were selected on the basis of high area under NHH-44 cotton. In the fourth stage, from each of selected villages, the list of irrigated NHH-44 cotton growers with area under the cotton crop was obtained. Obviously, six NHH-44 cotton farms were selected randomly from each of the villages. Thus, 48 sampled farms of irrigated NHH-44 cotton growers were selected for the present investigation.

Collection of data : Cross sectional data were collected from 48 NHH-44 cotton growers by personal interview method with the help of presented schedule. Data were related to seed cotton yield, area under NHH-44 cotton, hired and family labour utilization, use of bullock labour, use of nitrogen, phosphorus and potash, and use of manure. Data pertained to the year 1998-99.

Analysis of data : On the basis of goodness of fit (R^2), Cobb-Douglas production function (Acharaya and Madnani, 1988, Ahuja, 1995) was used to determine the resource productivity and resource use efficiency as well as factor share in irrigated NHH-44 cotton production. Cobb-Dougles Production function takes the following mathematical form.

$$Y = aX_1^{b1} . X_2^{b2} ....X_n^{bn} . e^u$$

The data were subject to functional analysis by using the following form of equation.

$$\hat{Y} = aX_1^{b1} . X_2^{b2} . X_3^{b3} . X_4^{b4} . X_5^{b5} . X_6^{b6} . X_7^{b7} . X_8^{b8}$$

Where

$\hat{Y}$ = Estimated seed cotton yield in quintals on farm, a = Intercept, bi = Regression coefficients of resources (i = 1, 2,.....8), X_1 = Farm size of irrigated NHH-44 cotton (ha), X_2 = Hired human labour (man days), X_3 = Family human labour (man days), X_4= Bullock labour (pair days), X_5 = Nitrogen (kg), X_6 = Phosphorous (kg), X_7 = Potash (kg) and X_8 = Manure in (qt)

The function was transformed into log-linear form as follows,

$$\text{Log } \hat{Y} = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + b_7 \log X_7 + b_8 \log X_8.$$

The test of significance of eight regression coefficients was conducted by computing 't' values and compared with table values at n-k-1 degrees of freedom.

Terms and concepts : Terms and concepts which were frequently used in the present study are described as follows.

Resources productivity : It refers to marginal physical product with respect to added unit of input. It is denoted by MP = bY / X in Cobb-Douglas production function. Where, b is elasticity of production, Y is geometric mean of seed cotton yield and X is geometric mean of respective input.

Marginal value product (MVP) : It refers to the product of MP and Py, where, Py is the price of seed cotton per quintal.

Resource use efficiency : It refers to magnitude of MVP with respect to unit of a particular resource divided by per unit price of that resource.

Factor share : It refers to the share of resource in total production where other resources remained constant. It can be calculated by the multiplication of geometric mean of input and marginal value product, divided by total production receipt and multiplied by 100.

Cobb-Douglas type of production function was fitted to the data and partial regression coefficients of various explanatory variables in irrigated NHH-44 cotton production were estimated.

The regression coefficient of area of NHH-44, cotton (0.440) was highly significant at 1 per cent level of probability (Table 1). It inferred that if use of area of the NHH-44 cotton was increased by 1 per cent from its geometric mean level, that would increase the production of seed cotton by 0.44 per cent. In other words, if the cotton area was increased by one hecatre from its geometric mean level by keeping other inputs as constant at their geometric mean levels, the production of seed cotton would increase by 7.6 quintals that could be resource productivity with respect to land under cotton. Similarly, the regression coefficient of nitrogen (0.33) was significant at 5 per cent level. It was inferred that if use of nitrogen was increased by 1 per cent from its geometric mean level, the production of seed cotton would increase by 0.033 per cent. In other words, if the use of nitrogen were increased by 1 kg it would lead to increase in the seed cotton yield by 0.72 kg that was resource productivity with respect to nitrogen. In the same way, regression coefficient of manure (0.11) was also significant at 5 per cent level. It could be concluded that if use of manure was increased by one per cent from its geometric mean level, the production of seed cotton would increase by 0.11 per cent. In other words, if the use of manure was increased by one quintal, it would lead to increase in the seed cotton yield by 12.280 kg that could be resource productivity with respect to manure. Regression coefficients of other variables were non-significant. The value of R^2 was 0.90, which indicated that 90 per cent variation in the seed cotton yield was explained due to variation in all independent variables. The sum of elasticities was 0.833 which showed decreasing return to scale. The results are in conformity with the results of Das (1968) and Shinde (1983).

It was evident from that MVP to price ratio was 2.50 which showed that a rupee spent on use of land rent under the cotton was giving return of Rs. 2.50 that could be the resource use efficiency with respect to the area under cotton. Factor share of the land under cotton was 43.99 per cent. It was inferred that irrigated land under cotton production was highly contributing factor for cotton production in the study area. In the case of nitrogen, marginal value product to price ratio was 1.77. It implied that a rupee spent on use of nitrogen was giving return of Rs. 1.77. The factor share of nitrogen was 3.30 per cent. In case of manure, resource use efficiency was the highest i. e. Rs. 7.78 which showed that a rupee spent on manure was giving return of Rs. 7.78. The share of manure was 10.99 per cent. The findings are in accordance with the findings of Abraham and Bokil (1966).

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Prospects of Cotton Seed Byproducts

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Cotton not only provides basic raw material for the textile industry, but also offers a large spectrum of byproducts of industrial importance in addition to edible oil. Presently, the total oil yield potential of cotton is not realized and, therefore, India suffers a loss of Rs. 500 crores annually despite the fact that cotton seed is used extensively in the vegetable fat production industry. The employment potential of cotton in farming and cotton based industries put together is around six million people in India.Thus cotton plays a significant role in national economy.

The world production of cotton seed is about 24 million tonnes which yields 5 million tonnes of very good quality edible protein flour and is 6 per cent of total protein available in the world. India alone produces about 3.6 million tones of cotton seed annually from which 5,45,000 tonnes of oil and 7,25,000 tonnes of good quality protein can be obtained if available seeds are processed properly. However, over 9,00,000 tonnes of cotton seeds are directly fed to cattle without removing the valuable oil and equal quantity is crushed undecorticated with inefficient methods, resulting in poor quality and low recovery of oil (Anonyomous, 1984). Cotton seed did not find acceptance as edible oil till a few decades back due to the presence of small quantities of gossypol, which was toxic and contributed to the colour of the oil in the unrefined state. Refined cotton seed oil which contained practically no gossypol, was pale yellow in colour and was being used directly as a cooking medium. In fact in Egypt cotton seed oil was the main oil used for cooking prupose (Sundaram, 1982).

In India, cotton seed oil industry has made steady progress, because of growing shortage of other edible oils in the country during sixties and seventies. The full development of scientific cotton seed processing industry in the country would mean additional production of 2.5 lakh tonnes of edible oil from cotton seed already available in the country as byproduct of cotton (Sirur, 1989; Pandey *et al*., 1993).

Cotton seed oil : Cotton is mainly cultivated for its fibres. However, the crop has high potential for producing good quality of oil from the cotton seeds. The seed contains about 14 to 22 per cent oil. Keeping aside about 10 per cent of the seeds grown for sowing purposes, if the rest was properly processed, about 5 lakh tones of cotton seed oil could be produced annually. Thus a significant contribution to be country's total availability of oil could be made from this source. Cotton seed oil comes under a useful group of vegetable oil, where fatty acid consists substantially of C_{16} and C_{18} fatty acids having not more than two double bonds. On an average, cotton seed oil contains, linolic acid 80.62 per cent, oleic acid 20.15 per cent, stearic acid 02.99 per cent, palmitoleic acid 1.16 per cent, palmitic acid 24.35 per cent and myristic acid 0.73 per cent. Fatty acid composition of cotton seed oil compares favourably with most of the traditional edible oils. Cotton seed oil has a better shelf life due to the absence of fatty acid with greater unsaturation (more than two double bonds). Coefficient of digestibility of cotton seed oil is 97 per cent. Refined cotton seed oil was completely free from gossypol and allied toxic pigments and completely safe for human consumption (Thejapa, 1988).

Cotton seed oil is used primarily for edible purposes. Low grade oil is used in manufacturing of soap, lubricants, sulphonated oils and protective coatings. The oil possesses emollient properties and is used in liminents. It is also used in place of olive oil in several pharmacopocial preparations. Occasionally it is used in large doses as lubricant. In USA and some other countries, refined cotton seed oil is a mojor ingradient of food products such as vegetable shortenings, margarine, salad and cooking oil, for canned fish etc.

Prospects of cotton seed in food stuffs : Cotton seed was a good potential source of high protein food, as evident from the composition of cotton seed (Table 1 and 2). The four major components of coton seed were linters, oil, cake and meal. The major components of cotton seeds are listed as below :

In addition to fat, protein, crude fibre and carbohydrate as the major constituents and gossypol, steriols, antioxidants, mineral compounds, there were certain flavonoid pigments as minor constituents. Cotton seed also contains stearic acid and malvic acid along with some other physiologically reactive cyclopropenoid fatty acids. The broad composition of cotton seed in different cultivated species of cotton is given in Table 2 and the data presented reveals that the linter content varied from 2.6 per cent (*desi* cotton Digvijay) to 15.5 per cent *hirsutum* variety (Sitaram *et al.,* 1988). The range of kernel content in different variety was from 42.0 to 63.4 per cent. Oil content in cotton seed varied from 14.6 to 25.6 per cent. The *desi* seeds showed an average oil content of 19 per cent whereas *hirsutum* and *barbadense* contained higher average oil content of 21 per cent. The highest protein content in cotton seed was 42.8 per cent in a *hirsutum* variety. In general *barbadense* varieties had highest average protein content of 36.6 per cent. The free gossypol varied from 0.30 to 1.49 per cent. The *arboreum* variety G27 was found to have the least free gossypol content. Cotton seed cake was a better feed than the whole cotton seed fed to dairy cattle, poultry, sheep and swine. Seed proteins and flour free from gossypol were also widely rercognised as potential sources of nutrition for human consumption.

Prospects of cotton seed cake/meal : The second most valuable product of cotton seed was cake or meal which was used almost entirely as a feed for livestock. It was a better feed than the whole cotton seed fed to dairy cattle, poultry, sheep and swine. Seed proteins and flour free from gosspol were almost widely recognised as potential sources of nutrition for human consumption. In a wide range of baked foods such as bread, biscuits, cookies and in macaroni, spaghetti noodle as well as snack foods, refined cotton seed proteins could be applied as nutrition supplements for protein fortification in the form of flour concentrates.

In India about 4 lakh tonnes of quality protein could be available from the cotton seed meal. It contained high percentage of protein and was quite rich in essential amino acids. It was an established fact that histidine and organine are the essential amino acids required in larger amounts for childern and adults, respectively. Cotton seed protein was very rich with respect to these amino acids in contrast to other seeds. The protein content in cotton seed meal of Indian varieties varied from 48 to 67 per cent (Idnani, 2002).

Utilization of cotton seed meal in fermentation : The fermentation industry required inexpensive source of complex organic nitrogen, and cotton seed meal was one such source available in abundance in India. However, to use it in a fermentation medium, it should be of high quality of pharmaceutical grade. Presently, India is importing such high quality cotton seed meal for its fermentation industry.

Cotton seed hull : Cotton seed hull, the outer covering of the seed, was available to the tune of 1.4 million tones per annum in our country. Cotton seed hull at present was used as fuel, roughage feed for livestock, packing meterial and soil conditioners. The hull was used in the chemical industry for making furfural which was essential in rubber and plastic manufacturing units and also in petroleum refining. Other potential industrial uses of hull were in manufacture of xylose, activated carbons and as filler for phenolic moulding compounds. They could also be utilised in the preparation of particle boards, water repellant boards, flame retardant boards for specified uses as ceiling tiles, false ceiling, interior decorative sheets, display boards partitioning etc.

Chemical analysis of hulls was carried out for holocellulose (Wise *et al.*, 1946; Erickson, 1962), lignin, pentosans and ash according to technical association of the pulp and paper industry (TAPPI) standards.

Normally, hull contributed about 37-60 per cent of the weight of cotton seed, depending upon the varieties, species and various other factors. Hull contained about 35-47 per cent of cellulose, 19-27 per cent of pentosan, 15-20 per cent of lignin and 60 per cent of ash, protein, fats, etc. (Pandey and Gurjar, 1987). Particle board made from cotton seed hull had a mosaic appearance owing to the presence of both dark and light coloured particles in the hull. Board made from hull could be cut, nailed, painted and polished by conventional methods. It was observed that, the finer the hull particle size, the better the quality of the board. Typical particle boards made from higher moisture content (15%) conform to the Indian standard specification. In addition hull was also cheaper. The development of a particle board making industry in rural area using cotton seed hull could provide an opportunity for employment and give a supplementary income to farmers.

Utility of linters : All the fibres present in cotton seed were not removed by ginning. These fibres could be extracted from the seed by especially designed gins delinters or removed by acid treatment. Linter content of Indian varieties was determined at Central Institute for Research on Cotton Technology, Bombay (Sundaram *et al.*, 1988). In case of oil content *G. hirsutum* species had yielded higher linter content of 10.5 per cent as against average linter content of 4.3 to 5.9 per cent in *arboreum* varieties and seed of *herbaceum* was mostly linterless.

Linters obtained from cotton seed had a variety of uses. First cut linters containing relatively long fibres were used in making medical supplies such as absorbent cotton, hospital pads, sterile compress, sanitary napkins and surgical sponges. They were also used in the making of auto-seats, chair and apparel padding, upholstry capping, sofa batting, mattress felts, cushion and pillow stuffing and also in paper manufacture since chemically they were pure cellulose.

The second cut linters had numerous applications in chemical industries such as artificial suede, X-ray films, meat casing, explosive tapes and liquors, cellophane packing, rayon tire card, air hose, industrial fabrics and in plastics for automotive parts, electrical equipments, toilet-ware and in pins and pencils. They were also useful in the manufacture of linoleum, battery casing, wiping materials and in yarn for twine, rays and wicks.

Linter based cellulose industry : An industry based on the linters obtained from the delinting plant of the cotton seed processing unit would be the manufacture of chemical cotton. The chemical cotton was standard cellulose obtained by refining of the linters. The cellulose cotton was used as raw material for a series of chemical derivatives from which were manufactured a variety of products such as rayon, plastic, protective coating and films. Beside cellulose, the linters contain pectic substances, minerals and nitrogenous constituents, waxes, resins and colouring matters. In USA seven different grades of linters based upon fibre length, colour and amount of trash present, had been adopted for use for different specific purposes. The low grade varieties were used as stuffing material for preparation of mattresses and upholstry for furniture. It was also used in the manufacture of coarse cotton yarn. Purified and bleached chemical cotton was used in paper making for plastic fillers and in the preparation of surgical dressings. The second cut linters, duly purified were used in manufacture of superior cellulose, high strength viscose, smokeless power etc. Tyre card rayon was made from chemical cotton. In India, chemical cotton may go a long way in meeting the requirement of tyre manufactures (Anonymous, 1992).

Gossypol in cotton seed : Cotton seed oil contains the deleterious compound known as 'gossypol' which was toxic to non-ruminants. Hence, utilization of cotton seed oil for edible purpose was for refining the material for removal of gossypol. The principal pigment of cotton seed was gossypol ($C_{30}H_3O_8$) yellow form; a phenolic compound present to the extent of 0.4-2.0 per cent in the kernels. Genetic factors exerted a significant influence on the gosspol content of the seed. Seed of *herbaceum* types were low in gossypol as compared to those of *hirsutum* while seeds of *barbadens* were richest in gossypol.

Seed and flower bud gossypol contents were determined for cultivars and several cotton stocks that have been selected for increased levels of flower-bud gossypol. The stocks were derivatives of Socorro Island wild cotton and fine Texas race stocks. The gossypol contents of the two cultivar checks, Stoneville-213 and Deltapine-16, were 0.64 per cent and 0.53 per cent (flowering bud) and 1.23 per cent and 1.19 per cent (seed), respectively. The flower bud gossypol content of the selected stocks ranged from 0.72 to 1.06 per cent and the seed gossypol content of this material ranged from 1.18 to 2.08 per cent (Dilday and Shaver, 1978). The amount of gosspol recoverable in the processing of cotton seed by solvent extraction was 10-15 lbs per ton. Gossypol could be used as an antioxidant in products which are not intended for use as food and in the dyeing of silk and wool. It was also used in antiseptics and plastics.

Fortunately, some lines of cotton were available which were glandless and hence, gossypol free. These lines were devoid of the small lysignous glands on the plant surface and contained gossypol under the admissible limits for human diets. The gossypol free cottons evolved in Madhya pradesh are Badnawar glandless (Bgl) and Indore glandless (lgl). Glandless cotton lines developed in Madhya pradesh could thrive well in the agro climatic conditions necessary for a good crop of any upland cotton (Parmar *et al*., 1973).

Cotton seed was being substituted now a days, to meet the deficit of other oilseeds, inspite of the necessity of refining the oil for removal of gossypol by a costly and time consuming process. The glandless types promised cheaper and easy solution to the cooking oil industries. Thus seed processing quality research in cotton was entering a new phase at both national and international levels. Improvement in oil and protein content of cotton seed was necessary through long and short term co-ordinated programme in order to develop the full potential of this valuable national assets, towards the next century. New approaches to achieve this goal would required steps such as establishment of a data base, development of methodology and instruments for measuring the quality traits and elucidation of the physiology, biochemistry and the morphology of cotton as realted to the processing quality traits