GENETICAL STUDIES IN OPIUM POPPY

(Papaver Somniferum Linn.)

THESIS

Submitted to the

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

in partial fulfilment of the requirements

for the Degree of

DOCTOR OF PHILOSOPHY

IN

AGRICULTURE

(PLANT BREEDING AND GENETICS)

By

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COLLEGE OF AGRICULTURE

JABALPUR, M.P.

1982

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CERTIFICATE I

This is to certify that the thesis entitled "Genetical studies in Opium Poppy(*Papaver somniferum* Linn.)" submitted in partial fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY IN AGRICULTURE of the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, is a record of the bonafide research work carried out by Shri KRISHAN BIHARI NIGAM under my guidance and supervision . The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions .

No part of the thesis has been submitted for any other degree or diploma (certificat awarded etc.) or has been published/published part has been fully acknowledged . All the assistance and help received during the course of the investigations have been duly acknowledged by him .

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CERTIFICATE II

This is to certify that the thesis entitled "Genetical studies in Opium Poppy(Papaver somniferum Linn.)" submitted by Shri KRISHAN BIHARI NIGAM to the J.N. Krishi Vishwa Vidyalaya, Jabalpur, in partial fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY in the Department of Plant Breeding and Genetics, has been approved by the Student's Advisory Committee and External Examiner(s) after an oral examination of the same .

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ACKNOWLEDGEMENTS

Indeed, it gives me great pleasure to express my deep sense of gratitude and indebtedness to my teacher Dr. S.P.Singh, M.Sc.(Ag.), Ph.D.(IARI), University Professor and Head, Department of Plant Breeding and Genetics, J.N. Krishi Vishwa Vidyalaya, Jabalpur, for his learned magnanimous guidance, precious suggestions, constructive criticism and ever helping attitude throughout the period of investigation and above all, immense encouragement received from him during entire period of this study and for timely preparation of this manuscript .

I feel pleasure in thanking Dr.S.S.Baghel, Dr.A.Seshagiri, Dr. S.M.Sharma and Dr. S.K.Rao members of my Advisory Committee and to Dr. A.R.Dabolkar, Dr.A.R.Sawant and Dr. C.B.Singh for their valuable suggestion, assistance and constant help during the course of the studies and preparation of manuscript .

My profound and sincere thanks are due to Dr.K.C. Dabral, Sarvshri N.K.Jain(Pathology), V.K.Shrivastava, R.C.Mishra, M.C.Chaurasia, Dr. R.K.Tugnawat, Dr.S.V.K.Prasad, Dr. G.S.Dwivedi, Dr.Panchratan, N.S.Sipani, K.K.Shah, Vijay Pradhan and Dr. Harish Pradhan, for their constant help, suggestions and stimulating inspirations during the period of study .

I am also highly thankful to Messrs G.S.Rawat, B.P.Agrwal, N.K.Jain(Agronomy), N.R.Jamley, G.K.Saura, D.A.Khan for their kind cooperation, help and assistance rendered to me during the course of present investigation.

I am thankful to Shri S.C.Gupta for excellent, careful and timely typing of thesis .

I am grateful to Dr.M.P.Singh, Director of Instructions Dr.S.N.Dubey, Director of Research Services, Dr. V.N.Shroff, Associate Director of Research, Dr. Rajendra Gupta, Project Co-ordinator (M&AP), ICAR and JNKVV, Jabalpur for providing the necessary facilities during the period of study .

It is my most pleasant duty, to express my gratitude and humble regards to my father, late Shri Keshorai Nigam and to my mother Smt. Anandibai whose blessings, inspired me to enter into the present investigation .

My thanks are also due to my children, Smita, Sarika and Sunil who endured all the sacrifice and hardship ungrudgingly.Indeed, last but not the least, I am highly thankful to my wife Mrs. Kusum Nigam, who gave me inspiration, unfailing help owing to which I could succeed in this endeavour .

(KRISHAN BIHARI NIGAM)

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CHAPTER 1

INTRODUCTION

Poppies rank amongst the most exciting flowers in cultivation with an exciting range of colours such as white, pink, red, bluish purple and purple . Poppy cultivation for opium has been in vogue in Italy, Greece and Asia Minor since antiquity . The spread of its cultivation through Asia appears to have been primarily due to Arabs . At present opium poppy is cultivated mainly in India, Turkey, Australia and U.S.S.R. It is also grown in smaller areas in Yugoslavia, Bulgaria, Afganistan, Pakistan and Japan . Iran, which has been once a major producer of opium had prohibited its cultivation in 1955 .

Opium poppy is restricted to notified compact tracts in three traditionally poppy growing States viz., Madhya Pradesh, Rajasthan and Uttar Pradesh . According to annual reports of Narcotics Department the area increased from 38,485 hectares in 1972 to 57,108 hectares in 1976 . From the year 1976 onwards, because of slump in demand of Indian opium in world market, area declined under this crop and at present it is grown in about 35,000 hectares . This crop provided subsistance to about 250 thousand families in about 7-8 thousand villages and fetches about Rupees 600 million in foreign exchange . The All India average yield of opium (70°c) increased from 30.39 kg/ha.in 1974-75 to 33 kg/ha. in 1979-80 . The highest average opium yield obtained at the

experimental farm is about 78 kg/ha. (70°c) and this shows the existance of wide gap between the potential and the average yield recorded . The average seed production of poppy is about 500-700 kg/ha.

The State of Madhya Pradesh constitutes about 50 percent of the total area in the country, of which about 80 percent area is in Mandsaur District . The physiologically matured capsule when incised yields the white to pinkish juice which solidifies and is called raw opium . Opium is known to possess 26 alkaloids of which morphine, Codeine, Thebaine, Papavarine and Narcotine are important and are extracted for medical use viz., analgesic, euphoric, relaxing voluntary muscles, spinal stimulant, and generally used as pain killer. Besids latex, seed and husk are also of economic importance . Poppy seed is a rich source of protein (22.3-24.4%), minerals, vitamins and oil (44.50%) . Poppy straw can be utilized for fibre boards and straw boards (Chawala, 1978) .

Poppy breeding has been done mostly in Russia and surrounding East European countries . The methods adopted were generally those prevalent in these areas i.e. simple selections, hybridization and exploitation of heterosis . However, the information regarding the use of latest statistical mating designs is notably absent . The published work in these areas are in slavic languages and journals are not easily available in India .

A survey of literature on opium poppy shows that although a good deal of information is available regarding growth, yield, climatic condition, requirement of soils and fertilizers (NPK), in Eastern literature, very little is reported about the nature and occurrence of variability, induced variability, germplasm evaluation, varietal evaluation, exploitation of heterosis and type of gene actions in available literature . Gupta et al(1978) feel that it is most desirable to have intensive breeding/selection programme to identify and to evolve specific lines for high yields and high morphine - codeine ratio .

Environment plays an important role in poppy cultivation . The factors like temperature, Relative Humidity and cloudiness of atmosphere during lancing operation affects the latex yield of this crop . Cold windy season, and rainfall during crop period affect the crop adversely (Nigam et al 1980) .

To formulate a detailed breeding programme for evolving better types of opium poppy, suitable for various growing conditions, it is essential that the inter-relationships among various economic characters and their nature of inheritance is properly understood . The combining ability analysis furnishes useful information regarding the selection of suitable parents for effective hybridization and at the same time to elucidate the nature and magnitude of different

type of gene actions involved . The diallel analysis in inter-varietal crosses of opium poppy will reflect the parameter we seek to interpret for different genetical consequences and phenomena in which we are interested, particularly on combining ability of parents and for isolation of specific hybrid combinations having good specific combining ability effects .

In the present investigation, eight parents were drawn from different agroclimatic zones of opium growing tracts of India . Selection of parents was based on importance of different economic characters, to generate the information on gene action and also to select desirable parents for further breeding programme . In the present investigations, the results of diallel crosses of these selected parents are reported .

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CHAPTER 2

REVIEW OF LITERATURE

This chapter emphasises on the aspects of varietal improvements and correlation studies, heterosis in intra and inter-specific crosses, gene action and combining ability analysis and few references to polyploids and mutation aspect of opium poppy crop . Literature on gene action in combining ability analysis is very scanty in this crop .

2.1 VARIETAL IMPROVEMENT, SELECTION AND CORRELATIONS

As early as in 1907, Hurst , reported that in *Papaver somniferum*, coloured petals were dominant over white, purple flowers over red and black basal area of the petal over white . Leake and Peyskad (1920) also reported the inheritance of petal colour and seed . Beguinot (1926) observed that the flower and seed coat colour is dominant . Miyake and Imai (1927 a) studied the flower colour, shape of corolla, petal serration, smoothness of stock, doubleness of flower and stem hairyness in opium poppy . Prochaska (1928) reported that opium poppy capsule appears striated due to empty locules, which is caused by ovules abortions . Psareva (1939) found that seed colour is inherited and is not related to the oil content and yield of seed is not affected by branching and shape of capsule . No correlation between shape of capsule and oil content of seed was reported by Kohoutova

(1953) . Kopp and Kotilla (1955) found in their breeding experiments that morphine content can be increased by 30% in Rumania and it is affected by time of sowing, percent cross pollination, varieties with blue seed and rain water received during growing seasons . Hlavackova (1955), found that under Czechoslovakian condition the Dutch variety Nordster contains the highest amount of morphine, while Bulgarian variety had relatively low amount of morphine . Kopp (1957) reported that plants with large, pear shaped capsule and blue seed generally yield high morphine content . Sarkany at al (1959) reported that blue colour of seed was dominant and capsule forms show maternal influence . Veskerusa (1960) observed a positive and significant correlation between seed and morphine content . Moresz (1960) performed selection in isolated self pollinated plants and observed that morphine content of capsule increased from 3.37% to 6.04% on an average. Kopp at al (1961) held the view that in selection procedure for high morphine, plants with highest as well as lowest contents should be discarded, since high amount had degeneration and a decrease of morphine will be observed in progenies . Zoschke (1962) found that German varieties which were bred for high oil and seed production, normally contain 0.2-0.4% morphine, however white varieties had morphine upto 0.6% . Andreev (1963) examined 6 varieties from Central Asia and USSR and observed that polyploid types are higher yielder of latex and morphine per unit area . Anderson and Loot (1966)

outlined the breeding objective of breeding trials . They held that since poppy cultivation for morphine is unprofitable, the new aim should be higher seed yield and oil content . Naickovska and Popovska (1967), observed that yield of opium and seed have positive and height and number of nodes had no correlation . Herisset (1967) conducted experiments with eight varieties . He found that early flowering was found to be associated with a high alkaloid level . Von H.Bohm (1970) reported breeding programme for several species of Papaver . Morphine and thebaine rich strains were obtained and described by him . He paid attention to agrotechnically important characters as well as alkaloids . Ved Kaj Henriksen (1970) did experiments with strains of opium poppy during 1965-1969 . He screened the typed material for high seed yielder . He found that crude fat and crude protein varied a little in his experimental material . A high heri tability in plant height and a low one in seed weight was reported in two varieties by Hlavackova (1972) . Khanna and Morty (1973) and Legg (1969) held view that production of alkaloid was both under genetical and environmental control .

New promising varieties were evolved by several scientists . Poppy et al (1975) did complex breeding trials. He came up with new promising poppy varieties with high morphine contents of dry capsule (over 0.7%) . New varieties so developed were stable type for winter seasons . Nigam (1980) evolved two cultivars viz., MOP 78/3 and MOP 78/16

in Madhya Pradesh, India, and reported that these two new varieties recorded 9.3 and 11.8% more latex, 2.68 and 0.89% more morphine yield/ha. respectively than the local check . Both types according to him, recorded slightly better seed and husk yield . Nigam et Al (1979) reported result of 1740 samples of 67 villages in Madhya Pradesh area of India and found that range of latex yield was 50 to 115 kg/ha. and that of seed was 478-1412 kg/ha. The morphine percentage varied from 4.09% to 16.46% . In another report Nigam et al.(1982) described the germplasm of Madhya Pradesh .

2.2 HETEROSIS IN INTRA-SPECIFIC CROSSES

As early as in 1923, Kirosi crossed several lines with distinct characters of size and form of capsule, maturatio etc and reported that hybrid vigour in hybrids was significant Cavara and Chistari (1926) found that hybrids between blue and white seeded varieties of poppy have higher and better quality of morphine and yield . Kohoutova (1953) attempted crosses between seven varieties and reported hybrid vigour for oil content in 60 percent of the hybrids he had studied . Hlavackova (1959) initiated crossing programme aimed at getting high morphine content of dry poppy seed and found that heterosis occurred in F_1 for seed weight and plant height, but the morphine content was intermediate between the parents . Sarkany et al.(1959) observed in his studies that hybrids grew 4-10 cm taller, flowered 2-4 days earlier and were higher in capsule and seed weight by 10.76 percent . Korohoda and Mlozulska (1962) attempted hybridization of four varieties and

found that effect of heterosis was most conspicuous when the parent differed slightly in respect of given features . Keskova (1963) reported that hybrid vigour was noted for yield of seed, pods and oil . Bosa- Bourdenil *et al*.(1963) reported that when two varieties viz., Marsellii (white flowered contain two glucosides) and Flora 111 (Petal with red base and 1 glucoside) were crossed, F_1 had generally violet colour in the petal . The F_2 showed regressions and intermediate types . Mraz (1964) described the method to find out the proportion attributable to an improvement in the state of health of a hybrid as a result of heterosis . Danos (1965) reports that hybrids differed in morphological characters and alkaloid spectrum . He observed heterosis in morphine content and secondary alkaloids . He also reported in 1966, that F_1 hybrids have greater morphine content and grater capsule weight than the parents but the secondary alkaloids were intermediate . In the F_2 generation, less coloured plants had more morphine and less secondary alkaloids than the dark coloured plants . Popov and Dimitrov (1966) found that heterosis effects are more pronounced in hybrid combination in which parents are ecologically distinct and higher yield of crude opium, seed and capsule was there, with resistance to low temperature and bacteriosis . Anderson and Loot (1966) studied the progenies of hybrids and found that 3 crosses had high morphine contents than their parents . Miczulske (1967) reported that if parents were blue seeded

poppy (Bulgarian origin) increased seed yield in F_1 was observed . Morphine content was either intermediate or exceeded both the parents . Morice and Louarn (1971), reported that despite variation caused by climatic factors, selection of lines for high morphine content can be made . This character shows no heterosis, F_1 being intermediate . Popov et al. (1971) used crosses within turcicum sub-species and found that morphine content of dry capsule showed intermediate heredity and lines with high morphine can be isolated . Popov et al. (1974) reported hybrid vigour for morphine content in dry capsule . Popov et al. (1975) reported that very promising offspring and hybrids (F_1) were obtained by hybridization between varieties of poppy . Popov et al. (1976) reported hybrid vigour for number of capsule (2-3 capsule per plant) . The total and mean capsule weight proved higher in all hybrids . The morphine content was also higher .

2.3 HETEROSIS IN INTER-SPECIFIC CROSSES

Blaringhem (1925) crossed P. somniferum var. nigrum with wild poppy P. setigerum DC, and found that hybrid had all the parental characters dwarfened . The plants were knotty, number of stamens were much reduced, pollens aborted and number of stigmatic rays ranged from 3-6 . Bres (1927) reported that P. hungarian is the hybrid of P. dubium x P. strigosum var. leniprophyllum and not that of P. dubium x P. rhoeas var. calvellum . Pirovano (1927) reporting the result of cross between P. somniferum x P. bracteatum and expressed that diversity of progenies may be infuenced by maturity of ovary

at time of pollination . Kasaeva (1929) working with same cross found 73-93 percent success , when P.bracteatum was used as male and no seed is obtained if it was used as female . The F_1 was not uniform . The F_2 plants were perennial but not cold resistant . He reported the same results in 1930 also . In the same cross Yasui (1937) reported that F_1 appeared intermediate and there was irregular chromosomal behaviour in meiosis . Kawatami & Asahina (1959) working with cross of P.somniferum and P.orientale, found that hybrid was perennial, resembling the female parents in stem, flowers, bud and leaves . Alkaliods common to both parents were present . In the same cross Tetenyi et al.(1961) found that in F_1 generation the main alkaloid in 75 percent of the plants was morphine, in 15 percent codeine, in 7 percent thebaine and in 3 percent papaverine . Morphine was always present but occasionally one or the other alkaloid was absent . Lorinz and Tulanyi (1963, 1966) working with the same cross reported that F_1 showed both intermediate and new morphological type . Heterosis effect was noticed in F_2 rather than F_1 . Von H. Bohm (1965) reported that when P.bracteatum lind (which contains large amount of thebaine) was crossed with P.somniferum L., the F_1 hybrids contained the alkaloids of both parents and morphine was the main alkaloid present . The hybrids seemed to have produced large amount of thebaine . Reckin (1972) working with P.somniferum (n=11) x P.pilosum Sipth et Smith (n=14), showed that morphine, codeine, papaverine and narcotine content of hybrid was similar to that of P.pilosum .

2.4 INDUCED VARIATION

Colchicine treatment of P.somniferum was used by workers to obtain tetraploids (Furusato,1940; Volovov,1941 and Michalski, 1959) . Hirishi (1960) concluded that P. setigerum is one of the allotetraploid of P.somniferum . Mutations induced by X-ray (Remussi,1959), by chemicals (Ivanova,1972) and by Gamma radiation (Nigam and Dhumale, 1982) are reported in literature . Spontaneously occurring male sterility was reported by Blaringham (1932) and Singh and Khanna (1970) in opium poppy .

2.5 COMBINING ABILITY AND GENE ACTION

A very little review is available on gene action and combining ability parameters of opium poppy . Only recently this aspect of gene action has been explored and some reports are being received .

Certain correlation between yield and components of yield in P.somniferum was reported by Khanna and Singh (1975) . Singh and Khanna (1975) studied the degree of heterosis and nature of combining ability in opium poppy in 5x5 diallel cross . They reported that heterosis was marked for capsule number and opium yield . Poor heterosis for morphine content was observed . Gca and sca variances were found to be significant, indicating additive and non additive gene action both of which are important in opium poppy .

Predominance of additive component for capsule weight indicated that this character can be improved .

Popov and Dimitrove (1966) studied fifty cross (Hybrids) combinations between varieties of Sadov, USSR and Hungary . These hybrids were evaluated for crude opium, seed yield and morphine percentage . Hybrid vigour for crude opium and seed was strongly manifested in hybrids with distinct parents . Heterosis effect in poppy is also manifested with regard to greater resistance to low temperature . They suggested that distinct parental crosses should be attempted for getting better latex yield .

Saini and Kaicker (1982) reported combining ability analysis for opium yield in opium poppy . They used line x tester analysis technique . Ten lines of diverse origin and five testers were used . They reported highly significant mean sum of square for parent Vs hybrid for opium yield, indicating a substantial amount of hybrid vigour present in those crosses Hybrids differed among themselves significantly indicating phenotypic diversity among themselves generated by the inherent variability present in lines and testers . Females were more genetically diverse than males . In combining ability analysis, it was indicated that (i) additive gene effect was predominant, (ii) gca was of greater magnitude than sca, indicating that the nature of gene action was predominantly

additive and (iii) parent DCG was found to be generally best combiner .

Saini and Kaicker felt from their observations that their studies showed mostly additive type of gene action in contrast to mostly non additive gene action reported by Singh and Khanna (1975) which may be due to the parental material used . Saini and Kaicker's material had wide genetic diversity (FROM Russia, Hungary, Iran, Yugoslova, Switzerland) while Singh and Khanna used limited genetic variability created by breeders .

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CHAPTER 3

MATERIAL AND METHODS

3.1 GEOGRAPHICAL LOCATION

Mandsaur (24°03'N, 75°08'E) is situated on the Malwa plateau at an average elevation of about 435.2 meters above sea level . Experimental area was located at JNKVV., Regional Research Station, Bahadari, Mandsaur, 3 kilometers away from Mandsaur city on Mandsaur Sitamau road .

3.2 GEOLOGY

The soil was black clay loam and the rock underlying is deccan trap composed of basalt . Average depth of soil being 3' to 4' . The experimental soil was analysed to 263, 7.2, 588 kg/ha. available NPK respectively . The soil was high in organic carbon (.70%) with pH 8.2 .

3.3 CLIMATE

The climate of Mandsaur is monsoonic with characteristic three seasons viz., Rainy (June-September), Winter (October-January) and Summer (February to May) . The average rainfall of the tract is 960 mm, mean maximum and minimum temperature being 35.14°c and 19.54°c respectively. During 1979-80 and 1980-81 the total rainfall was 456 mm and 662 mm, while the number of rainy days were 37 days and

43 days respectively .

3.4 AGRICULTURAL OPERATIONS

The experimental field was brought to fine tilth by ploughing and Bakharing . Sowing was done in the second week of November (normal sowing) and late sowing was done 30 days later . Seeds were treated with fungicide, Dithane M-45 @ 3 g /kg seed . Sowing was done in lines 30 cm apart . Well rotten FYM was added uniformly @ 10 t./ha. and thoroughly mixed in soil . 100,50,30 NPK kg/ha. was applied . 1/3 N and full P and K was applied before sowing . Remaining N was top dressed in two equal splits at 30 and 60 days age of the crop . Irrigation was done immediately after sowing, and repeated 7 days after to help germination . Subsequent irrigation was given to bring the soil at field capacity . Care was taken that irrigation was not missed at rosset, bud, flowering and prelancing stage of crop growth . Thinning and weeding were done thrice in crop season, to maintain plant to plant distance of 10 cm to obtain optimum plant population of 3-3.5 lakhs/ha. Time to time uniform spraying of fungicide and insecticides were done to protect the crop from diseases and pests .

Capsules were lanced when they attained physiological maturity . The lancing was done with the help of a three bladed lancer during the hottest part of the day in the

afternoon . Incisions were made vertically from bottom to top of capsule (Fig.1) taking care that the incision should not cross the mesocarp thickness . The viscous latex was collected early next morning with the help of iron scoop (Fig.2) and the process was repeated every 72 hours till the capsule stopped oozing out latex .

3.5 EXPERIMENTAL MATERIAL

3.5.1 PARENTS

On the basis of diverse morphological characters and adaptation, eight parents were selected for the present study . The pure and selfed seed maintained at Mandsaur by Shri R.C.Mishra, Jr.Scientist, Plant Breeding was taken for further work . The parents were :-

P1 (Ranzatak)	Petals pink and big, non serrated margin . Peduncle non hairy . Plants of average height (80 cm). Capsules come to lancing in 120 days . Selection belongs to Madhya Pradesh .
P2 (OCG)	Petals white and medium size, non serrated margin . Peduncle non hairy . Plants having little smaller height (75 cm) . Capsules come to lancing in 105 days . Selection belongs to Rajasthan .
P3 (Telia 1)	Petals pink and medium size, non serrated margin . Peduncle non hairy . Plants of average height (80 cm) . Capsules have

FIG 2

typical green shining characteristic giving oilish look . Capsules come to lancing in 120 days . Selection belongs to Madhya Pradesh .

P4 (Irrianian) — Petals white and big, non serrated margin Peduncle hairy . Plants of medium height (75-80 cm) . Capsules come to lancing in 125 days . Selection from exotic material

P5 (LL3) — Petals pink and medium size, non serrated margin . Peduncle non hairy . Plants little taller (82 cm) . Capsules come to lancing in 135 days . Seed originally received from IARI, New Delhi .

P6 (UP white) — Petals white and big, non serrated margin Peduncle non hairy . Plant height 80 cm . Capsules come to lancing in 115 days . Selection belongs to Uttar Pradesh .

P7 (Hafemea) — Petals pink and medium size, non serrated margin . Peduncle non hairy . Plants little taller (84 cm) . Capsules come to lancing in 120 days . Seed originally received from IARI New Delhi .

P8 (Galania) — Petals red and big, serrated margin . Plant height normal (80 cm) . Capsules come to lancing in 120 days . Selection belongs to Rajasthan .

3.5.2 HYBRIDS

During rabi season of 1978-79, selfed pure seed of 8 genotypes were grown in an isolated plot and F_1 hybrids in all possible combination excluding reciprocals were

prepared i.e. P(P-1)/2 = 28 . These hybrids are identified in text as 1x2 = Ranzatak x DCG, 1x3 = Ranzatak x Telia 1 and so on . Sufficient seeds of F_1 hybrids were made during that year and half of the seed was utilized for 1979-80 and next half was utilized in 1980-81 trials .

3.5.3 ENVIRONMENTS

Four seperate environments were formed by date of sowing and year of planting . Since contrast environments were to be prepared for accurate evaluation of experiments, date of sowing separated by one month, created the contrast environments . The four environments were :-

E1 (Environment one)	Normal sowing during 1979-80(12-11-1979)
E2 (Environment two)	Late sowing during 1979-80 i.e. one month late from E1 date (12-12-1979).
E3 (Environment three)	Normal sowing during 1980-81(15-11-1980)
E4 (Environment four)	Late sowing during 1980-81(15-12-1980).

3.5.4 LAYOUT AND DESIGN

3.5.4.1 TREATMENTS

Eight parents and twenty eight hybrids (in all 36 entries) were tested .

3.5.4.2 DESIGN

Randomised block design was used .

3.5.4.3 PLOT SIZE

Single row of 1.5 meter length, 30 cm apart for each entries was taken (1.5 x 0.3 m^2) .

3.5.4.4 REPLICATIONS

Three replications for each environment . Two guard rows were kept on each side of replication .

3.6 SAMPLING

Five randomly selected plants per plot were tagged and following observations were recorded on these plants . Mean of these five randomly selected plants were worked out and reported as mean per plot .

3.7 OBSERVATIONS RECORDED

Observation were recorded on the following characters .

3.7.1 HEIGHT OF PLANT

Height of plant was recorded in cm, from the first leaf node to apex of terminal bud on the main stem .

3.7.2 LEAF AREA

Observations were recorded on the Ninth leaf from bottom (decision of group meeting of opium research workers at Lucknow 1978) . Maximum length of leaf and maximum leaf width in cm were recorded . Leaf area was calculated by multiplying LxB of leaf (cm^2) .

3.7.3 STEM DIAMETER

Stem diameter was recorded by vernier callipers . Diameter of stem was recorded near about 9th leaf .

3.7.4 NUMBER OF CAPSULES/PLANT

Total number of capsules were recorded on plants . Only those capsules which had contributated to yield paramater were counted .

3.7.5 CAPSULE SIZE

Length and breadth of capsule on main branch were recorded in cm and converted to capsule size by multiplying LxB (cm^2) .

3.7.6 NUMBER OF STIGMATIC RAYS

Number of stigmatic rays on capsule on main branch was recorded .

3.7.7 OPIUM YIELD PER PLANT

Opium yield per plant was recorded in gm and converted to 70° consistancy .

3.7.8 SEED YIELD PER PLANT

Seed yield per plant was recorded in gm .

3.7.9 HUSK YIELD PER PLANT

Husk is the left out of capsule after seed has been taken out . Its yield per plant was recorded in gm .

3.7.10 NUMBER OF EFFECTIVE LANCING PER CAPSULE

Effective lancing is defined as lancing which has given latex yield . This can be easily verified by inspecting the lanced capsule and finding whether that lancing has given

latex or not . Mean number of effective lancing per capsule was recorded .

3.7.11 MORPHINE PERCENTAGE

Since opium collected from each plant or by 5 plants per plot was very small in quantity, and as there exsisted no facilities at Research Station to carry out morphine analysis, samples for morphine analysis were sent to Opium and Alkaloid Works, Neemuch . The factory requires 15 gms minimum sample to run the morphine test . Therefore, composit samples of full row of treatment over replications were made, the latex was thoroughly mixed and sample drawn and sent for analysis .

3.8 STATISTICAL ANALYSIS

3.8.1 TESTING THE SIGNIFICANCE OF GENOTYPIC DIFFERENCES IN EACH ENVIRONMENT

The data for each character were analysed in a conventional way as recommended for randomised block design (Panse and Sukhatme 1957) . The sum of squares for 36 genotypes were partitioned into three components viz., Parental lines (p-1), F_1's (H-1) and parents Vs F_1's (1 df). Appropriate ANOVA is given below :

ANOVA FOR HBD ANALYSIS IN EACH ENVIRONMENTS

Source of variation	df	
Replications	(r-1)	= 2
Genotype	(g-1)	=35
(a) Parents	(p-1)	= 7
(b) Hybrids	(h-1)	=27
(c) (P Vs H)		= 1
Error	(r-1) (g-1)	=70
Total		=107

3.8.2 TESTING THE SIGNIFICANCE OF GENOTYPIC DIFFERENCES (OVER ENVIRONMENTS)

3.8.2.1 REPLICATED DATA

When analysis was significant in each of the environments, pooled analysis was done following Panse and Sukhatme (1954) . For pooled analysis only those environments were considered for a character in which mean squares were significant . An appropriate ANOVA is presented below :

ANOVA (OVER ENVIRONMENTS)

Source of variation	df	E=4	E=2
Environments	(e-1)	3	1
Replication over E.	pooled	8	4
Genotypes	(g-1)	35	35
(a) Parents	(p-1)	7	7
(b) Hybrids	(h-1)	27	27
(c) (P Vs H)		1	1
Genotype x E.	(g-1) (e-1)	105	35
(a) PxE	(p-1) (e-1)	21	7
(b) HxE	(h-1) (e-1)	81	27
(c) (P Vs H) x E	(e-1)	3	1
Error	pooled	280	140
Total		431	215

3.8.2.2 NON REPLICATED DATA (MORPHINE%)

Taking environments as locations 36 genotypes were analysised in RBD . Appropriate format for ANOVA is presented below :

ANOVA (MORPHINE ANALYSIS)

Source of variation	df	
Environments	(e-1)	= 3
Genotype	(g-1)	=35
(a) Parent	(p-1)	= 7
(b) Hybrid	(h-1)	=27
(c) P Vs H)		= 1
Error	(e-1) (g-1)	=105
Total		=143

3.8.3 COMBINING ABILITY ANALYSIS

Griffing's model I method II was followed .

3.8.3.1 COMBINING ABILITY ANALYSIS IN EACH ENVIRONMENT

Mean values of each character over replications were used for analysis as suggested by Griffing (1956).

3.8.3.1.1 ESTIMATION OF SUM OF SQUARES

$$SS_g = 1/(P+2)\left[\sum_i (X_{i.} - x_{ii})^2 - 4/P\ X_{..}^2\right]$$

$$SS_s = \sum_i\sum_j x_{ij}^2 - 1/P+2)\sum_i\left[(x_{i.}+x_{ii})^2\right] + \left\{2/(P+1)(P+2)\right\} X_{..}^2$$

M'_e = Mean squares obtained in RBD is further divided by 3 (number of replications).

3.8.3.1.2 ANOVA FOR COMBINING ABILITY (GRIFFING 1956 MODEL I METHOD II)

Source	df	SS	M_s	Exp.ms
GCA	(P-1)	SS_g	M_g	$\sigma^2 + \{(P+2)/(P-1)\} \sum_i g_i^2$
SCA	P(P-1)/2	SS_s	M_s	$\sigma^2 + \{2/P(P-1)\} \sum_i\sum_j s_{ij}^2$
Error			M'_e	σ^2

3.8.3.1.3 ESTIMATION OF GCA EFFECTS

The general combining ability effects is estimated as follows :

$$\hat{g}_i = 1/(P+2)\left[\sum_i (X_{i.} + x_{ii})^2 - (2/P)\ X_{..}\right]$$

Accordingly, $g_1, g_2, \ldots g_8$ effects were calculated .

3.8.3.1.4 ESTIMATION OF SCA EFFECTS

The specific combining ability effects were calculated by using following formula :

$$\hat{S}_{ij} = x_{ij} - 1/(P+2)\left[X_{i.} + x_{ii} + X_{.j} + x_{ii}\right] + \left[2/(P+1)(P+2)\right] X_{..}$$

Accordingly, S_{12}, S_{13} .... S_{78} (in all 28 effects) were calculated .

3.8.3.1.5 STANDERED ERRORS

In order to evaluate the accuracts of combining ability estimates, standered error for different comparisions were calculated as under :

$$SE_{(\hat{g}i)} = \left[\{(P-1)/P(P+2)\} \times \sigma^2\right]^{\frac{1}{2}}$$

$$SE_{(\hat{g}i-\hat{g}j)} = \left[\{2/(P+2)\} \times \sigma^2\right]^{\frac{1}{2}}$$

$$SE_{(\hat{S}ij)} = \left[\{(P^2+P+2)/(P+1)(P+2)\} \times \sigma^2\right]^{\frac{1}{2}}$$

$$SE_{(\hat{S}ij-\hat{S}ik)} = \left[\{2(P+1)/(P+2)\} \times \sigma^2\right]^{\frac{1}{2}}$$

$$SE_{(\hat{S}ij-\hat{S}lk)} = \left[\{2P/(P+2)\} \times \sigma^2\right]^{\frac{1}{2}}$$

Using appropriate standered error the significance of combining ability effects were tested .

3.8.3.2 COMBINING ABILITY ANALYSIS (OVER ENVIRONMENTS)

Mean values for each character were obtained for genotypes over environments, which were used for pooled combining ability analysis (Daljit Singh 1973) .

3.8.3.2.1 ESTIMATION OF SUM OF SQUARES

$$SS_g = \sum(x_{i...} + x_{ii.})^2/(P+2)E - 4/P(P+2)E \quad X...^2$$

$$SS_s = \sum_i\sum_j x_{ij}^2/E - \sum_i(x_{i...} + x_{ii.})^2/(P+2)E + 2/(P+1)(P+2)E \quad X...^2$$

$$SS_{gxe} = \sum_k\sum_l(X_{i.k} + x_{iik})^2 - 4\sum X^2_{..k}/P(P+2) - (X_{i..} + x_{ii.})^2/(P+2)e + 4X^2_{...}/P(P+2)E$$

$$SS_{sxe} = \sum_k\sum_i\sum_j x^2_{ijk} - \sum_k\sum_l(X_{i.k} + x_{iik})^2/(P+2) + 2\sum_k X^2_{..k}/(P+1)(P+2) - \sum_i\sum_j x^2_{ij}/E + (X_{i..} + x_{ii})^2/(P+2)E - (2/(P+1)(P+2)E)\ X^2_{...}$$

M'_e = Mean squares obtained in RBD (pooled) is further divided by 4 or 2 (number of environments).

3.8.3.2.2 ANOVA FOR POOLED ANALYSIS

Source	df	SS	MS
Environments	(e-1)	SS_e	M_e
GCA	(p-1)	SS_g	M_g
SCA	p(p-1)/2	SS_s	M_s
GCA x E	(p-1)(e-1)	SS_{gxe}	M_{ge}
SCA x E	P(p-1)(e-1)/2	SS_{sxe}	M_{se}
Error			M'_e

3.8.3.2.3 ESTIMATION OF GCA EFFECT (OVER ENVIRONMENTS)

As in 3.8.3.1.3

3.8.3.2.4 ESTIMATION OF SCA EFFECT (OVER ENVIRONMENT)

As in 3.8.3.1.4

3.8.3.2.5 STANDERD ERRORS

Standerd error for combining ability effects were estimated following Daljit Singh (1973) .

$$SE_{(\hat{g}i)} = \left[\left\{(P+1)/P(P+2)E\right\} \times \sigma^2\right]^{\frac{1}{2}}$$

$$SE_{(\hat{g}i-\hat{g}j)} = \left[\left\{2/(P+2)E\right\} \times \sigma^2\right]^{\frac{1}{2}} \qquad i \neq j$$

$$SE_{(\hat{s}ij)} = \left[\left\{(P^2+P+2)/(P+1)(P+2)E\right\} \times \sigma^2\right]^{\frac{1}{2}} \qquad i \neq j$$

$$SE_{(\hat{s}ij-\hat{s}ik)} = \left[\left\{2(P+1)/P+2)E\right\} \times \sigma^2\right]^{\frac{1}{2}} \qquad i \neq j, k; \; j \neq k.$$

$$SE_{(\hat{s}ij-\hat{s}ik)} = \left[\left\{2P/(P+2)E\right\} \sigma^2\right]^{\frac{1}{2}} \qquad i \neq j,k,m; \; j \neq k,m; \; k \neq m.$$

Using appropriate standerd error the significance of combining ability effects were tested .

3.8.4 CALCULATION OF HETEROSIS

The expression of hybrid vigour in different hybrids for each character, were calculated by obtaining the difference between means of hybrids and means of better parent and between means of hybrid and means of midparental values . These were tested for significance by obtaining the standerd errors as follows :

$$SE_{H(BP)} = (2\ M'e/E)^{1/2}$$

$$SE_{H(MP)} = (3\ M'e/2\ E)^{1/2}$$

The hybrid vigour was expressed as percentage in text.

3.9 NONSTANDARD ABBREVIATION USED IN PRESENT THESIS

P1 1st parent in Ranzatak.

P2 Second parent i.e. DCG.

P3 Third parent i.e. Telia 1.

P4 Fourth parent i.e. Irrianian.

P5 Fifth parent i.e. LL3.

P6 Sixth parent i.e. UP White.

P7 Seventh parent i.e. Hafemea.

P8 Eighth parent i.e. Galania

1x2 Cross Ranzatak x DCG, and so on.

E1 Environment one (normal sowing 1979-80).

E2 Environment two (late sowing 1979-80).

E3 Environment three (normal sowing 1980-81).

E4 Environment four (late sowing 1980-81).

3.10 ASSUMPTION OF DIALLEL ANALYSIS

The theory of diallel cross analysis is based on the following assumptions :-

1. Homozygosity of the parents.
2. Diploid segregation.
3. No maternal effects.
4. No multiple allelism.
5. Independent distribution of non-allelic gene.
6. Linkage is absent.

***

CHAPTER 4

EXPERIMENTAL FINDINGS

In the present investigation eleven characters of opium poppy have been studied . Ten characters have been analysed for combining ability following Griffing (1956) . Since replication wise data were not available for morphine percentage, combining ability analysis was not undertaken . However, treating environments as replication, data was subjected to RBD analysis .

4.1 ANOVA RBD

Significant differences were found to exsist among thirtysix genotypes for all the characters in all the environments except for stem diameter, number of capsules per plant and number of stigmatic rays per capsule, where significant differences were only observed in E4, E2, E3 and E2, E4, respectively (Table 1) . In pooled analysis, genotypes were found to have significant differences for all the characters except for stem diameter, where pooled analysis was not performed (Table 2).

Mean squares for parents were observed to be significant for all characters in all the environments except for stem diameter in E1, E3 and E4, number of capsules per plant in E1 and E4, number of stigmatic

ANOVA FOR VARIOUS CHARACTERS INALYSIS) ; (MEAN SQUARES)

Characters		Height of plant(em diameter (cm)				
Source of variation	df	E1	E2	E2	E3	E4
Replications	2	37.69	4.90**	0.0154	0.0031	0.0304
Genotypes	35	77.54**	109.76**	0.0087	0.0102	0.0117**
Parents	7	76.24**	99.76**	0.0041	0.0043	0.0077*
Hybrids	27	73.25**	50.61**	0.0085	0.0101	0.0111**
P Vs H	1	262.52**	1776.68**	0.0474*	0.0429*	0.0582**
Error	70	23.27	3.40	0.0073	0.0116	0.0003
Total	107					

Table Continue

Number of capsule					Number of stigmatic rays/capsule
	E1	E2	E2	E3	E4
	3.0768**	0.0218**	0.1075**	0.4619	0.0184**
	0.6820	0.7512**	1.4062**	0.4952	0.8044**
	0.3543	0.2981**	1.2073**	0.3521	0.6569**
	0.7622	0.8938**	1.3000**	0.5259	0.8699**
	0.8100	0.0726**	5.6674**	0.6689	0.0661**
	0.4135	0.0058	0.0178	0.6299	0.0103

Table Continue

Latex yield/plant			Number of effective lancing		
E1	E2	E1	E2	E3	E4
0.00005*	0.000267**	2.801074	0.0069**	0.2145**	0.0165
0.02260**	0.203890**	0.906620**	1.4816**	6.1581**	0.6475**
0.01010**	0.008991**	0.264800**	1.2343**	2.3168**	0.3936**
0.02530**	0.022087**	0.476300**	1.2211**	7.3747**	0.7016**
0.03720**	0.053763**	0.004000**	10.2450**	0.2001**	0.9640**
0.00003	0.000081	0.001120	0.010	0.0196	0.0394

* Significant at 5%

Table 2

ANOVA FOR VARIOUS CHARACTERS IN 8x8 DIALLEL OF OPIUM POPPY (OVER ENVIRONMENTS RBD ANALYSIS) (MEAN SQUARES)

Source of variation	df E=4	df E=2	Height of plant(cm) E=4	Leaf area (cm^2) E=4	Number of capsule/ plant E=2	Capsule size (cm^2) E=4	Number of stigmatic rays/ capsule E=2	Opium yield/ plant(gm) E=4	Seed yield/ plant (gm) E=4	Husk yield/ plant(gm) E=4	Number of effective lancing/ capsule E=4
Environments	3	1	22012.68**	248701.56**	0.5481**	291.50**	4.36**	0.420233**	749.5951**	301.2000**	499.82**
Replication over E's	8	4	43.79**	19.93	0.2714**	1.6128**	0.06	0.708075**	1.4075	0.9747	0.0662
Genotypes	35	35	101.01**	2642.35**	0.4121**	6.9668**	1.394**	0.045291**	11.6539**	9.4803**	3.8205**
(a)Parents	7	7	32.40**	1987.52**	0.2033**	5.8357**	1.569**	0.010185**	2.3930**	3.8582**	0.1690**
(b)Hybrids	27	27	37.69**	2845.02**	0.4524**	5.1581**	1.271**	0.044385**	14.2516**	11.0416**	3.7730**
(c) P Vs H	1	1	2290.80**	2384.04**	0.7848**	63.7200**	3.500**	0.315500**	13.3421**	6.6800**	23.6650**
Genotype x E	105	35	33.97**	3065.41**	0.5498**	5.8141**	0.817**	0.004433**	6.9920**	3.6268**	2.5476**
(a)Parent xE	21	7	54.91**	2134.95**	0.1578**	4.2814**	0.296**	0.003528**	2.3993**	1.7879**	3.3310**
(b)Hybrid xE	81	27	49.56**	3210.65**	0.0581*	5.7285**	0.897**	0.004532**	7.6584**	4.0470**	2.6669**
(c)P Vs H xE	3	1	166.46**	5657.02**	16.6127**	18.8566**	2.280**	0.008100**	21.1482**	5.1878**	9.3060**
Error	280	140	11.44	137.77	0.0449	0.7172	0.0141	0.000074	0.9156	0.3395	0.0201
Total	431	215									

* Significant at 5% level

**Significant at 1% level

--32--

rays per capsule in E1 and E3 and for seed yield in E2 (Table 1) . In pooled analysis, parental lines had highly significant mean squares for all the characters (Table 2) .

Hybrids differed significantly in each environments for all characters except in E1, E2 and E3 for stem diameter, E1 and E4 for number of capsules per plant and E1 and E3 for number of stigmatic rays per capsule . Significant differences were also observed in all the characters in pooled analysis for different hybrids (Table 1,2) .

The interaction (P Vs H), was also found to be significant for all characters in all the environments except for stem diameter in E1, number of capsule per plant in E1 and E4, for number of stigmatic rays per capsule in E1 and E3 and for capsule size, seed yield and husk yield in E4 . Highly significant mean squares were observed for all characters for this component in pooled analysis . The highly significant values for (P Vs H) component in all characters indicated the presence of heterosis for these characters in present studies . The interaction (GxE) and its components viz., PxE, HxE and (P Vs H)xE were found to be highly significant for all the characters (Table 1,2).

Significant differences were observed for genotypes, parents and hybrids for morphine percentage . However,

(P vs H) component was found to be nonsignificant (Table 3).

4.2 AVONA COMBINING ABILITY ANALYSIS

The component of variation due to gca was found to be significant for all the characters in all the environments (Table 4), and in pooled analysis (Table 5).

Mean squares for sca were observed to be significant in all the environments for all the characters except for capsule size in E3. All the attributes had significant mean squares for sca in pooled analysis

4.3 PLANT HEIGHT

4.3.1 *Per se* PERFORMANCE

Per se performance in pooled data for parental lines and hybrids is presented in Table 6. P7 had highest

Table 3

ANOVA FOR MORPHINE PERCENTAGE (MEAN OF 4 ENVIRONMENTS)

Source of variation	df	S.S.	M.S.	Cal.F.Value
Environments	3	130.39	43.460	42.36**
Genotypes	35	69.23	1.978	1.93**
(a)Parents	7	20.67	2.953	2.88**
(b)Hybrids	27	48.54	1.798	1.75**
(c) P Vs H	1	0.02	0.02	0.019
Error	105	107.74	1.026	
Total	143	307.36		

** Significant at 1% level

Table 4

ANOVA FOR COMBINING ABILITY ANALYSIS FOR DIFFERENT CHARACTERS IN 8x8 DIALLEL IN OPIUM POPPY FOR DIFFERENT ENVIRONMENTS

(MEAN SQUARES)

Characters		Height of plant(cm)				Leaf area (cm^2)				Stem diameter (cm)	Number of capsule/ plant		Capsule size(cm^2)				Number of stigmatic rays per capsule	
Source of variation	df	E1	E2	E3	E4	E1	E2	E3	E4	E4	E2	E3	E1	E2	E3	E4	E2	E4
gca	7	35.33**	9.79**	11.39**	13.92**	1222.97**	457.73**	1078.57**	561.00**	0.0036**	0.5278**	0.03422	.23143**	.35570**	.38683**	.47050**	.42850**	.3937**
sca	28	23.97**	43.22**	7.53*	20.09**	2085.07**	951.68**	708.93**	396.41**	0.0039**	0.0296**	0.08141**	.27043**	.92740**	.01621	.54340**	.53990**	.1896**
Error	70	7.76	1.13	5.15	1.22	45.3	67.86	10.30	58.9	0.0001	0.0019	0.02800	.01390	.46230	.01620	.46370	.00590	.0034
Total	105																	

Table Continue

	Opium yield/plant(gm)				Seed yield/plant(gm)				Husk yield/plant(gm)				Number of effective lancing/capsule			
	E1	E2	E3	E4	E1	E2	E3	E4	E1	E2	E3	E4	E1	E2	E3	E4
gca	0.015614**	0.102736**	0.006980**	0.002083**	31.19**	5.37**	2.00**	4.54**	2.41**	3.84**	0.5358**	3.2176**	0.3967**	0.8097**	1.480**	0.5205**
sca	0.005913**	0.048475**	0.002727**	0.003091**	2.20**	3.21**	1.89**	2.44**	2.24**	18.93**	0.8528**	1.3163**	0.1909**	0.4129**	2.1969**	0.1394**
Error	0.000010	0.000027	0.000021	0.000043	0.31	0.54	0.21	0.17	0.033	0.223	0.090	0.11	0.0038	0.0033	0.0066	0.0131

* Significant at 5% level

** Significant at 1% level

Table 5

ANOVA FOR COMBINING ABILITY ANALYSIS FOR DIFFERENT CHARACTERS IN 8x8 DIALLEL IN OPIUM POPPY (OVER ENVIRONMENTS)(MEAN SQUARES)

Characters	df		Height of plant(cm)	Leaf area (cm^2)	Number of capsule/ plant	Capsule size(cm^2)	Number of stigmatic rays/capsule	Opium yield per plant (gm)	Seed yield/ plant(gm)	Husk yield/ plant(gm)	Number of effective lancing/ capsule
Source of variations	E=4	E=2	E=4	E=4	E=2	E=4	E=2	E=4	E=4	E=4	E=4
Environments	3	1	22012**	248701.56**	0.5481**	291.50**	4.36**	0.420233**	749.5951**	301.20**	499.82**
gca	7	7	40.37**	49588.60**	0.1016**	1.1468**	0.2444**	0.052519**	1.2630**	1.2810**	0.1159**
sca	28	28	9.59*	215.50**	0.0601**	0.4546**	0.2139**	0.000076**	0.88586**	0.6432**	0.3496**
gca x E	21	7	22.14**	992.98**	0.4604**	2.7658**	0.5773**	0.039971**	13.9531**	2.91050**	1.00584**
sca x E	84	28	28.43**	633.44**	0.0470**	2.4430**	0.4629**	0.019379**	3.9561**	1.82754**	0.80357**
Error	280	140	2.86	34.19	0.0225	0.1793	0.0071	0.000019	0.2289	0.085	0.0050

* Significant at 5% level

** Significant at 1% level

(81.69 cm) height as compared to 76.32 cm, the lowest for P2. Cross 3 x 7 recorded highest height of 88.64 as against lowest in 4 x 8 (81.94 cm).

4.3.2 HETEROSIS

All crosses except 3x5, 4x5, 4x7, 4x8 and 5x7 recorded significant positive heterosis over better parent. Highest and lowest significant positive heterosis were recorded by 2x4 and 1x3 respectively (Table 7).

4.3.3 GCA EFFECTS

Only P7 had significantly large and positive gca effect in E1 (Table 8). In E2, except P3 and P5 all parents had significant gca effects (Two having negative effects). P2 was found to be significantly superior to P4 for negative

Table 6

Per se performance of parents and hybrids in 8x8 diallel of opium poppy for plant height(in cm)

(Pooled means)

Parent	P1 (Renzetek)	P2 (DCG)	P3 (Telia-1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemsa)	P8 (Galania)
P1	78.58	83.74	81.97	84.81	83.30	86.81	85.65	83.69
P2		76.32	83.95	86.49	84.30	84.08	88.52	83.76
P3			78.96	82.65	83.10	84.43	88.64	86.11
P4				72.64	81.99	86.45	83.05	81.94
P5					80.41	85.60	83.94	83.96
P6						78.85	85.07	83.47
P7							81.60	86.08
P8								80.10

Note : Diagonal entries for parents and off diagonal entries for hybrids .

Table 7

Heterosis for plant height in pooled data

Crosses	Heterosis %	
	Over better parent	Over mid parent value
1x2	6.57**	7.98**
1x3	3.81**	4.06**
1x4	9.92**	12.17**
1x5	4.83**	6.04**
1x6	10.10**	10.28**
1x7	4.96**	6.94**
1x8	4.48**	5.48**
2x3	6.32**	8.13**
2x4	13.33**	16.13**
2x5	4.64**	7.56**
2x6	6.63**	8.37**
2x7	8.48**	12.11**
2x8	4.57**	7.10**
3x4	4.67	9.04**
3x5	3.35**	4.29**
3x6	6.93**	7.00**
3x7	8.63**	10.41**
3x8	7.50	8.57*
4x5	1.96**	3.75**
4x6	9.64	10.48**
4x7	1.78	4.30*
4x8	2.30**	3.89**
5x6	6.45	7.50*
5x7	2.87**	3.62**
5x8	4.41*	4.62**
6x7	4.25*	6.04**
6x8	4.20**	5.03**
7x8	5.49	6.47

* Significant at 5% level

** Significant at 1% level

Table 8

gca effects (diagonal) and sca effects (off diagonal), for plant height in 8x8 diallel of opium poppy in E1

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemma)	P8 (Galania)
P1	-0.120	3.40	-7.71**	1.61	0.26	4.44	-0.38	-3.37
P2		0.57	4.20	0.02	0.47	-1.15	9.93**	7.14**
P3			-1.37	-1.24	-2.49	0.59	4.07	1.48
P4				-0.69	1.43	5.81*	2.09	-6.50*
P5					-1.24	-1.74	1.04	0.25
P6						-1.42	-3.88	5.83*
P7							4.30*	-0.49
P8								-0.01

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

$SE_{(\hat{gi})} \pm 0.82$ $SE_{(\hat{gi}-\hat{gj})} \pm 1.245$ $SE_{(\hat{sij})} \pm 2.53$

$SE_{(\hat{sij}-\hat{sik})} \pm 3.74$ $SE_{(\hat{sij}-\hat{skl})} \pm 3.52$

gca effect . Though P1 and P8 did not differ significantly for positive gca effects, these were found to be inferior to P7 and P6 . However, P3 and P5 had nonsignificant gca effect for this character (Table 9) . In E3, negative gca effect was only recorded by P8 and positive effect by P2 (Table 10). In E4, highly negative gca effects were observed for P1, P2 and P4 and that of positive effect by P6 . No significant differences existed between P1, P2 and P4 (Table 11) . In pooled analysis only P7 recorded positive gca effects ((Table 12) .

4.3.4 SCA EFFECTS

In E1, only two crosses viz., 1x3 and 4x8 had negative sca effects, where as, 2x7, 2x8, 4x6 and 6x8 had significant positive effects (Table 8) . In E2, highest and significant negative sca effect was observed for 1x2 but it did not differ significantly from 1x8 . Nine hybrids recorded significant positive effects (Table 9) . In E3, no cross recorded significant negative effects but only 3x6 and 7x8 had significant positive sca effects (Table 10) . In E4, in all eighteen crosses recorded significant sca effect (Table 11) . Five crosses viz., 1x5, 2x6, 2x8, 4x7 and 6x8 had significant sca effects and there existed no significant difference among them .

Table 9

Gca effects (diagonal) and sca effects (off diagonal), for plant height in 8x8 diallel of opium poppy in E2

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Talia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galenia)
P1	1.18**	-19.18**	-14.89**	-12.64**	-12.54**	-17.94**	-14.70**	-16.99**
P2		- 2.88**	11.17**	8.42**	0.22	6.12**	0.36	- 0.23
P3			0.13	- 0.99	3.81**	1.11	7.35**	4.76**
P4				- 1.72**	- 3.64**	3.96**	- 1.50	- 4.09**
P5					0.48	3.46**	- 5.00**	3.41**
P6						0.88**	1.26	- 0.69
P7							0.64*	- 3.54**
P8								1.23**

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)}$ ± 0.32

$SE_{(\hat{g}i-\hat{g}j)}$ ± 0.48

$SE_{(\hat{S}ij)}$ ± 0.97

$SE_{(\hat{S}ij-\hat{S}ik)}$ ± 1.43

$SE_{(\hat{S}ij-\hat{S}kl)}$ ± 1.35

Table 10

Gca effects (diagonal) and sca effects (off diagonal) for plant height in 8x8 diallel of opium poppy in E3

Parent	P1 (Ranzatak)	P2 (OCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafamea)	P8 (Galania)
P1	-0.67	-0.75	-1.27	1.16	0.10	2.53	0.16	0.33
P2		2.04**	0.22	3.75	3.09	0.42	0.65	-0.68
P3			0.36	2.33	-3.33	5.80**	1.63	3.40
P4				0.23	0.14	-1.27	0.06	-0.07
P5					0.21	-2.83	-0.10	2.07
P6						0.24	-0.77	-2.50
P7							0.23	5.03**
P8								-1.74**

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)}$ ± 0.67

$SE_{(\hat{g}i-\hat{g}j)}$ ± 1.01

$SE_{(\hat{s}ij)}$ ± 2.06

$SE_{(\hat{s}ij-\hat{s}ik)}$ ± 3.04

$SE_{(\hat{s}ij-\hat{s}kl)}$ ± 2.89

Table 11

Gca effects (diagonal) and sca effects (off diagonal), for plant height in 8x8 diallel of opium poppy in E4

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-1.18**	4.69**	-0.65	-0.48	-2.34*	5.38**	-0.67	2.56*
P2		-0.98**	-1.85	4.62**	2.06*	-3.12**	1.43	-3.34**
P3			0.51	0.43	2.27*	-1.31	2.24*	2.17*
P4				-0.96**	0.74	5.16**	-4.29**	8.64**
P5					-0.10	9.00**	1.85	-1.92
P6						2.48**	2.97**	-3.50**
P7							0.23	5.45**
P8								0.00

* Significant at 5% level

**Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.33$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.49$

$SE_{(\hat{s}ij)} \pm 1.00$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 1.48$

$SE_{(\hat{s}ij-\hat{s}kl)} \pm 1.40$

Table 12

Gca effects (diagonal) and sca effects (off diagonal), for plant height in 8x8 diallel of opium poppy(over environments)

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Talia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-0.212	+0.87	-1.03	2.43	1.38	3.33*	2.91	0.65
P2		-0.277	1.01	4.17**	1.44	0.66	4.05**	0.78
P3			-0.148	0.20	0.11	0.88	4.04**	3.00
P4				-0.759	0.39	3.51*	-0.94	0.56
P5					-0.224	2.13	0.59	0.93
P6						0.336	-0.02	-0.12
P7							1.390	1.43
P8								-0.104

* Significant at 5% level

**Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.50$ $SE_{(\hat{S}ij-\hat{S}ik)} \pm 2.27$

$SE_{(\hat{S}ij)} \pm 1.53$ $SE_{(\hat{S}ij-\hat{S}kl)} \pm 2.14$

The lowest significant and positive sca effect was recorded by 2x5 and it was found to be at par with 1x2 and 3x5 .

In pooled analysis no cross recorded significant negative sca effect but five hybrids viz., 2x4, 2x7, 3x7, 4x6 and 1x6 had significant and positive sca effects (Table 12). No significant differences existed between these crosses .

4.4 LEAF AREA

Leaf is the site of photosynthesis and in opium poppy is the important site of latex and alkaloids synthesis. More leaf area is desirable in this crop .

4.4.1 Per se PERFORMANCE

The performance of genotypes in pooled data for this character revealed the fact that the range for parents was 170.41 cm^2(P5) to 130.48 cm^2 (P7) . The highest leaf area of 197.72 cm^2 was recorded by 2x6 as against lowest of 1x8 (136.80 cm^2) . The performance is presented in Table 13.

4.4.2 HETEROSIS

Only seven crosses recorded significant and positive heterosis and eight crosses recorded significant

Table 13

Per-se performance of parents and hybrids in 8x8 diallel of opium poppy for leaf area (cm^2) in pooled analysis

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Talia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	149.46	156.58	142.74	159.09	171.22	160.36	143.13	136.80
P2		157.29	158.86	173.54	193.49	197.72	167.97	174.72
P3			164.98	163.14	160.28	147.01	168.34	175.07
P4				161.56	163.70	168.51	186.19	140.36
P5					170.41	153.32	172.94	193.72
P6						166.80	142.90	163.83
P7							163.83	170.30
P8								130.48

Note: Diagonal entries for parents ; off diagonal entries for hybrids.

and negative heterosis over better parent . Highest, significant and positive heterosis was observed for2x6, while 3x5 recorded highest, significant and negative heterosis (Table 14) .

4.4.3 GCA EFFECTS

In E1, all parental lines except P5 had highly significant gca effects (Table 15) . P2 (29.14) was found to be significantly superior to P3 (8.23), P7 (6.98) and P4 (5.56) for positive gca effects, but no significant differences were present between P3, P7 and P4 . P1 was found to be significantly superior to P6 and P8 for negative gca effects . In E2, P5 and P2 had positive gca effects but were found to be at par (Table 16) . Three parents viz.,P4, P6 and P7 recorded negative and significant gca effect and were at par . In E3, all parents recorded significant gca effects (Table 17).Out of five parents which recorded positive effects , P4 (10.49) was found to be significantly superior to P2, P5 and P7, but was at par with P6 . Though there existed no significant difference between P3 and P8 for negative gca effect, both of these were found to be significantly inferior to P1 . In E4, four parents viz., P1, P5, P6 and P8 had significant gca effects . Out of these only two viz P5 and P6 had positive effect with no significant difference between them . P1 (-4.55) was significantly inferior to P8 (Table 18) .

Table 14

Heterosis for leaf area in pooled data

Crosses	Heterosis %	
	Over better parent	Over mid parent value
1x2	- 0.45**	2.09**
1x3	-13.48	-9.21
1x4	- 1.53	-2.30**
1x5	0.48	7.06
1x6	- 3.86*	-1.41**
1x7	-12.64**	-8.63
1x8	- 8.47	-2.26
2x3	- 3.71*	-1.41**
2x4	7.42**	8.85**
2x5	13.54**	18.09**
2x6	18.54	22.02
2x7	2.53 **	4.62**
2x8	11.08	21.43
3x4	- 1.12*	-0.08
3x5	- 5.94**	-4.42**
3x6	-11.86	-11.38
3x7	2.04*	2.39**
3x8	6.12	18.51
4x5	- 3.94	- 1.38
4x6	1.03**	2.64**
4x7	13.65	14.44
4x8	-13.12**	- 3.88**
5x6	-10.03	- 9.07
5x7	1.48**	3.48**
5x8	13.68**	28.76**
6x7	-14.32	-13.56**
6x8	- 1.78	10.22**
7x8	3.95	15.73

* Significant at 5% level

** Significant at 1% level

Table 15

Gca effects (diagonal) and Sca effects (off diagonal) for leaf area in 8x8 diallel of opium poppy in E1

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Tellis 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafamma)	P8 (Galania)
P1	-18.83**	29.14**	-30.40**	-1.73	40.99**	40.17**	-55.75**	-22.42**
P2		14.29**	10.48	-28.55**	5.87	72.85**	8.33	54.06**
P3			8.23**	28.71**	-0.97	-22.09**	-48.41**	43.12**
P4				5.56**	41.00**	1.08	39.76**	-38.71**
P5					-1.36	-67.80**	38.48**	0.51
P6						- 7.84**	-68.24**	-39.19**
P7							6.98**	22.17**
P8								- 6.55**

* Significant at 5% level

**Significant at 1% level

$SE_{(\hat{g}i)}$ ± 1.99

$SE_{(\hat{g}i-\hat{g}j)}$ ± 3.01

$SE_{(\hat{S}ij)}$ ± 6.10

$SE_{(\hat{S}ij-\hat{S}ik)}$ ± 9.02

$SE_{(\hat{S}ij-\hat{S}kl)}$ ± 8.50

Table 16

Gca effects (diagonal) and sca effects (off diagonal), for leaf area in 8x8 diallel of opium poppy in E2

Parent	P1 (Ranzatak)	P2 (OCG)	P3 (Talia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemen)	P8 (Galenia)
P1	4.55	-24.04**	40.77**	7.94	-3.01	-15.29*	1.71	-48.06**
P2		7.63**	-31.61**	13.76	10.71	17.43*	-25.49**	11.06
P3			- 1.98	21.27**	-16.38*	-13.76	-30.18**	- 1.53
P4				- 5.75*	-54.31**	22.61**	-13.41	-23.96**
P5					10.20**	37.36**	4.44	78.49**
P6						- 5.02*	12.86	-41.59**
P7							- 8.60**	-29.29**
P8								- 1.05

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)}$ ±2.44

$SE_{(\hat{g}i-\hat{g}j)}$ ±3.68

$SE_{(\hat{s}ij)}$ ±7.47

$SE_{(\hat{s}ij-\hat{s}ik)}$ ± 11.05

$SE_{(\hat{s}ij-\hat{s}kl)}$ ± 10.42

Table 17

Gca effects (diagonal) and sca effects (off diagonal), for leaf area in 8x8 diallel of opium poppy in E3

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 Hafemea	P8 (Galania)
P1	-18.76**	-15.12**	-30.44**	16.81**	14.71**	8.95**	18.77**	6.38*
P2		6.12**	- 3.92	12.53**	36.93**	49.97**	-21.91**	-8.90**
P3			- 9.16**	-21.49**	-31.89**	-15.65**	77.57**	22.48**
P4				10.49**	-13.44**	10.60**	0.22	11.03**
P5					6.79**	-25.80**	-22.38**	5.33
P6						7.15**	-29.94**	5.17
P7							4.63**	-9.91**
P8								-7.28**

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.95$

$SE_{(\hat{g}i-\hat{g}j)} \pm 1.44$

$SE_{(\hat{s}ij)} \pm 2.91$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 4.31$

$SE_{(\hat{s}ij-\hat{s}kl)} \pm 4.06$

Table 18

Gca effects (diagonal) and sca effects (off diagonal), for leaf area in 8x8 diallel of opium poppy in E4

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-4.55*	-5.65	-14.57*	-5.57	-7.07	-3.85	-11.35	23.27**
P2		1.92	-12.63	10.97	13.77*	-31.71**	24.19**	-10.49
P3			- 4.07	-25.45**	20.55**	- 5.93	24.87**	20.09**
P4				- 3.97	- 1.55	-18.93**	5.37	-16.31*
P5					11.04**	- 9.63	-12.13	-39.21**
P6						7.92**	- 2.01	27.35**
P7							3.52	10.11
P8								-11.81**

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 2.27$

$SE_{(\hat{g}i-\hat{g}j)} \pm 3.43$

$SE_{(\hat{s}ij)} \pm 6.96$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 10.30$

$SE_{(\hat{s}ij-\hat{s}kl)} \pm 9.71$

In pooled analysis four parents had significant gca effect and out of these P5 and P2 had positive effect with no significant difference between them . No significant difference was observed between P1 & P8, the two parents having negative gca effects (Table 19) .

4.4.4 SCA EFFECTS

In E1, twenty one crosses had significant sca effects (Table 15) . Eleven crosses recorded significant positive sca effects . Cross 2x6 (72.85) was found to be significantly superior to the remaining crosses . There existed no significant differences among 2x8, 3x8, 4x5, 1x5, 1x6, 4x7 and 5x7 for positive sca effects . Out of ten crosses having significant negative sca effects, 3x6 recorded lowest effect; but was found to be at par with 1x8, 2x4, 1x3 & 4x8 . In E2, seventeen crosses had significant sca effects with only six crosses showing positive effects (Table 16) . Highest, significant and positive sca effect was observed for 5x8 (78.49) and it was found to be highly significantly superior to the remaining crosses . No significant differences existed among 1x3, 5x6, 4x6, 3x4 and 2x6 at 1% level of significance. Highest, significant and negative sca effect was recorded by 4x5 and it was found to be at par with 1x8 and 6x8 . There, however, existed no significant differences among

Table 19

Gca effect (diagonal) and sca effects (off diagonal), for leaf area in 8x8 diallel in opium poppy (Over environments)

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-9.88**	-3.69	-6.22	4.90	9.85	7.21	-11.24*	-11.20*
P2		6.98**	-9.27	2.49	15.25**	27.71**	- 3.26	9.86
P3			-2.23	1.29	- 8.75	-13.99**	6.32	19.42**
P4				0.99	- 8.55	4.48	20.44**	-15.52**
P5					8.18**	-17.89**	0.51	27.65**
P6						0.04	-21.31**	5.99
P7							1.18	11.24
P8								- 5.19**

* Significant at 5% level

** Significant at 1% level

$SE_{(gi)} \pm 1.73$

$SE_{(gi-gj)} \pm 2.61$

$SE_{(Sij)} \pm 5.38$

$SE_{(Sij-Sik)} \pm 7.84$

$SE_{(Sij-Skl)} \pm 7.40$

other crosses having negative sca effects . In E3, twenty four crosses had significant sca effects with twelve having positive effects (Table 17) . Cross 3x7 (77.57) recorded highest, significant and positive sca effect and was found to be superior to the remaining crosses . Next in order of significance were 2x6 (49.97), 2x5 (36.93) and 3x8 (22.48). Lowest negative and significant sca effect was observed for 2x8 (-8.90) but it did not differ significantly from 7x8, 4x5, 1x2 and 3x6 . In E4, out of seventeen significant crosses for sca effects, seven crosses viz., 6x8, 3x7, 2x7, 1x8, 3x5, 3x8 and 1x5 recorded significant positive effects, and there exsisted no significant difference between these seven crosses (Table 18) . Out of six crosses having negative sca effects, 5x8 was significantly superior to remaining crosses, which were also at par .

In pooled analysis, out of eleven significant crosses only five viz., 2x6, 5x8, 4x7, 3x8 and 2x5 had positive sca effects (Table 19) . No significant differences were present among these five crosses . Lowest and significant negative sca effect was recorded by 1x8 and it was found to be at par with other crosses .

4.5 STEM DIAMETER

Latex, once manufactured at leaf site is

translocated through stem to peduncle and capsule where it is stored and at a later date lanced and taken out (Fairbrain et al 1974) . Thick stem impart antilodging character in opium poppy, which is a common feature at the time of lancing and collection operations . Therefore, gca and sca effects in positive direction are desirable .

4.5.1 Per se PERFORMANCE

P2 (0.65 cm) was the thickest stem parent while P4 had the lowest stem diameter (0.52) . The range in crosses being 0.77 cm for 2x8 to 0.55 for 5x8 (Table 20).

4.5.2 HETEROSIS

Twenty four crosses recorded significant heterosis over better parent, out of which seventeen showed positive heterosis (Table 21) . Highest, significant and positive heterosis over better parent was recorded by 4x6 .

4.5.3 GCA EFFECT

In E4 five parents recorded significant gca effect and out of these three viz., P7, P2 and P8 recorded positive effects (Table 22) . There existed no significant differences between these three parents . The parents having negative gca effect were also at par .

Table 20

Per se Performance of parents and hybrids in 8x8 diallel of opium poppy, for stem diameter(cm) in E4

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemaa)	P8 (Galania)
P1	0.63	0.56	0.59	0.56	0.66	0.58	0.67	0.62
P2		0.65	0.56	0.62	0.67	0.58	0.72	0.77
P3			0.55	0.72	0.61	0.58	0.67	0.76
P4				0.52	0.68	0.67	0.67	0.61
P5					0.54	0.58	0.59	0.55
P6						0.52	0.61	0.62
P7							0.61	0.64
P8								0.60

Note: Diagonal entries for parents; Off diagonal entries for hybrids .

Table 21

Heterosis for stem diameter in E4

Crosses	Heterosis% Over better parent	Over mid parent value
1x2	-13.85**	-12.50**
1x3	- 6.34**	0
1x4	-11.11**	- 2.61*
1x5	4.76	12.82**
1x6	- 7.94**	- 0.87
1x7	6.35**	8.06**
1x8	- 1.58	0.81
2x3	-13.85**	- 6.67*
2x4	- 4.62**	5.98**
2x5	3.08*	12.60**
2x6	-10.77**	- 0.85
2x7	10.77**	14.29**
2x8	18.46**	23.20**
3x4	30.91**	34.58**
3x5	10.91**	11.93**
3x6	5.45**	8.41**
3x7	9.84**	18.52**
3x8	26.67**	32.17**
4x5	25.93**	28.30**
4x6	28.85**	28.85**
4x7	9.84**	18.58**
4x8	1.67	8.93**
5x6	7.41**	9.43**
5x7	- 3.28*	2.61*
5x8	- 8.33**	- 3.51*
6x7	0	7.96**
6x8	3.33*	10.71**
7x8	4.92**	5.79**

* Significant at 5% level

** Significant at 1% level

Table 22

Gca effect (diagonal) and sca effects (off diagonal), for stem diameter in 8x8 diallel of opium poppy in E4

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-0.009	-0.072**	-0.023	-0.051**	0.064**	0.00	0.037*	-0.011
P2		0.019**	-0.081**	-0.019	0.046**	-0.028	-0.059**	0.111**
P3			0.00	0.100**	0.005	-0.009	0.028	0.120**
P4				-0.002	0.077**	0.083**	0.030	-0.028
P5					-0.017**	-0.008	0.059**	-0.073**
P6						-0.033**	0.001	0.013
P7							0.020**	-0.020
P8								0.018**

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.005$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.008$

$SE_{(\hat{s}ij)} \pm 0.017$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.024$

$SE_{(\hat{s}ij-\hat{s}kl)} \pm 0.023$

4.5.4 SCA EFFECTS

Of the fourteen significant crosses for sca effect in E4, nine had positive effects (Table 22) . No significant differences were observed among these crosses . Crosses having negative effects, were also at par .

4.6 NUMBER OF CAPSULES PER PLANT

Number of capsules per plant contribute to yield components in major crops . This character can increase seed yield in opium poppy (Jablonski,1967) . In opium poppy it is the terminal and main capsule which contributes to the lion share of latex yield (Gupta _et al._,1978), and therefore, in the present investigation also, this character was studied and positive gca and sca effect have been summarised below .

4.6.1 _Per se_ PERFORMANCE

The means for parents and hybrids have been presented in table 23 . P3 (2.15) had highest number of capsules per plant while P1 (1.67) had lowest value . The range of number of capsules per plant in hybrids was from 2.47 (4x6) to 1.70 (1x7) .

Table 23

Per se Performance of parents and hybrids in 8x8 diallel of opium poppy, for number of capsules per plant in pooled analysis

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafamua)	P8 (Galania)
P1	1.67	2.12	1.91	1.89	1.87	2.33	1.70	2.05
P2		1.83	1.80	2.16	2.31	2.12	1.99	1.99
P3			2.15	1.97	2.08	2.28	1.99	2.09
P4				1.99	2.39	2.47	1.88	2.22
P5					1.85	2.01	2.17	2.45
P6						1.87	2.03	1.83
P7							1.99	1.91
P8								1.85

Note:- Diagonal entries for parents; off diagonal entries for hybrids .

4.6.2 HETEROSIS

Fourteen crosses had significant heterosis over better parent and out of these eight had positive effect (Table 24) . The cross 4x6 recorded highest positive heterosis while lowest negative effect was observed for 2x8 .

4.6.3 GCA EFFECTS

In E2, all parents recorded significant gca effects and out of these five parents had positive effects (Table 25) . P4 (0.22) was found to be significantly superior to the remaining parents for gca effects except P5 (0.19) from which it did not differ significantly . P2 having negative effect was found to be significantly superior to P2 and P3 . In E3, only P2 (0.12) had significant and positive gca effect (Table 26) .

In pooled analysis only four parents had significant gca effects (Table 27) . Only P4 and P5 had positive effect but there existed no significant difference between them . The other two parents having negative effect were found to be at par .

Table 24

Heterosis for number of capsules per plant (pooled data)

Crosses	Heterosis%	
	Over better parent	Over mid parent value
1x2	13.19*	14.79**
1x3	- 8.11	3.34
1x4	- 4.40	6.75
1x5	2.52	7.59
1x6	15.38**	20.00**
1x7	-19.25**	- 8.76
1x8	0	6.80
2x3	-19.46**	- 8.31
2x4	- 0.55	-12.42**
2x5	25.79**	33.78**
2x6	3.21	8.78
2x7	-15.51**	- 3.36
2x8	-11.52*	- 4.26
3x4	-21.62**	-20.98**
3x5	- 5.41	1.74
3x6	0	- 8.50
3x7	- 6.42	- 5.91
3x8	1.08	6.85
4x5	30.22**	39.00**
4x6	43.96**	55.03**
4x7	-12.83**	-11.65**
4x8	4.95	10.09
5x6	6.92	7.94
5x7	9.63*	18.50**
5x8	33.33**	35.80**
6x7	10.16*	20.12**
6x8	- 3.03	- 0.31
7x8	- 3.21	2.84

* Significant at 5% level

** Significant at 1% level

Table 25

Gca effect (diagonal) and sca effects (off diagonal), for number of capsules per plant in 8x8 diallel of opium poppy in E2

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galenia)
P1	-0.26**	0.19**	-0.06	-0.08*	-0.20**	-0.01	-0.35**	-0.24**
P2		-0.42**	-0.11**	-0.24**	-0.15**	-0.20**	-0.09*	-0.22**
P3			-0.05**	-0.70**	-0.06	-0.04	-0.10*	0.39**
P4				0.22**	0.43**	1.22**	-0.59**	-0.23**
P5					0.19**	-0.22**	0.44**	0.71**
P6						0.16**	0.43**	-0.25**
P7							0.12**	0.01
P8								0.04**

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.0128$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.0195$

$SE_{(\hat{s}ij)} \pm 0.0395$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.0585$

$SE_{(\hat{s}ij-\hat{s}kl)} \pm 0.0551$

Table 26

Gca effect (diagonal) and sca effects (off diagonal), for number of capsules per plant in 8x8 diallel of opium poppy in E3

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galenia)
P1	-0.01	0.12	0.26	0.04	-0.01	0.25	0.07	0.30*
P2		0.12	-0.07	0.29*	0.72**	0.08	-0.04	-0.08
P3			-0.01	-0.12	-0.10	0.18	0.08	-0.11
P4				0.05	0.30*	0.04	0.01	0.28
P5					0.02	-0.21	-0.12	-0.03
P6						-0.06	0.00	-0.16
P7							-0.06	0.09
P8								-0.04

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{gi})} \pm 0.0477$

$SE_{(\hat{gi}-\hat{gj})} \pm 0.0721$

$SE_{(\hat{sij})} \pm 0.1462$

$SE_{(\hat{sij}-\hat{sik})} \pm 0.2163$

$SE_{(\hat{sij}-\hat{skl})} \pm 0.2040$

Table 27

Gca effect (diagonal) and sca effects (off diagonal), for number of capsules per plant in 8x8 diallel of opium poppy (Over environments)

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-0.131**	0.148	0.100	-0.021	-0.102	0.120	-0.147	0.026
P2		-0.147**	-0.094	0.065	0.284*	-0.054	-0.061	-0.148
P3			-0.029	-0.413**	-0.082	0.068	-0.009	0.144
P4				0.132**	0.377**	0.677**	-0.290*	0.023
P5					0.103*	0.212	0.161	0.344*
P6						0.051	0.221	-0.206
P7							0.028	0.027
P8								-0.005

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.04437$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.06708$

$SE_{(\hat{s}ij)} \pm 0.13601$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.20125$

$SE_{(\hat{s}ij-\hat{s}kl)} \pm 0.18974$

4.6.4 SCA EFFECTS

In E2, twenty three crosses (Seven with positive effect) had significant sca effects (Table 25) . The cross 4x6 (1.22) recorded the highest and significantly positive sca effect as compared to remaining crosses . Next in order of merit was 5x8 (0.71) . Cross 3x4 (-.70) was significantly superior to all other hybrids . In E3, only four hybrids, all having positive sca effect, were significant (Table 26). Cross 2x5 (0.72) was found to be significantly superior to the remaining crosses (1x8, 4x5, 2x4), which in turn were at par .

In pooled analysis, only six crosses recorded significant sca effects (Table 27) . Out of four crosses having positive effect, though 4x6 recorded highest and significant sca effect, was found to be at par with 4x5 and 5x8 . No significant difference existed between 3x4 and 4x7, the crosses having negative sca effects .

4.7 CAPSULE SIZE

In India capsule is generally lanced vertically downward and sometime 5 to 6 lancing on a single capsule are affected, thus more area is required to accomodate greater number of lancings . Positive gca and sca effects,

therefore are desirable in opium poppy for this character .

4.7.1 Per se PERFORMANCE

P7 (15.27 cm^2) recorded the highest capsule size as against the lowest of P8 (13.04 cm^2) . Among crosses, 4x7 had the highest mean (16.18 cm^2) as compared to the lowest of 2x5 (Table 28) .

4.7.2 HETEROSIS

Out of sixteen crosses which had significant heterosis over better parent, only one (7x8) recorded negative heterosis (Table 29) . Highest, significant and positive heterosis over better parent was recorded by 1x6 .

4.7.3 GCA EFFECTS

Except P2, all parents had significant gca effects in E1 and positive effects were recorded by P7, P6 and P3 . P7 (0.84) was significantly superior to P6 and P5, but P6 was found to be superior to P5 (Table 30) . Lowest and significantly negative gca effect was observed for P1 . In E2, five parents had significant gca effects (Table 31). P7 (1.49) was found to be significantly superior to only other significant and positive effect parent P3 (0.64) .

Table 28

Per se performance of parent and hybrids in 8x8 diallel of opium poppy for capsule size(Cm^2) in pooled analysis

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafamea)	P8 (Galenia)
P1	13.62	14.83	13.96	14.13	14.25	15.27	14.63	14.46
P2		13.85	14.80	14.84	13.87	15.02	15.30	14.08
P3			14.17	15.00	15.10	14.90	15.96	14.18
P4				13.62	14.13	14.16	16.18	14.85
P5					13.59	14.01	18.33	14.76
P6						13.12	16.04	13.84
P7							15.27	13.91
P8								13.04

Note:- Diagonal entries for parents; off diagonal entries for hybrids .

Table 29

Heterosis for capsule size (pooled data)

Crosses	Heterosis%	
	Over better parent	Over mid parent value
1x2	7.08**	7.97**
1x3	-1.48	0.47
1x4	2.24	2.99
1x5	4.63	4.74
1x6	12.11**	14.21**
1x7	- 4.19	1.28
1x8	6.17*	8.48**
2x3	4.45	5.64*
2x4	7.15**	7.26**
2x5	-0.14	1.09
2x6	8.45**	11.38**
2x7	0.20	5.08*
2x8	1.66	4.72*
3x4	5.86*	7.18**
3x5	6.56**	8.79**
3x6	5.15*	9.20**
3x7	4.52*	8.42**
3x8	-0.07	4.23
4x5	2.24	3.10
4x6	2.46	5.12*
4x7	5.96**	11.24**
4x8	7.45**	10.57**
5x6	8.98**	10.89**
5x7	0.39	6.24**
5x8	8.61**	10.85**
6x7	5.04*	13.00**
6x8	5.49*	5.81*
7x8	-8.91**	-1.73

* Significant at 5% level

** Significant at 1% level

Table 30

Gca effects (diagonal) and sca effects (off diagonal) for capsule size in 8x8 diallel of opium poppy in E1

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Talia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemsa)	P8)(Galania)
P1	-0.07*	-0.32**	0.13	0.82**	0.24*	3.00**	-0.02	-0.63**
P2		-0.06	1.27**	0.11	0.25*	1.29**	-0.63**	-1.14**
P3			-0.66**	-0.29**	-0.35**	0.00	-0.13	-0.04
P4				-0.20**	-0.21*	1.67**	1.21**	0.10
P5					0.26**	-0.13	1.25**	0.54**
P6						0.32**	0.29**	-0.82**
P7							0.84**	0.66**
P8								-0.45**

* Significant at 5% level
** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.0349$
$SE_{(\hat{g}i-\hat{g}j)} \pm 0.0527$
$SE_{(\hat{s}ij)} \pm 0.1069$
$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.1582$
$SE_{(\hat{s}ij-\hat{s}kl)} \pm 0.1491$

Table 31

Gca effects (diagnal) and sca effects (off diagonal) for capsule size in 8x8 diallel of opium poppy in E2

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafamaa)	P8 (Galania)
P1	-0.63**	-0.33	-1.33*	-0.25	-0.08	-1.44*	-1.58*	4.57**
P2		0.04	0.20	0.88	-0.75	0.87	2.35**	1.20
P3			0.64**	0.78	0.05	0.19	1.33*	-0.40
P4				-0.24	0.63	-0.53	3.43**	0.58
P5					-0.81**	0.64	-2.00**	0.55
P6						0.05	2.14**	-1.41*
P7							1.49**	-3.45**
P8								-0.56**

* Significant at 5% level

**Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.2011$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.3041$

$SE_{(\hat{S}ij)} \pm 0.6165$

$SE_{(\hat{S}ij-\hat{S}ik)} \pm 0.9122$

$SE_{(\hat{S}ij-\hat{S}lk)} \pm 0.8600$

There existed no significant differences among parents having negative and significant effects . In E3, all parents except P5 had significant gca effects, with only three parents viz., P3, P8 and P1 having positive effects (Table 32) . P3 (0.31) was found to be significantly superior to P8 (0.19) and P1 (0.14), however, P8 and P1 were at par . No significant differences were present among crosses having negative gca effects . In E4, only four parents (two each with positive and negative effects) had significant gca effects (Table 33). No significant difference were observed either between parents having positive effects or parents having negative effects .

In pooled analysis only P7 (having positive effect) and P8 (having negative effects) were significant for gca effects (Table 34) .

4.7.4 SCA EFFECTS

In E1, out of twenty crosses having significant gca effects, as many as twelve recorded significant and positive sca effects (Table 30) . Cross 1x6 (3.00 was significantly superior to the remaining crosses . Cross 4x6 was next in merit and was found to be superior to other crosses . Hybrid 4x5, though recorded lowest negative sca effect, was found to be at par with 3x4, 1x2 and 3x5 .

Table 32

Gca effect (Diagonal) and sca effects (off diagonal) for capsule size in 8x8 diallel of opium poppy in E3

Parent	P1 (Ranzetak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	0.14**	1.69**	-0.53**	0.10	-0.52**	2.22**	0.25*	0.09
P2		-0.11**	-0.08	-0.05	0.87**	0.47**	-0.40**	-0.54**
P3			0.31**	-0.27*	1.01**	-0.45**	0.58**	0.92**
P4				-0.12**	0.24*	-0.22	0.51**	0.15
P5					0.00	0.06	0.15	-0.07
P6						-0.14**	0.73**	1.77**
P7							-0.27**	0.50**
P8								0.19**

* Significant at 5% level.
** Significant at 1% level.

$SE_{(\hat{g}i)} \pm 0.0376$
$SE_{(\hat{g}i-\hat{g}j)} \pm 0.0569$
$SE_{(\hat{S}ij)} \pm 0.1154$
$SE_{(\hat{S}ij-\hat{S}ik)} \pm 0.1708$
$SE_{(\hat{S}ij-\hat{S}ik)} \pm 0.1610$

Table 33

Gca effect (Diagonal) and sca effects (off diagonal) for capsule size in 8x8 diallel of opium poppy in E4

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-0.18	1.05	-0.39	-1.09	0.99	0.05	-0.38	-1.63**
P2		-0.04	-0.72	0.36	-0.76	-0.30	-0.92	-0.48
P3			0.30	1.02	1.30*	1.36*	0.53	-0.72
P4				0.60**	-1.80**	1.06	-1.47*	0.28
P5					0.02	1.24*	0.11	2.36**
P6						-0.44*	0.27	-0.48
P7							0.79**	-1.21*
P8								-1.06**

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.2014$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.3045$

$SE_{(\hat{s}ij)} \pm 0.6175$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.9136$

$SE_{(\hat{s}ij-\hat{s}lk)} \pm 0.8613$

Table 34

Gca effect (Diagonal) and sca effects (off diagonal) for capsule size in 8x8 diallel of opium poppy (over environment)

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Talia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemoa)	P8 (Galania)
P1	-0.20	0.53	-0.52	-0.22	0.05	0.99**	-0.42	0.59
P2		-0.03	0.15	0.32	-0.50	0.07	0.09	0.04
P3			0.15	0.30	0.55	0.27	0.57	-0.04
P4				0.02	-0.29	-0.34	0.92*	0.76*
P5					-0.13	0.46	0.22	0.82*
P6						-0.05	0.84*	-0.18
P7							0.71**	-0.38*
P8								-0.46**

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.1253$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.1894$

$SE_{(\hat{s}ij)} \pm 0.3840$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.5681$

$SE_{(\hat{s}ij-\hat{s}lk)} \pm 0.5356$

In E2, eleven crosses (five with positive effects) recorded significant sca effects (Table 31) . Comparison among crosses having positive effects revealed that cross 1x8, though did not differ significantly from 4x7, was found to be significantly superior to the remaining crosses . No significant differences existed between these remaining crosses . Cross 7x8 recorded highest, significant and negative sca effect as compared to all other crosses . The remaining negative effect crosses were found to be at par . In E3, nineteen crosses (fourteen with positive effects) had significant sca effects (Table 32) . Cross 1x6 (2.22) was significanficantly superior to the remaining crosses which had positive sca effects . It was followed by 6x8 (1.77) and 1x2 (1.69) which did not differ significantly among themselves . All the five crosses having negative sca effects were at par . In E4, only eight crosses recorded significant sca effects (Table 33) . Four crosses viz., 5x8, 3x6, 3x5 and 5x6 recorded significant and positive sca effects and there existed no significant differences among themselves . No significant differences were observed among crosses having negative sca effects .

In pooled analysis, only six crosses recorded significant sca effects (Table 34) . Out of these five crosses viz., 1x6, 4x7, 5x8, 6x7 and 4x8, recorded significant and positive and only 7x8 recorded significant and negative

sca effect . No significant differences were observed among these crosses .

4.8 NUMBER OF STIGMATIC RAYS

4.8.1 Per se PERFORMANCE

Among the parents highest and lowest mean values were recorded by P7 (13.70) and P6 (12.65) respectively . Highest and lowest values among the crosses were observed for 5x7 (14.32) and 1x3 (12.88) respectively (Table 35).

4.8.2 HETEROSIS

Out of twenty four significant crosses for heterosis over better parent, only nine had positive heterosis values . Highest positive heterosis over better parent was observed for 5x7 (Table 36) .

4.8.3 GCA EFFECTS

In E2, six parents recorded significant gca effect and out of these three had positive effects (Table 37). P4 (0.27) was significantly superior to P2 and P7, and no significant difference was observed between P2 and P7 . Significantly lowest negative gca effect was recorded by P5. In E4, all parents had significant gca effects with only three parents viz., P8, P7 and P6 having positive effects

Table 35

Per-se performance of parents and hybrids in 8x8 diallel of opium poppy for number of stigmatic rays/capsule in pooled analysis

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Talia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafamca)	P8 (Galania)
P1	13.35	13.53	12.88	13.41	13.05	13.52	13.20	12.89
P2		13.58	13.41	13.43	13.21	13.63	13.59	13.78
P3			13.43	13.16	13.22	13.53	13.20	13.50
P4				13.63	13.50	13.62	13.58	13.76
P5					13.17	13.31	14.32	13.79
P6						12.65	13.57	13.65
P7							13.70	13.48
P8								13.41

Note: Diagonal entries for parents; off diagonal entries for hybrids.

Table 36

Heterosis for number of stigmatic rays per capsule (pooled data)

Crosses	Heterosis%	
	Over better parent	Over mid parent value
1x2	-0.37	0.48
1x3	-4.10**	-3.81**
1x4	-1.47**	-0.52**
1x5	-2.25**	-1.58**
1x6	1.27**	4.00**
1x7	-3.65**	-2.40**
1x8	-3.88**	-3.66**
2x3	-1.25**	-0.63*
2x4	-1.47**	-1.29**
2x5	-2.72**	-1.23**
2x6	0.37	3.93**
2x7	-0.80*	-0.04
2x8	1.47**	2.11**
3x4	-3.45**	-2.73**
3x5	-1.56**	-0.60
3x6	0.75*	3.76**
3x7	-3.64**	-2.69**
3x8	0.52	0.60
4x5	-0.95*	0.75*
4x6	-0.07	3.65**
4x7	-0.88*	-0.62*
4x8	0.95**	1.78**
5x6	1.06**	3.10**
5x7	4.53**	6.59**
5x8	2.83**	3.76**
6x7	-0.95**	3.00**
6x8	1.78**	4.76**
7x8	-1.61**	-0.55

* Significant at 5% level

** Significant at 1% level

Table 37

Gca effects (diagonal) and sca effects (off diagonal) for number of stigmatic rays/capsule in 8x8 diallel of opium poppy in E2

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Malania)
P1	-0.29**	-0.03	0.15*	-0.40**	0.25**	0.35**	-0.65**	-1.17**
P2		0.20**	-0.33**	- 0.18**	0.56**	-0.13	0.24**	0.25**
P3			0.02	0.20**	-0.55**	-0.25**	0.22**	0.63**
P4				0.27**	0.20**	0.70**	-0.23**	1.58**
P5					-0.09**	0.45**	1.42**	0.13
P6						-0.29**	0.52**	0.03
P7							0.15**	0.50**
P8								0.04

* Significant at 5% level

**Significant at 1% level

$SE(\hat{g}i) \pm 0.0227$

$SE(\hat{g}i-\hat{g}j) \pm 0.0344$

$SE(\hat{s}ij) \pm 0.0696$

$SE(\hat{s}ij-\hat{s}ik) \pm 0.1031$

$SE(\hat{s}ij-\hat{s}ik) \pm 0.0972$

Table 38

Gca effects (diagonal) and sca effects (off diagonal) for number of stigmatic rays/capsule in 8x8 diallel of opium poppy in E4

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-0.25**	-0.47**	-0.71**	-0.42**	-0.57**	-0.05	-0.14*	0.10
P2		-0.08**	-0.58**	-0.29**	-0.74**	0.38**	-0.51**	0.63**
P3			-0.20**	-0.07	+0.08	0.20**	0.09	0.25**
P4				-0.09**	0.27**	-0.01	0.10	-0.06
P5					-0.04**	-0.16**	0.65**	0.59**
P6						0.14**	0.27**	0.21**
P7							0.23**	-0.28**
P8								0.29**

* Significant at 5% level

**Significant at 1% level

$SE_{(\hat{gi})} \pm 0.0172$

$SE_{(\hat{gi}-\hat{gj})} \pm 0.0261$

$SE_{(\hat{sij})} \pm 0.0529$

$SE_{(\hat{sij}-\hat{sik})} \pm 0.0782$

$SE_{(\hat{sij}-\hat{sik})} \pm 0.0738$

(Table 38) . P8 (0.29) was significantly superior to other two parents while P7 was superior to P6 . Comparision of crosses with negative effects showed that P5 (-.04)recorded lowest gca effect but was found to be at par with P4 and P2.

In pooled analysis, all parents (four with positive effects) had significant gca effects (Table 39). Though P7 (0.19) did not differ significantly from P8(0.17), it was found to be significantly superior to P2 and P4, which were at par . Lowest significant and negative gca effect was recorded by P5 but it was found to be at par with P6 and P3 .

4.8.4 SCA EFFECT

In E2, twenty four crosses (sixteen with positive effects) were found to possess significant sca effects (Table 37) . Cross 4x8, though did not differ significantly from 5x7, was found to be significantly superior to the remaining crosses . Lowest, significant and negative sca effect was recorded by 2x4, but it was found to be at par with 4x7, 3x6 and 2x3 . In E4, twenty crosses (nine with positive effects) had significant sca effects (Table 38) . Cross 5x7 was found to be significantly superior to remaining crosses having positive effects, but was found to be at par with 2x8 . Lowest significant and negative

sca effect was recorded by 1x7 but it was found to be at par with 5x6, 7x8 and 2x4 .

In pooled analysis, except 3x6, all crosses (fifteen with positive effects) had significant sca effects (Table 39) . Cross 5x7 (1.07) was found to be significantly superior to remaining crosses . The next cross in order of merit was 4x8 (0.74) . Though, 4x7 recorded lowest, significant and negative sca effect, it was found to be at par with eight other crosses .

4.9 LATEX YIELD

4.9.1 Per se PERFORMANCE

The highest and lowest mean values were recorded by parents P4 (0.274 gm) and P1 (0.190 gm) respectively (Table 40) . Among crosses highest and lowest mean values were observed for 4x8 (0.446 gm) and 1x7 (0.201 gm) respectively .

4.9.2 HETEROSIS

All crosses except 4x7 recorded significant heterosis with only three having negative heterosis over better parent (Table 41) . Highest positive heterosis was recorded by 4x8 followed by 2x5 .

Table 39

Gca effects (diagonal) and sca effects (off diagonal) for number of stigmatic rays/capsule in 8x8 diallel of opium poppy (Over environments)

Parent	P1 (Ranzatak)	P2 (OCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-0.26**	0.20**	-0.21**	-0.43**	-0.18**	0.14**	-0.43**	0.51**
P2		0.06*	-0.43**	-0.25**	-0.10*	0.12**	-0.15**	0.47**
P3			-0,13**	0.14**	-0.21**	0.01	0.14**	0.42**
P4				0.09**	0.27**	0.39**	-0.08*	0.74**
P5					-0.06*	0.13**	1.07**	0.39**
P6						-0.08**	0.39**	0.11**
P7							0.19**	-0.36**
P8								0.17**

* Significant at 5% level

**Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.0249$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.0377$

$SE_{(\hat{s}ij)} \pm 0.0764$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.1130$

$SE_{(\hat{s}ij-\hat{s}lk)} \pm 0.1066$

Table 40

Per-se performance of parents and hybrids in 8x8 diallel of opium poppy for latex yield/plant (gm) (pOOled analysis)

Parent	P1 (Ranzatak)	P2 (OCS)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	0.190	0.318	0.286	0.297	0.254	0.260	0.201	0.229
P2		0.221	0.285	0.321	0.360	0.338	0.278	0.267
P3			0.272	0.411	0.360	0.356	0.288	0.338
P4				0.274	0.375	0.296	0.280	0.446
P5					0.222	0.270	0.275	0.293
P6						0.233	0.281	0.282
P7							0.234	0.287
P8								0.253

Note: Diagonal entries for parents; off diagonal entries for hybrids.

Table 41

Heterosis for opium yield per plant (Pooled data)

Crosses	Heterosis%	
	Over better parent	Over mid parent value
1x2	43.89**	54.74**
1x3	- 5.15**	23.81**
1x4	8.39**	28.02**
1x5	14.41**	23.30**
1x6	11.59**	22.93**
1x7	-14.10**	- 5.19**
1x8	- 9.49**	3.39**
2x3	4.78**	15.62**
2x4	17.15**	29.70**
2x5	62.16**	62.53**
2x6	45.86**	48.90**
2x7	18.80**	22.20**
2x8	5.53**	12.66**
3x4	50.00**	50.50**
3x5	32.35**	45.75**
3x6	30.88**	40.99**
3x7	5.88**	13.83**
3x8	24.26**	28.76**
4x5	36.86**	51.21**
4x6	8.03**	16.77**
4x7	2.19	10.24**
4x8	62.77**	69.26**
5x6	15.88**	18.68**
5x7	17.52**	20.61**
5x8	15.81**	23.37**
6x7	20.09**	20.34**
6x8	11.46**	16.05**
7x8	13.44**	17.86**

* Significant at 5% level

** Significant at 1% level

4.9.3 GCA EFFECTS

In E1, all parents had significant gca effects (Table 42) . Five parents viz., P4, P3, P8, P5 and P2, recorded positive gca effects . P4 was significantly superior to the remaining crosses . The order of significance in other parents was P3, P8, P5 and P2 . Lowest significant and negative gca effect was recorded by P6 . In E2, all parents (four with positive effects)had significant gca effects (Table 43) . P4 was found to be significantly superior to remaining crosses . Though P8 did not differ significantly from P5 for negative gca effect, it had lowest negative effect . In E3, six parents (four with positive effects) recorded significant gca effects (Table 44) . P4 was significantly superior to remaining crosses, having positive effects . P1 recorded lowest, significant and negative gca effect . In E4, six crosses (three having positive effects) had significant gca effect (Table 45) . P4 was significantly superior to other crosses possessing positive effects, but it did not differ significantly from P3 . Lowest negative effect was recorded by P5 .

In pooled analysis, out of six significant parents for gca effect three parents viz., P4, P3 and P8 had positive

Table 42

Gca effects (diagonal) and sca effects (off diagonal) for latex yield per plant in 8x8 diallel of opium poppy in E1

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Talia 1)	P4 (Irranian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-0.0523**	0.1013**	-0.0094**	0.0018	-0.0365	0.0476**	-0.0481**	-0.0499**
P2		0.0046**	-0.0603**	-0.0411**	0.0486**	0.1117**	0.0750**	-0.0378**
P3			0.0363**	0.1002**	-0.0441**	0.0450**	-0.0207**	-0.0005
P4				0.0541**	0.0731**	-0.1338**	-0.0350**	0.2007**
P5					0.0084**	0.0109**	0.0182**	0.0844**
P6						-0.0257**	-0.0297**	0.0725**
P7							-0.0410**	-0.0262**
P8								0.0158**

* Significant at 5% level

**Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.0009354$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.0014142$

$SE_{(\hat{s}ij)} \pm 0.0028674$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.0042426$

$SE_{(\hat{s}ij-\hat{s}lk)} \pm 0.0040000$

Table 43

Gca effects (diagonal) and sca effects (off diagonal) for latex yield per plant in 8x8 diallel of opium poppy in E2

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Talia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemaa)	P8 (Galania)
P1	-0.1531**	0.2904**	0.7543**	0.0355**	-0.0736**	0.0853**	-0.1721**	-0.0794**
P2		-0.0123**	-0.1517**	-0.1339**	0.1820**	0.3089**	0.1565**	-0.0578**
P3			0.0890**	0.2744**	-0.0777**	0.0012	-0.1072**	0.0915**
P4				0.1812**	0.2331**	-0.2450**	-0.1654**	0.5993**
P5					-0.0127**	0.0049	0.3355**	-0.2698**
P6						-0.0226**	0.0154**	-0.0599**
P7							-0.0822**	-0.0463**
P8								-0.0119**

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.001537$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.002324$

$SE_{(\hat{s}ij)} \pm 0.004712$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.006971$

$SE_{(\hat{s}ij-\hat{s}lk)} \pm 0.006573$

Table 44

Gca effects (diagonal) and sca effects (off diagonal) for latex yield per plant in 8x8 diallel of opium poppy in E3

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-0.0191**	0.0601**	0.0144*	-0.0040	0.0336**	-0.0036	0.0133*	-0.0230**
P2		0.0045*	0.0089	0.0285**	0.1081**	-0.0011	-0.0422**	-0.0335**
P3			0.0102**	0.0338**	0.0354**	0.0852**	0.0171**	0.0268**
P4				0.0166**	0.0250**	0.0608**	0.0027	0.0224**
P5					0.0010	-0.0246**	-0.0357**	-0.0030
P6						0.0012	-0.0059	0.0208**
P7							-0.0258**	0.0507**
P8								0.0116**

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.001894$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.002864$

$SE_{(\hat{s}ij)} \pm 0.005806$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.008591$

$SE_{(\hat{s}ij-\hat{s}lk)} \pm 0.008099$

Table 45

Gca effects (diagonal) and sca effects (off diagonal) for latex yield per plant in 8x8 diallel of opium poppy in E4

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Tella 1)	P4 (Irrianian)	P5 (LL 3)	P6 (UP White)	P7 (Hafemea)	P8 (Galenia)
P1	-0.0224**	0.0547**	0.0074	0.0020	0.0391**	0.0	0.0029	-0.0210**
P2		-0.0038	0.0128*	-0.0344**	0.0775**	0.0134*	-0.0317**	-0.0306**
P3			0.0145**	0.0301**	0.0402**	0.0751**	0.0620**	0.0241**
P4				0.0189**	0.0198	0.0607**	0.0176**	0.0317**
P5					-0.0072**	-0.0222**	-0.0363**	0.0038
P6						0.0029	-0.0184**	0.0598**
P7							-0.0140**	0.0606**
P8								0.0109**

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.001940$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.002933$

$SE_{(\hat{s}ij)} \pm 0.005946$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.008798$

$SE_{(\hat{s}ij-\hat{s}lk)} \pm 0.008295$

effects (Table 46) . P4 (.0366) was significantly superior to P3 (.0260) and P8 (.0040) . P3 was significantly superior to P8 . Significantly lower negative gca effect was recorded by P6 (-.0059) .

4.9.4 SCA EFFECTS

All crosses recorded significant sca effects in E1 (Table 42) . Thirteen crosses were observed to have significant and positive sca effect . Out of these, 4x6 was found to be significantly superior to remaining crosses except cross 2x6, with which it was at par . Though 5x6 did not differ from 5x7, it had recorded lowest negative sca effect . In E2, all crosses had significant sca effects (Table 43) . Thirteen crosses had positive effects. Cross 1x3 recorded highest and positive sca effect and was found to be significantly superior to remaining crosses . It was followed by 4x8, 5x7 and 2x6 in order of significance . Though 7x8 was found to be at par with 2x8, it recorded lowest, significant and negative effects . In E3, twenty crosses (sixteen with positive effects) had significant sca effects (Table 44) . Cross 2x5 was observed to be significantly superior to remaining crosses having positive effects . Cross 3x6, though did not differ from 1x2, was significantly superior to remaining thirteen crosses, with positive effects . Lowest, significant and negative sca

Table 46

Gca effects (diagonal) and sca effects (off diagonal) for latex yield per plant in 8x8 diallel of opium poppy (Over environments)

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Talia 1)	P4 (Irrlanian)	P5 (LL3)	P6 (UP White)	P7 (Hafemsa)	P8 (Galania)
P1	-0.0363**	0.0666**	0.0087*	0.0091*	0.0	0.0146**	-0.0253**	-0.0263**
P2		0.0001	-0.0307**	-0.0053	0.0600**	0.0542**	0.0133**	-0.0267**
P3			0.0260**	0.0588**	0.0421**	0.0463**	-0.0026	0.0184**
P4				0.0366**	0.0465**	-0.0243**	-0.0212**	0.0116**
P5					0.0023	-0.0160**	0.0081*	-0.0029
P6						-0.0059**	0.0223**	-0.0057
P7							-0.0250**	0.0184**
P8								0.0040**

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.001289$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.001949$

$SE_{(\hat{s}ij)} \pm 0.003952$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.005048$

$SE_{(\hat{s}ij-\hat{s}lk)} \pm 0.005514$

effect was observed for 1x8, though it did not differ from 5x6 and 2x8 . In E4, twenty three crosses had significant sca effects (Table 45) . Out of sixteen crosses possessing significant and positive effects, cross 2x5 was significantly superior to remaing crosses except 3x6 and 3x7, with whome, it was found to be at par . The lowest negative effect was recorded by 6x7 but it was found to be at par with five other crosses .

In pooled analysis, twenty three crosses had significant sca effects (Table 46) . Out of sixteen crosses having positive and significant effect, 2x5 (.0680) was significantly superior to remaing crosses, but was found to be at par with 1x2 (.0666) and 3x4 (.0588) . Lowest, significant and negative sca effect was recorded by 5x6 (-.0160), but it was found to be at par with five other crosses .

4.10 SEED YIELD

4.10.1 Per se PERFORMANCE

P5 (7.28 gm) had highest mean value for seed yield per plant followed by, P7 (7.18 gm), P2 (7.18 gm) and the lowest value of 6.22 gm was observed for P1 (Table 47). Highest and lowest mean values of seed yield in crosses were recorded by 4x6 (10.54 gm) and 2x8 (5.50 gm) respectively .

Table 47

Per se Performance of parents and hybrids in 8x8 diallel of opium poppy for seed yield/ plant (gm) in pooled analysis

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Talia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemma)	P8 (Galania)
P1	6.22	7.55	6.54	6.66	6.47	8.88	6.26	6.41
P2		7.18	6.31	7.55	8.12	7.19	7.14	5.50
P3			6.96	6.68	7.40	8.57	7.75	7.24
P4				7.06	9.30	10.54	7.05	7.12
P5					7.28	7.22	8.12	8.37
P6						6.79	8.09	6.21
P7							7.18	6.54
P8								7.09

Note:- Diagonal entries for parents; Off diagonal entries for hybrids.

4.10.2 HETEROSIS

Only thirteen crosses recorded significant heterosis over better parent and out of these eight crosses had positive heterosis (Table 48) . Cross 4x6 recorded highest significant and positive heterosis over better parent .

4.10.3 GCA EFFECTS

In E1 only P2 (Positive effect) and P8 (negative effect) had significant gca effects (Table 49) . In E2, five parents recorded significant gca effects (Table 50) . Three parents viz., P4, P5 and P6 had significant and positive gca effects but all were found to be at par . There was no significant difference present between two parents having significant and negative gca effects . In E3, five parents (three with positive effects) had significant gca effects (Table 51) . There existed no significant differences among three parents viz., P6, P2 and P1 having positive gca effect . P8 was significantly inferior to P7 for negative gca effects . In E4, only P6 (with positive effect) and P2 (with negative effect) had significant gca effects (Table 52) .

In pooled analysis, five parents had significant

Table 48

Heterosis for seed yield per plant in pooled data

Crosses	Heterosis%	
	Over better parent	Over mid parent value
1x2	5.15	12.69*
1x3	-6.03	- 0.76
1x4	-5.67	- 0.30
1x5	-11.13*	- 4.15
1x6	30.78**	36.51**
1x7	-12.81*	- 6.57
1x8	- 1.59	- 3.68
2x3	-12.12*	-10.75*
2x4	5.15	6.04
2x5	11.54*	12.31*
2x6	0.14	2.93
2x7	- 0.56	- 0.56
2x8	-23.40**	-22.92**
3x4	- 5.38	- 4.71
3x5	1.65	3.93
3x6	23.12**	24.65**
3x7	7.94	9.62*
3x8	2.12	3.06
4x5	27.75**	29.71**
4x6	49.29**	52.20**
4x7	- 1.81	- 0.98
4x8	- 0.42	- 0.64
5x6	- 0.82	- 2.63
5x7	11.54*	12.31*
5x8	14.97**	16.49**
6x7	12.67*	15.82**
6x8	-12.41*	-10.52*
7x8	- 8.91	- 8.34

* Significant at 5% level

** Significant at 1% level

Table 49

Gca effects (diagonal) and sca effects (off diagonal) for seed yield per plant in 8x8 diallel of opium poppy in E1

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-0.310	2.253**	-0.964**	-1.199**	-1.537**	+3.641**	-1.105**	0.693**
P2		0.933**	-0.147	0.028	1.270**	0.228	1.182**	-1.180**
P3			0.010	1.481**	-0.067	1.531**	-0.105	0.873**
P4				-0.065	2.438**	-0.584*	0.550*	0.768**
P5					0.213	0.248	1.202**	-0.080
P6						0.215	-1.180**	-1.362**
P7							0.061	-0.938**
P8								-1.057**

* Significant at 5% level

**Significant at 1% level

$SE_{(\hat{g}i)}$ ± 0.1647

$SE_{(\hat{g}i-\hat{g}j)}$ ± 0.2490

$SE_{(\hat{s}ij)}$ ± 0.2549

$SE_{(\hat{s}ij-\hat{s}ik)}$ ±0.7470

$SE_{(\hat{s}ij-\hat{s}ik)}$ ±0.7043

Table 50

Gca effects (diagonal) and sca effects (off diagonal) for seed yield per plant in 8x8 diallel of opium poppy in E2

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Talia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafamea)	P8 (Malania)
P1	-1.049**	0.049	-0.696	0.041	-0.831	0.351	-1.352*	-1.168
P2		-0.888**	-1.157	-0.602	-1.632*	-1.440*	-0.113	-1.669*
P3			-0.143	-2.477**	0.0	0.985	1.482*	0.786
P4				0.532*	0.848	4.870**	-0.863	-0.849
P5					0.862**	-1.960**	0.337	3.321**
P6						0.740**	1.699**	-2.127**
P7							0.343	-0.600
P8								-0.401

* Significant at 5% level

**Significant at 1% level

$SE_{(\hat{g}i)}$ ± 0.2174

$SE_{(\hat{g}i-\hat{g}j)}$ ± 0.3286

$SE_{(\hat{s}ij)}$ ± 0.6663

$SE_{(\hat{s}ij-\hat{s}ik)}$ ±0.9859

$SE_{(\hat{s}ij-\hat{s}lk)}$ ±0.9295

Table 51

Gca effects (diagonal) and sca effects(off diagonal) for seed yield per plant in 8x8 diallel of opium poppy in E3

Parent	P1 (Ranzatak)	P2 (OCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemsa)	P8 (Galania)
P1	0.369**	0.816*	0.926*	-0.173	-0.674	1.654**	1.320**	1.577**
P2		0.395**	-0.940*	1.941**	3.690**	0.668	-0.156	-0.789
P3			-0.185	-0.889*	-0.290	0.178	0.684	-0.399
P4				0.234	1.051*	0.479	0.325	0.672
P5					0.105	-1.022*	-1.256**	-0.529
P6						0.347*	-0.658	0.059
P7							-0.849**	0.035
P8								-0.416**

* Significant at 5% level

**Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.1356$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.2049$

$SE_{(\hat{s}ij)} \pm 0.4155$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.6148$

$SE_{(\hat{s}ij-\hat{s}lk)} \pm 0.5797$

Table 52

Gca effects (diagonal) and sca effects (off diagonal) for seed yield per plant in 8x8 diallel of opium poppy in E4

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemma)	P8 (Galania)
P1	-0.798**	0.510	-0.030	-0.650	0.010	0.540	-1.130**	-1.230**
P2		-1.208**	-0.420	-0.940*	-0.880*	-0.950*	-0.620	-1.120**
P3			-0.168	-1.580**	-0.420	1.110**	0.440	0.640
P4				0.652**	0.760*	4.990**	-2.180**	-0.980**
P5					0.392**	-0.950*	1.580**	1.680**
P6						0.562**	1.610**	-1.090**
P7							0.332**	0.240
P8								0.232

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.1220$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.1844$

$SE_{(\hat{s}ij)} \pm 0.3739$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.5532$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.5215$

gca effects (Table 53) . Three parents viz., P6 (0.464), P5 (0.392) and P4 (0.338) had positive and significant effects but all were at par . No significant difference existed between the two parents having negative gca effects.

4.10.4 SCA EFFECTS

In E1, twenty one crosses had significant sca effects (Table 49) . Twelve crosses had positive and significant effects . Cross 1x6, though did not differ significantly from 4x5 and 1x2, was observed to be significantly superior to remaining crosses having positive effects . No significant differences were found to exsist among crosses having negative sca effects . In E2, only ten crosses had significant sca effects (Table 50) . Only three crosses viz., 4x6, 6x7 and 3x7 had significantly and positive gca effects . Cross 4x6 was significantly superior to other crosses . All crosses having negative and significant sca effects were at par . In E3, out of twelve significant sca effect crosses, eight had positive effect (Table 51) . Cross 2x5 was found to be significantly superior to other crosses possessing positive effects . All crosses having negative and significant sca effects were at par . In E4, out of seventeen significant sca effect crosses, only six had positive effect (Table 52) . Cross 4x6 was significantly superior to other crosses

Table 53

Gca effects (diagonal) and sca effects (off diagonal) for seed yield per plant in 8x8 diallel of opium poppy (Over environments)

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemsa)	P8 (Galania)
P1	-0.442**	0.886*	-0.193	-0.534	-0.778	1.560**	-0.563	-0.039
P2		-0.192	-0.673	0.106	0.622	-0.380	0.067	-1.199**
P3			-0.123	-0.833	-0.167	0.931*	0.608	0.472
P4				0.328*	1.272**	2.440**	-0.553	-0.109
P5					0.392**	-0.934*	0.463	1.087**
P6						0.464**	0.361	-1.145**
P7							-0.033	-0.318
P8								-0.407**

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{gi})} \pm 0.1415$

$SE_{(\hat{gi}-\hat{gj})} \pm 0.2140$

$SE_{(\hat{sij})} \pm 0.4338$

$SE_{(\hat{sij}-\hat{sik})} \pm 0.6419$

$SE_{(\hat{sij}-\hat{slk})} \pm 0.6052$

possessing positive effects . Lowest, significant and negative sca effect was observed for 2x5, but it was found to be at par with nine other crosses .

In pooled analysis, nine crosses had significant sca effects (Table 53) . Six crosses viz., 4x6, 1x6, 4x5, 5x8, 1x2 and 3x6 had positive and significant sca effect . Cross 4x6 though did not differ significantly from 1x6 and 4x5, was found to be significantly superior to remaining crosses . There existed no significant differences among crosses having significant and negative sca effects .

4.11 HUSK YIELD

4.11.1 Per se PERFORMANCE

P7 (6.30 gm) recorded the highest mean husk yield and was followed by P4 (5.43 gm), P2 (5.40 gm) and P5(5.34gm). The lowest mean value was observed for P1 (4.32 gm). Among crosses highest and lowest mean values were observed for 4x6 (8.06 gm) and 1x7 (4.44 gm) respectively (Table 54) .

4.11.2 HETEROSIS

Fourteen crosses had significant heterosis over better parent and out of these only five recorded positive

Table 54

Per se performance of parents and hybrids in 8x8 diallel of opium poppy for husk yield/plant(gm) in pooled analysis

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	4.32	5.31	5.01	4.95	4.33	5.90	4.44	4.49
P2		5.40	4.55	5.43	5.30	5.33	5.13	3.85
P3			4.97	4.97	5.68	5.91	5.95	5.52
P4				5.43	7.20	8.06	5.31	5.80
P5					5.34	5.39	6.58	7.37
P6						4.84	6.37	5.00
P7							6.30	5.18
P8								5.08

Note:- Diagonal entries for parents; Off diagonal entries for hybrids .

heterosis (Table 55) . Highest positive heterosis over better parent was observed for 4x6 followed by 5x8, 4x5, 1x6 and 3x6 .

4.11.3 GCA EFFECTS

In E1 except for P3 all other parent had significant gca effects and out of these only three viz., P2, P6 and P7 had positive effects (Table 56) . P2, though did not differ significantly from P6, was observed to be significantly superior to P7 . Lowest, significant and negative gca effect was recorded by P4, though it was found to be at par with P8 and P5 . In E2, six parents had significant gca effect (Table 57) . Four parents viz., P5, P4, P7 and P6, had positive effect and were found to be at par . For negative gca effect P8 was significantly inferior to P1 . In E3, only four parents had significant gca effects (Table 58) . P4 and P2 had positive effect and were found to be at par . P7 and P8 had negative effect and no significant difference existed between them . In E4, except P8 all parents had significant gca effect (Table 59) . Four parents (P5, P7, P4 and P6) recorded positive effect and were found to be at par . Lowest, significant and negative gca effect was recorded by P3 .

In pooled analysis, six parents (four with positive) had significant gca effects (Table 60) . P4,

Table 55

Heterosis for husk yield per plant (Pooled data)

Crosses	Heterosis%	
	Over better parent	Over mid parent value
1x2	- 1.67	9.26*
1x3	0.80	7.86
1x4	- 8.84*	1.54
1x5	-18.91**	-10.35*
1x6	21.90**	28.82**
1x7	-29.52**	-16.38**
1x8	-11.61*	- 4.47
2x3	-15.74**	-12.25**
2x4	0	0.28
2x5	- 1.85	- 1.30
2x6	- 1.30	- 4.10
2x7	-18.57**	-12.30**
2x8	-28.70**	-26.53**
3x4	- 8.47	- 4.42
3x5	6.37	10.18*
3x6	18.91**	20.49**
3x7	- 5.56	5.59
3x8	8.66	9.85*
4x5	32.60**	33.70**
4x6	48.43**	56.96**
4x7	-15.71**	- 9.46*
4x8	6.81	10.37**
5x6	0.94	5.89
5x7	4.44	13.06**
5x8	38.01**	41.46**
6x7	1.11	14.36**
6x8	- 1.57	0.81
7x8	-11.78**	- 8.96*

* Significant at 5% level

** Significant at 1% level

Table 56

Gca effects (diagonal) and sca effects (off diagonal) for husk yield per plant in 8x8 diallel of opium poppy in E1

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-0.796**	1.993**	0.154	-0.258	-0.974**	0.757**	-1.296**	-0.094
P2		0.595**	-0.347*	0.421*	0.205	1.686**	-0.287	-2.485**
P3			0.104	1.732**	0.026	0.287	-0.006	-0.944**
P4				-0.254**	-3.836**	0.035	0.772**	1.804**
P5					-0.308**	0.439**	1.206**	3.328**
P6						0.561**	-2.233**	0.459**
P7							0.374**	-1.314*
P8								-0.278**

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.0537$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.0812$

$SE_{(\hat{s}ij)} \quad 0.1647$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.2437$

$SE_{(\hat{s}ij-\hat{s}lk)} \pm 0.2298$

Table 57

Gca effects (diagonal) and sca effects (off diagonal) for husk yield per plant in 8x8 diallel of opium poppy in E2

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Nafamaa)	P8 (Galenia)
P1	-0.880**	-0.045	0.071	-0.324	-1.172**	0.484	-0.803	-0.875*
P2		-0.789**	-1.020*	-1.215**	-1.063*	-0.807	-0.264	-0.766
P3			-0.205	-2.129**	0.783	0.399	0.852*	1.620**
P4				0.500**	1.888**	4.674**	-1.183**	-0.615
P5					0.708**	-1.644**	1.009*	2.407**
P6						0.422**	1.495**	-1.737**
P7							0.439**	-0.294
P8								-0.259

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.1397$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.2112$

$SE_{(\hat{s}ij)} \pm 0.4282$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.6336$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.5973$

Table 58

Gca effects (diagonal) and sca effects (off diagonal) for husk yield per plant in 8x8 diallel of opium poppy in E3

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	0.092	0.782**	0.859**	0.260	-0.521**	1.466**	-0.128	0.794**
P2		0.184*	-0.153	1.559**	1.889**	-0.736**	0.200	-0.478
P3			-0.103	-0.905**	-0.106	0.121	-0.653*	0.249
P4				0.376**	0.665*	0.822**	-0.212	0.740**
P5					0.117	-0.299	-0.203	0.209
P6						-0.150	-0.026	-0.004
P7							-0.336**	-0002
P8								-0.178*

* Significant at 5% level

** Significant at 1% level

$SE_{(gi)} \pm 0.0887$

$SE_{(gi-gj)} \pm 0.1342$

$SE_{(Sij)} \quad 0.2720$

$SE_{(\hat{S}ij-\hat{S}ik)} \pm 0.4025$

$SE_{(\hat{S}ij-\hat{S}\hat{i}k)} \pm 0.3795$

Table 59

Gca effects (diagonal) and sca effects (off diagonal) for husk yield per plant in 8x8 diallel of opium poppy in E4

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-0.587**	0.220	0.020	-0.240	-0.590*	0.360	-0.410	-0.650*
P2		-1.027**	-0.370	-0.430	-0.650*	-0.500	-0.603*	-0.780**
P3			-0.227**	-1.003**	-0.194	0.502	0.827**	0.620*
P4				0.336**	0.413	2.999**	-1.766**	-0.743**
P5					0.557**	-0.712**	0.712**	1.506**
P6						0.331**	1.699**	-0.808**
P7							0.506**	-0.443
P8								0.113

* Significant at 5% level

**Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.0862$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.1304$

$SE_{(\hat{s}ij)} \pm 0.2644$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.3912$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.3688$

Table 60

Gca effects (diagonal) and sca effects (off diagonal) for husk yield per plant in 8x8 diallel of opium poppy (Over environments)

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-0.593**	0.793**	0.310	-0.255	-0.870**	0.789**	-0.663*	0.206
P2		-0.330**	-0.413	-0.038	-0.163	-0.044	-0.236	-1.097**
P3			-0.147	-0.681*	0.034	0.353	0.401	0.390
P4				0.358**	1.049**	1.998**	-0.744**	0.165
P5					0.353**	-0.667*	0.531*	1.740**
P6						0.264**	0.410	-0.541*
P7							0.256**	-0.353
P8								-0.163

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.0962$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.1303$

$SE_{(\hat{s}ij)} \pm 0.2642$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.3909$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.3686$

P5, P6 and P7 possessed positive effect and were found to be at par . For parents having negative gca effect P2 was inferior to P1 .

4.11.4 SCA EFFECTS

In E1, nineteen crosses had (eleven with positive effects) significant sca effects (Table 56) . Cross 5x8 was significantly superior to the remaining ten crosses possessing positive effect . Lowest, significant and negative sca effect was recorded by 2x3 . In E2, sixteen crosses had significant sca effects (Table 57) . Seven crosses had positive and significant sca effect and among them cross 4x6 was significantly superior to remaining crosses . Cross 1x8 recorded significantly lowest negative sca effect but was found to be at par with seven other crosses . In E3, nine crosses recorded positive and four recorded negative significant sca effects (Table 58) . Though there were no significant differences between 2x5, 2x4 and 1x6, the cross 2x5 was found to be significantly superior to remaining crosses, possessing positive sca effect . All crosses having negative effects were at par . In E4, out of sixteen crosses significant for sca effect, only six had positive effects (Table 59) . Among crosses having positive effect, cross 4x6 was found to be significantly superior to the remaining crosses . Lowest,

significant and negative sca value was observed for 1x5 but it was found to be at par with eight other crosses .

In pooled analysis, out of thirteen crosses having significant sca effect, only six had positive effect (Table 60) . The cross 4x6 (1.998) though did not differ significantly from 5x8, was observed to be significantly superior to the remaining crosses having positive effects . No significant differences were present among seven crosses having negative sca effects .

4.12 NUMBER OF EFFECTIVE LANCINGS

Number of effective lancing is a new character introduced in the present investigation in opium poppy . More number of effective lancings is desirable character in opium poppy .

4.12.1 Per se PERFORMANCE

Highest and lowest mean values in parents were observed for P7 (4.96) and for P8 (4.01) respectively (Table 61) . Among crosses highest and lowest mean values were observed for 2x5 (6.60) and for 1x3 (4.26) respectively.

Table 61

Per se performance of parents and hybrids in 8x8 diallel of opium poppy for number of effective lancing/capsule in pooled analysis

Parent	P1 (Ranzatak)	P2 (OCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	4.52	5.25	4.26	4.38	4.79	5.89	4.64	5.09
P2		4.48	4.44	5.22	6.60	5.66	5.24	4.99
P3			4.58	5.39	4.88	5.02	4.56	4.35
P4				4.76	5.06	4.96	5.48	5.08
P5					4.34	4.32	5.01	6.15
P6						4.12	4.44	4.83
P7							4.96	4.93
P8								4.01

Note:- Diagonal entries for parents; Off diagonal entries for hybrids .

4.12.2 HETEROSIS

All the crosses except 5x6, 5x7 and 7x8 had recorded significant heterosis over better parent and out of these eighteen crosses had shown positive heterosis (Table 62) . Highest positive heterosis was observed for 2x5 .

4.12.3 GCA EFFECTS

In E1, out of five significant crosses for gca effect, only P2 had positive effect and there were no significant differences present among crosses having negative effects (Table 63) . In E2 except P5 all other parents had significant gca effects (Table 64) . Only P7, P2 and P1 had significant and positive effect . P7 was observed to be significantly superior to P2 and P1 . Lowest, significant and negative gca effect was recorded by P8 . In E3, all parents had significant gca effect (Table 65) . Four parents viz., P5, P4, P2 and P6 possessed positive effects . P5 though did not differ significantly from P4, was found to be superior to P2 and P6 . For negative effect, P3 recorded significantly lower gca effect as compared to others . In E4, only four parents recorded significant gca effects (Table 66) . P8 was significantly superior to P7, both having positive

Table 62

Heterosis for number of effective lancing per capsule (Pooled data)

Crosses	Heterosis%	
	Over better parent	Over mid parent value
1x2	16.15**	16.67**
1x3	- 6.99**	- 6.37**
1x4	- 7.98**	- 5.60**
1x5	5.97**	8.13**
1x6	30.31**	36.34**
1x7	- 6.45**	- 2.11*
1x8	12.61**	19.34**
2x3	- 3.06*	1.99
2x4	9.66**	12.99**
2x5	47.32**	49.66**
2x6	26.34**	31.62**
2x7	5.65**	11.02**
2x8	11.38**	17.55**
3x4	13.24**	15.42**
3x5	6.55**	9.42**
3x6	9.61**	15.40**
3x7	- 8.06**	- 4.40**
3x8	- 5.02**	- 1.28
4x5	6.30**	11.21**
4x6	4.20**	11.71**
4x7	10.48**	12.76**
4x8	6.72**	15.85**
5x6	- 0.46	2.13
5x7	1.01	7.73**
5x8	41.71**	47.31**
6x7	-10.48**	- 2.20*
6x8	17.23**	18.82**
7x8	- 0.80	9.45**

* Significant at 5% level

** Significant at 1% level

Table 63

Gca effects (diagonal) and sca (off diagonal) effects for number of effective lancing/plant in 8x8 diallel of opium poppy in E1

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-0.094**	0.309**	0.174**	-0.003	-0.348**	0.150**	-0.155**	0.552**
P2		0.443**	-0.583**	1.010**	3.255**	1.186**	0.178**	-0.505**
P3			0.016	0.215**	0.240**	0.621**	-0.267**	-0.340**
P4				-0.075**	-0.177*	0.694**	0.546**	-0.317**
P5					0.030	-0.511**	-0.031	-0.142**
P6						-0.231**	-0.708**	-0.071
P7							0.017	1.051**
P8								-0.110**

* Significant at 5% level

** Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.01823$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.02757$

$SE_{(\hat{s}ij)} \pm 0.5590$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.08270$

$SE_{(\hat{s}ij-\hat{s}lk)} \pm 0.07798$

Table 64

Gca effects (diagonal) and sca effects (off diagonal) effects for number of effective lancing per plant in 8x8 diallel of opium poppy in E2

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telin 1)	P4 (Arrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	0.117**	0.478**	-0.538**	-0.864**	0.661**	0.294**	-0.068	0.453**
P2		0.159**	0.050	-0.276**	0.319**	0.602**	-0.100	0.731**
P3			-0.465**	-0.022	-0.027	0.536**	-0.446**	0.395**
P4				0.231**	-0.093	1.160**	1.498**	0.049
P5					-0.024	-0.185**	-0.403**	-0.066
P6						-0.297**	-0.644**	0.187**
P7							0.395**	0.195**
P8								-0.116**

* Significant at 5% Level

**Significant at 1% Level

$SE_{(\hat{g}i)} \pm 0.01699$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.02569$

$SE_{(\hat{s}ij)} \pm 0.05209$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.07707$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.07266$

Table 65

Gca effects (diagonal) and sca effects (off diagonal) for number of effective lancing/plant in 8x8 diallel of opium poppy in E3

Parent	P1 (Ranzatak)	P2 (OCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemaa)	P8 (Galania)
P1	-0.336**	0.385**	-1.183**	-1.469**	-1.561**	3.040**	-0.069	0.557**
P2		0.267**	-1.156**	-0.572**	1.886**	1.127**	-0.142	-0.816**
P3			-0.215**	2.210**	-0.402**	-0.649**	0.330**	-1.344**
P4				0.421**	-0.198**	-1.807**	-0.526**	1.010**
P5					0.483**	-1.329**	-0.328**	4.308**
P6						0.202**	-0.487**	-1.121**
P7							-0.499**	-0.790**
P8								-0.325**

*Significant at 5% level

**Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.02403$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.03633$

$SE_{(\hat{s}ij)} \pm 0.07347$

$SE_{(\hat{s}ij - \hat{s}ik)} \pm 0.1090$

$SE_{(\hat{s}ij-\hat{s}ik)} \pm 0.1028$

Table 66

Gca effects (diagonal) and sca effects (off diagonal) for number of effective lancing/plant in 8x8 diallel of opium poppy in E4

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemaa)	P8 (Galania)
P1	-0.027	-0.352**	0.146	0.199	0.609**	-0.356**	-0.468**	-0.360**
P2		0.001	-0.212*	-0.159	-0.109	- 0.389**	0.504**	0.342**
P3			-0.187**	-0.011	0.289**	-0.196	-0.268**	0.210*
P4				-0.210**	0.182	0.127	0.375**	-0.127
P5					0.040	-0.513**	-0.235*	0.623**
P6						0.005	0.180	1.288**
P7							0.107**	-0.114
P8								0.269**

* Significant at 5% level

**Significant at 1% level

$SE_{(\hat{g}i)}$ ± 0.03386

$SE_{(\hat{g}i-\hat{g}j)}$ ± 0.05119

$SE_{(\hat{s}ij)}$ ± 0.10380

$SE_{(\hat{s}ij-\hat{s}ik)}$ ± 0.1536

$SE_{(\hat{s}ij-\hat{s}lk)}$ ± 0.1448

effects . Two other significant parent having negative gca effects were at par .

In pooled analysis, seven parents recorded significant gca effects (Table 67) . Only three parents viz., P2, P5 and P4 possessed positive gca effect . P2 (.219) was found to be significantly superior to other two which in turn were at par . Though P8 (-.073) had lowest significant gca effect,it was found to be at par with P6 and P3 .

4.12.4 SCA EFFECTS

In E1 twenty five (fourteen with positive effects) crosses had significant sca effects (Table 63) . Among crosses possessing positive effect, cross 2x5 was found to be significantly superior to remaing crosses . Lowest significant and negative value was recorded by 5x8 but it was found to be at par with 3 other crosses . In E2, twenty crosses were found to possess significant sca effect out of which thirteen had positive effects (Table 64) . Cross 4x7 was observed to be significantly superior to remaining crosses having positive effects . It was followed by 4x6 . Significantly lowest negative sca effect was recorded by 5x6 . In E3, twenty six crosses had significant sca effects (Table 65) . Out of nine significant and

Table 67

Gca effects (diagonal) and sca effects (off diagonal) for number of effective lancing/plant in 8x8 diallel of opium poppy (over environment)

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemea)	P8 (Galania)
P1	-0.083**	0.210**	-0.350**	-0.533**	-0.162**	1.150**	-0.186**	0.342**
P2		0.219**	-0.472**	0.000	1.345**	0.678**	0.112	-0.060
P3			-0.211**	0.605**	0.055	0.408**	-0.138*	-0.270**
P4				0.092**	-0.068	0.045	0.479**	0.157*
P5					0.132**	-0.635**	-0.031	1.187**
P6						-0.081**	-0.388**	0.080
P7							0.005	0.094
P8								-0.073**

* Significant at 5% level

**Significant at 1% level

$SE_{(\hat{g}i)} \pm 0.02092$

$SE_{(\hat{g}i-\hat{g}j)} \pm 0.03162$

$SE_{\hat{S}ij)} \pm 0.06412$

$SE_{(\hat{S}ij-\hat{S}ik)} \pm 0.09487$

$SE_{(\hat{S}ij-\hat{S}ik)} \pm 0.08944$

positive effect possessing crosses, 5x8 was significantly superior over rest of the crosses . It was followed in order of significance by 1x6, 3x4, and 2x5 . Cross 4x5 and 5x7 were at par but recorded significantly lower negative sca effect than fifteen other crosses . In E4, seventeen crosses recorded significant sca effect and out of these eight had positive effect (Table 66) . Cross 6x8 was significantly superior to the remaining crosses having positive effect . No significant differences were observed among crosses having negative effects .

In pooled analysis, eighteen crosses had significant sca effect and out of these nine had positive effects (Table 67) . Cross 2x5 (1.345) though did not differ significantly from 5x8 (1.187), was found tobe significantly superior to remaining crosses . 5x8 was at par with 1x6 . Lowest, significant and negative sca effect was recorded by 3x7, but it did not differ significantly from 1x5, 1x7 and 3x8 .

4.13 MORPHINE PERCENTAGE

4.13.1 Per se PERFORMANCE

Though P2 (10.68%) did not differ significantly from P3 (10.56%), it was found to be superior to remaining

parents (Table 68) . Among crosses 2x4 (10.47%) recorded highest morphine percentage but it was found tobe at par with sixteen other crosses .

It was observed that for this character, normal sowing environments during both year of testing (E1 and E3) were significantly superior to late sowing environments (E2 and E4) .

4.13.2 HETEROSIS

Only twelve crosses recorded significant heterosis over better parent, but only two out of these viz., 4x8 (18.5%) and 6x8 (10.01%) recorded significant positive heterosis .

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Table 68

Morphine percentage of different genotypes (mean of four environments)

Parent	P1 (Ranzatak)	P2 (DCG)	P3 (Telia 1)	P4 (Irrianian)	P5 (LL3)	P6 (UP White)	P7 (Hafemca)	P8 (Galania)
P1	8.89	10.06	8.38	9.49	8.78	8.82	8.48	9.06
P2		10.68	9.21	10.47	9.79	9.38	10.16	10.38
P3			10.56	8.09	8.44	8.96	10.16	9.66
P4				8.71	9.37	9.20	8.93	10.40
P5					8.57	9.28	9.79	8.48
P6						8.79	10.07	9.67
P7							9.59	8.69
P8								8.77

Means for environments: E1=9.96; E2=8.37; E3=10.55 E4=8.44

$SE_{\bar{x}}$ (for genotypes): ±0.7162

CD5%(for genotype) : 1.40

CD1%(for genotype) : 1.84

SE_{means} ± 0.1688

CD5% 0.47

CD1% 0.62

Table 69

Heterosis for morphine percentage

Crosses	Heterosis%	
	Over better parent	Over mid parent value
1x2	- 5.80	2.81
1x3	-20.64**	-13.83**
1x4	6.75	7.84
1x5	- 1.24	0.57
1x6	- 0.79	- 0.23
1x7	-11.57**	- 8.23*
1x8	1.91	2.60
2x3	-13.76**	-13.28**
2x4	- 1.97	7.99*
2x5	- 8.33*	1.71
2x6	-12.17**	- 6.48
2x7	- 4.87	0.25
2x8	- 2.81	6.74
3x4	-23.39**	-16.04**
3x5	-20.08**	-11.76**
3x6	-15.15**	- 7.39*
3x7	- 3.79	0.84
3x8	- 8.52	- 0.05
4x5	7.58	8.45*
4x6	4.66	5.14
4x7	- 6.88	- 2.40
4x8	18.59**	18.99**
5x6	5.57	6.91
5x7	2.09	7.82
5x8	- 3.31	- 2.19
6x7	5.01	9.58*
6x8	10.01*	10.14*
7x8	-9.38*	- 5.34

* Significant at 5% level

** Significant at 1% level

CHAPTER 5

DISCUSSION

Crop improvement work in opium poppy is, in general, a two dimensional approach i.e. improvement in latex yield and breeding for high morphine types . Recently with increasing cost of opium seed (posta-dana), the third dimension of seed yield is also added to the breeding programmes . Evolution of new varieties, generally progressed with collection of germplasm and exploiting it either for direct release of the types or by utilising in breeding programme (Ved Kaj Henrikssen,1970, Nigam et al,1979, 1982). Performance of Dutch, Czechslovakian, Bulgarian, German, Asian origin and USSR types have been reported in literature (Hlavackova,1955, Zochka,1962, Andrews,1963) . In India opium poppy research work started with agronomical trials . Recently, Nigam (1980a) reported evolution of two new opium varieties for M.P. region of India .

The utilization of available variability in cultivator's field is in progress, but for future breeding programme either new variability is to be created or available variabilities are to be utilised for better yields, or possibilities of new hybrids in opium poppy need to be explored . Having these objectives in mind,

a 8x8 diallel cross was undertaken at Mandsaur .

Latex yield, is one of the most important character, which is directly and positively correlated with leaf area (Prasad, 1980), stem diameter and number of stigmatic rays per capsule (Prasad 1980, Horowtiz 1930, Khanna and Singh 1975) . Seed yield is directly and positively correlated with number of capsules per plant (Prasad 1980, Horowtiz 1930, Khanna and Singh 1975), capsule size (Khanna and Singh 1975, Prasad 1980), number of stigmatic rays per capsule (Prasad 1980, Khanna and Singh 1975) and leaf area (Prasad 1980) . Morphine percentage is positively correlated with leaf area, number of stigmatic rays per capsule, seed yield and plant height (Prasad 1980), but is not correlated with number of capsules per plant (Prasad 1980) .

Environmental agencies play an important role in opium poppy . Mean squares for environments in pooled analysis was highly significant indicating that artificially created environments were effective as different environments. The highest mean squares was observed for environments, followed by its interactions and then by genotypic components, for all characters . This indicates that characters studied had differential expression in different environments, and that in opium poppy, all these characters were greatly

influenced by environmental agencies .

Pooled analysis indicated significant differences among genotypes for all the characters . In the present discussion only results from pooled data have been considered, except for stem diameter, for which the differences in only E4 were significant .

Highly significant differences among parental lines clearly established that these lines were genetically diverse for all the attributes . Significant differences were also noticed among the hybrids for all the characters . The comparison of parents Vs hybrid as a group is indicative of over all expression of heterosis and also confirmed the presence of genotypic diversity among parental lines, since the differences were observed to be significant for all characters except morphine percentage .

In present investigation, positive and significant heterosis was observed in most of the crosses for plant height . The findings are in agreement with those of Hlavackova (1959) and Sarkany et al (1959) . The plant height in opium poppy was reported to be a highly heritable character (Hlavackova 1972) . Combining ability analysis revealed that plant height is determined predominantly by additive gene action . However non additive genetic variance

was also playing an important role in its expression . Hafemaa (P7) had positive and significant gca effects for this character . None of the crosses had significant sca effects in negative direction .

Leaf area is the single most important factor for agricultural crop yields (Watson 1956) . Combining ability analysis indicated that this character is governed both by additive and non additive gene action . In the present study, heterosis for this character was also observed . Since larger leaf area is desirable in opium poppy, parental lines showing gca effects in positive direction were desirable . Parents P2 (DCG) and P5 (LL3) recorded significant and positive gca effects for this attribute, and therefore, were desirable combiners . Among hybrids, five (2x5, 2x6, 3x8, 4x7 and 5x8) combinations possessed significant and positive sca effects .

Significant differences were observed among thirty six genotypes for stem diameter only in environment E4 . Combining ability analysis suggested that since gca and sca variance were equal in proportion, both additive and non additive gene action were important for this attribute . Heterosis was also recorded for this character in both direction . Parental lines with thicker stem diameter would be desirable . Parents P1 (Ranzatak),

P3 (Telia 1) and P4 (Irrianian) were desirable combiner since they had significant gca effect in positive direction . Among crosses, nine combinations were found to possess significant and positive sca effects .

In the present investigation, it was found that, genetypes differed significantly for number of capsule per plant in E2 and E3 environments only . Combining ability analysis (pooled) revealed the fact that gca and sca variances were highly significant, with greater magnitude of gca variance, suggesting that though, both additive and non additive type of gene action are important, the predominant role is played by additive variance for number of capsules per plant . Heterosis was noticed for this character, which is in confirmation with findings of Popov et al (1976) and Singh & Khanna (1975) .

Parent P4 (Irrianian) and P5 (L.3) had gca effect in favourable direction and these parents can be used to improve this character in future breeding programme . Among crosses, three combinations viz., 4x6, 4x5 and 5x8 can be identified as having favourable direction of sca effects .

All components of variation were found to be significant in pooled analysis for capsule size . Heterosis for this attribute was observed in the present study, as

also reported by Hirosi (1923), Sarkany (1959), Mraz (1964) Danos (1963) and Dimitrov (1963) . Sarkany (1959) reports 10.67 percent positive hybrid vigour for this character in this material, where as in the present study a maximum of 12.11 percent positive heterosis over better parent was observed (cross 1x6) .

Combining ability analysis revealed the significance of both additive and non additive type of gene action for capsule size . Additive component was more important as reflected by greater mean squares of gca . Parental lines with greater capsule size would be desirable and therefore, gca effects in positive direction could be taken to imply desirable combiners . Results of present studies suggested that P7 (Hafemea) was observed to be best combiner . Among crosses, 1x6, 4x7, 5x8, 6x7 and 4x8 were good specific combinations for this character .

Number of stigmatic rays per capsule is an important character in opium poppy because it has positive correlation with latex and seed yield (Khanna & Singh 1975 ; Horowtix 1930 and Prasad, 1980), and with that of morphine percentage (Prasad 1980) . All the parental lines and crosses differ significantly in pooled analysis indicating genetic diversity in the material . Present study indicated presence of heterosis for this attribute . No other report was

available for heterosis for this character .

Combining ability analysis revealed the significance of both additive and non additive type of gene actions for this character . The gca variance was of higher magnitude . Since more number of stigmatic rays per capsule is a desirable character, the lines with positive gca effects would be desirable . In the present investigation, P7 (Hafemea) and P8 (Galania) were found to be the best combiners . Among crosses, 5x7 was best specific combination for this character, though as many as eighteen other crosses also had positive and significant sca effects .

Economically, latex yield in opium poppy is most important character . This character was reported to possess positive correlation with leaf area (Prasad 1980) and that of number of stigmatic rays (Horowitz 1930, Khanna and Singh 1975 , Prasad 1980) .

Genetic diversity for this character in parental lines was indicated by analysis of variance . Positive and significant heterosis was observed for this character in present investigation, and was also reported by several workers (Naicvevska and Popovska 1967, Dimitrov 1966, Singh and Khanna 1975, Saini and Kaicker 1980) .

Predominance of additive genetic variance in its expression was indicated by the highly significant general combining ability variance . Non additive genetic variance also played an important role . However, its magnitude was less than that of additive genetic component . The predominance of additive genetic variance in the expression of latex yield was also reported by Saini and Kaicker (1980). On the other hand, Khanna (1975) observed the predominance of non additive genetic component .

Obviously, parents having positive gca effects are the best combiners for latex yield . P4 (Irrianian) was found to be significantly superior combiner . P3 (Talia 1) and P8 (Galania) were also desirable combiners . As many as sixteen crosses had significant positive sca effects . However, 2x5, 1x2 and 3x4 were superior and therefore can be treated as most desirable specific combinations .

Genetic diversity was noticed in present investigation for seed yield . With increasing cost of grain, this character is likely to assume greater importance in future breeding programmes . As early as in 1966, Anderson and Loot, reported that greater attention should be paid for seed yield instead of morphine percentage because in time

to come this will be unprofitable enterprise .

In the present studies, positive heterosis over better parent were observed in many crosses . Heterosis in positive direction for seed yield was reported by several workers (Hlavackova 1959, Sarkany et al 1959, Keskova 1963, Dimitrov 1966, Miczulska 1967) . The results of present studies were confirmatory with these earlier findings .

Combining ability analysis results indicate the predominance of additive geneaction for this character, though non additive gene action was also important . Khanna (1975) observed predominance of additive genes for capsule weight . The results of present investigation are in agreement with findings of Khanna (1975) .

Desirable parents for seed weight were identified by positive gca effects . Three parents viz., P6 (UP white), P5 (LL3) and P4 (Irrianian) were found to be superior combiners for this character . Among crosses, 4x6, 1x6 and 4x5 were superior combinations for seed yield in comparasion to remaining crosses .

Genetic diversity was found to exist for

husk yield in the material under study . Heterosis was observed for this character in the present investigation . The result of combining ability analysis revealed that both types of gene actions viz., additive and non additive, govern the inheritance of this character, though predominant role was played by additive genetic variance .

Desirable parent for husk yield were identified as P4 (Irrianian), P5 (LL3) and P6 (UP White), which had recorded significant and positive gca effects . Among crosses 4x6 and 5x8 were significantly superior combinations.

Genetic variability was observed for number of effective lancing per capsule in present study . No reports were available for this character . Heterosis in positive direction in most of crosses were observed .

Both gca and sca variances were significant, however, the later was about three times larger in magnitude, indicating the predominance of non additive gene action . P2 (DCG) was superior parent having significantly higher magnitude of gca effects, than all other parents . However, P4 (Irrianian) and P5 (LL3) with significant gca effects were also desirable parents . Among crosses, 2x5, and 5x8 were best combinations having positive and significant sca effects . Cross 2x5 also had significantly higher value

of sca effects for latex yield . Thus, number of effective lancing per capsule could be considered as an effective criterion in the selection for latex yield .

Parents and hybrid differed significantly and (P Vs H) interaction was found to be non significant, for morphine analysis in RBD analysis . Significant heterosis in positive direction was observed only in two crosses viz., 4x8 and 6x8 . Singh and Khanna (1975) also reported poor heterosis for morphine content . Intermediate morphine types were reported by Hlavackova (1959) and Popov et al (1971) . However, positive heterosis for this character was observed by Oanos (1965), Anderson and Loot (1966) and Kopp and Kotilla (1955) . Breeding for high morphine content can be achieved indirectly since seed yield is positively correlated with it (Voskerruse 1960, Schrader 1966) and according to Kopp (1957) large bear shape capsule contains more morphine .

The crosses having good morphine percentage were, 2x4 (10.47), 4x8 (10.40), 2x8 (10.38), 2x7 and 3x7 (10.16).

On the basis of the results obtained and discussed so far, the choice of best combiner parents as well superior cross combinations for the different characters can now be identified .

The opium crop is valued for its latex . It is therefore, imperative that farmers get not only good seed yield but also latex yield . Combining ability analysis identified three parental lines as most desirable for this trait viz., P4 (Irrianian), P3 (Telia 1) and P8 (Galania) (Table 70) . Parent P4 had significant gca effect for, latex yield, number of effective lancing, number of stigmatic rays, seed and husk yield; P3 had significant gca effects for latex and number of effective lancing and P8 had significant gca effect for latex, stem diameter and number of stigmatic rays .

Seed yield is another important character and for which, P5, P6 and P8 were identified as desirable parent based on combining ability analysis . P5 (LL3) had significant gca effect for seed yield, husk yield, leaf area, and number of stigmatic rays (Table 70); P6 (UP White) had significant gca effect for seed and husk yield and P8 (Galania) had significant gca effects for seed yield, number of stigmatic rays and stem diameter .

Thus for latex yield best combiner identified is P4 (Irrianian), for seed yield it is P6 (UP White) and for latex and seed both, it is P4 (Irrianian) .

Table 70 Desirable gca effects of parents and sca effects in crosses for different characters

Genotypes	Significant effects for characters							
P1				CH6				CH10
P2	CH2	CH3			CH7			CH10
P3				CH6	CH7	CH8	CH9	CH10
P4						CH8	CH9	CH10
P5	CH2					CH8	CH9	
P6							CH9	
P7		CH3	CH5	CH6				
P8		CH3		CH6	CH7			
1x2				CH6	CH7	CH8	CH9	CH10
1x3					CH7			
1x4					CH7			
1x5		CH3	CH5	CH6	CH7	CH8	CH9	CH10
1x6								
1x7		CH3		CH6				CH10
1x8								
2x3								
2x4					CH7			CH10
2x5	CH2	CH3			CH7			CH10
2x6	CH2				CH7			
2x7				CH6				
2x8		CH3		CH6	CH7			CH10
3x4		CH3			CH7			
3x5					CH7	CH8		CH10
3x6				CH6				
3x7				CH6				
3x8	CH2	CH3		CH6	CH7	CH8	CH9	
4x5		CH3		CH6		CH8	CH9	
4x6		CH3						CH10
4x7	CH2		CH5					CH10
4x8			CH5	CH6	CH7			
5x6				CH6				
5x7		CH3		CH6	CH7		CH9	
5x8	CH2		CH5	CH6		CH8	CH9	CH10
6x7			CH5	CH6	CH7			
6x8				CH6				
7x8								

CH1 = Height; CH2 = Leaf area; CH3 = Stem diameter; CH4 = Number of capsules per plant; CH5 = Capsule size CH6 = Number of stigmatic rays/capsule; CH-7 = Latex yield; CH8 = Seed yield; CH9 = Husk yield; CH10 = Number of effective lencinge/capsule .

Desirable sca effects for more than one character for different crosses are presented in table 70 . A comparision of different significant crosses for latex and seed yield, in terms of latex yield, seed yield and morphine percentage is also presented in Table 71 .

Based on the specific combining ability effects, crosses 2x5, 1x2 and 3x4 were found to be desirable combinations for latex yield . On the other hand crosses 4x8 and 4x5 were the top most combinations for latex yield, on the basis of Per se performance of hybrids . There is thus no agreement between the Per se performance of the cross and their sca effects . Jatasra and Paroda (1979) also reported that there is no agreement between crosses chosen on the basis of Per se performance and sca effects . Unlike seed yield the best cross on the basis of sca effect did not involve both parents having high gca effects . The cross 4x8 selected on Per se basis, on the other hand, had both parents having high gca effects in desirable directions . Since the farmer is interested in latex yield, it will be fruitful to grow F_1 of P4 and P8 (cross 4x8) as commercial hybrid . The segregating progenies of this cross involving high gca x high gca lines may throw segregants which may be at par with F_1 in their performance and therefore, it will be worth while to pursue the segregating material .

Table 71 Comparision of significant crosses for latex and seed yield in 8x8 diallel of opium poppy

Crosses	Per se performance		Morphine%	Remark
	Latex	Seed		
A. LATEX YIELD				
2x5	.360	8.12	9.79	NS for seed yield.
1x2	.318	7.55	8.38	PS for seed yield.
3x4	.411	6.68	8.09	NS for seed yield.
2x6	.338	7.19	9.38	NS for seed yield.
4x5	.375	9.30	9.37	PS for seed yield.
3x6	.356	8.57	8.96	PS for seed yield.
3x5	.360	7.40	8.44	NS for seed yield.
6x7	.281	8.09	10.07	NS for seed yield.
7x8	.287	6.54	8.69	NS for seed yield.
3x8	.338	7.24	9.66	NS for seed yield.
1x6	.260	8.88	8.82	PS for seed yield.
2x7	.278	7.14	10.16	NS for seed yield.
4x8	.446	7.12	10.40	NS for seed yield.
1x4	.297	6.66	9.49	NS for seed yield.
1x5	.254	6.47	8.78	NS for seed yield.
5x8	.293	8.37	8.48	PS for seed yield.
B. SEED YIELD				
4x6	.296	10.54	9.20	Neg. for latex yield.
5x8	.293	8.37	8.48	PS for latex yield.
6x7	.281	8.09	10.07	PS for latex yield.
5x7	.275	8.12	9.79	NS for latex yield.
3x6	.356	8.57	8.96	PS for latex yield.
4x5	.375	9.30	9.37	PS for latex yield.

NS = Nonsignificant; PS = Positive significant;

Neg. = Negative;

Note:- Per se performance of latex and seed yield in g/plant.

Seed yield is an important character for which desirable combination need to be identified as in future, hybrid for high seed yield will be required . Hybrid 4x6, having both parents of significant gca effect for seed yield performed on top in per se as well as for sca effect, and therefore is the best choise for seed yield .

Among the five crosses identified for latex yield i.e. 2x5, 1x2, 3x4 on sca performance, 4x8 and 4x5 on Per se performance, and one cross identified for seed yield, one or two crosses for further exploitation need to be identified . For seed yield cross 4x6 was most desirable . On the other hand for latex (for which a farmer mainly raises his crop) the cross combination 4x8 was found to be the best . It possess best Per se performance, significant & positive sca effects for latex, non significant sca effect for seed yield, the morphine content of the cross being much higher than other crosses in consideration and above all showing positive, significant, heterosis (18.59%) for morphine content over better parent .

The cross 4x6 has negative sca effect for latex yield and therefore, this combination may not be considered for future commercial hybrid . However, since the parents of this cross (P4 and P6) are desirable combiners for seed yield, as well as latex, it can be expected that in

segregating progenies selections may be obtained, which are better not only for latex yield but also for seed yield .

Thus, it can be safly concluded that for future commercial hybrid the best choice will be 4x8 .

The genetic variances for all characters except number of effective lancing per capsule were found to be predominantly additive, as well as non additive genetic variances were also important . For number of effective lancing non additive variance was predominant with important role of additive variance .

The additive variance may be exploited by conventional breeding methods like mass selection, modified bulk selection method, pedigree method or mass pedigree method . In segregating progenies of cross involving lines P4, P3, and P8 (for latex yield)and P4 and P6 (for seed yield), segregents having high gca x high gca could be isolated .

The non additive variance can be utilized by using non conventional methods of breeding viz., biparental matings, recurrent selection or any other cyclical breeing method, or this component of variance could be exploited by releasing F_1 hybrids as commercial hybrid .

The present study therefore, concludes that out of eight parents tested Irrianian (P4) is the best combiner for latex and seed yield and UP White (P6) for seed yield only . Among crosses the cross 4x8 is the best and can be considered for future commercial F_1 hybrid .

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CHAPTER 6

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

5.1 SUMMARY

A 8x8 diallel in opium poppy was executed with two parents of Madhya Pradesh (Ranzatak and Telia 1), two parents from Rajasthan (DCG and Galania), one from Uttar Pradesh (UP White), two from IARI New Delhi (LL3 and Hafamea) and one drawn from exotic material (Irrianian) . Normal sowing and one month late sowing coupled with two years of testing created four different and contrast environments . Thirty six genotypes (eight parents and twenty eight hybrids) were tested in RBD with three replication in each environment .

Mean squares for all component of variations in RBD for all characters (plant height, leaf area, stem diameter, number of capsules per plant, capsule size, latex, seed and husk yield, number of effective lancings per capsule and morphine percent) were found to be significant .

Combining ability analysis was performed by following Griffing model I method II for all characters except morphine percentage . Components of variation in combining ability analysis were found to be significant for all characters . Heterosis was observed for all

characters . Hafemee was the most undesirable parent for height . Irrianian was best combiner for latex yield, seed yield and their components . Talia 1 and Galania were better combiners for latex yield also . LL3,UP White and Irrianian were best combiners for seed yield . Irrianian x Galania (4x8) having highest positive heterosis for morphine percentage, was found to be overall best combination for latex yield while Irrianian x UP White (4x6) was best combination for seed and husk yield, though it possessed negative sca effect for latex yield .

Additive genetic variance was predominant for all character except for number of effective lancings per capsule, where non additive genetic variance in its expression was predominant . However, role of additive geneaction for number of effective lancings and of non additive gene action for rest of characters, also were important .

5.2 CONCLUSION

Irrianian, Talia 1 and Galania were best combiner parents for latex yield . LL3, UP White and Irrianian were found to be best combiner parents for seed yield . Irrianian x Galania (4x8) was best combination for latex yield . Irrianian x UP White (4x6) was best combination for seed and husk yield . Both type of geneaction i.e. additive and non

additive were important for these characters. Number of effective lancings per capsule had predominant role of non additive genetic variance, while for other characters, additive genetic variance had predominant role in its expression .

5.3 SUGGESTION FOR FURTHER WORK

The following relevant suggestions have been made to highlight the further work of the present investigation .

(a) The possibilities of exploiting hybrid vigour in opium poppy can be explored by testing Irrianian x Galania, F_1 combination, for commercial use .

(b) The segregants of two crosses viz., Irrianian x Galania and Irrianian x UP White, should be pursued, to isolate desirable segregants having high gca x high gca component . It is possible to get segregants with high seed as well as latex yield in segregating population of these crosses .

(c) For selection, concentration should be focused on more number of stigmatic rays, more number of effective lancing per capsule and capsule size, for improving latex and seed yield .

(d) In opium poppy, conventional breeding methods are suggested to exploit additive genetic variance for most of characters .

(e) Non conventional breeding methods are suggested to utilize non additive genetic variance, particularly for improvement in number of effective lancing .

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R E F E R E N C E S

Anderson, G. and B. Loot (1966). In the cropping value of the poppy through breeding (Ger.) . Pharmazie, 21:240-245.

Andreev, V.S.(1963). The increase of morphine content in polyploids of the common poppy (Papaver somniferum L). (Russ). Dokl. Akad,. Nank. USSR,148 (1):206-209.

Annonymous, (1979). Annual report of opium research project, Mandsaur

Beguinot, A(1926). Research on hybrids in several races of Papaver.(Ital). Atti. Soc. Naturalisti Modena,4:1-18.

Blaringham, (1925) A sterile hybrid of field poppy (Papaver somniferum L.Var.nigrum D.C.) and a wild poppy (Papaver setigenum D.C.) (Fr.) Bull.Soc.Bot. France. 72:623-628.

Blaringham L.(1932) .A Case of atavism appearing in an opium poppy line (Fr.). Compt. Rend. Hebd. Searices Acad. Sci.,195 (25) : 1192-1195 .

Bros, A (1927) Concerning Papaver hungaricum Borb.(Hung).Bot. Kozlem.,24 (516):212.

Cavara, F and A.Chistari (1926) Hybridization and morphine content in Papaver somniferum L.(Ital). Atti.Reale. Accad.Naz.Lincei, Rendiconti cl.Sci.Fir.3(6):113-118.

Chawala, J.S.(1978). Poppy straw a new source of fibre boards . Indian pulp and paper, 32(4):3-4.

Danos, B(1965). Effect of generative hybridization on the pattern of alkaloids content of the opium poppy.I. Investigation of the first filial generation (F_1).(Ger.). Pharmazie, 20(II):727-730.

Danos,B(1966) Genetic study of fertile poppy hybrids (F_1-F_2) with special consideration of the types of alkaloids (Ger.). Abh.Deutch. Akad. Wiss. Berlin,Kl.Chem, 1966(3):363-367.

Fairbrain, J.W., F.Hakim and Y EL Khair (1974). Alkaloidal storage, metabalism and translocation in the vescicles of Papaver somniferum latex . Phytochemistry, 13 (7):1133-1139 .

Furusato, K (1940). Polyploid plants produced by Colchicine (Jap.). Bot. X 200L. 8(8):1303-1311.

Griffing, B (1956).Concept of general and specific combining ability in relation to diallel and related population. Aust.J.Biol.Sci.9:403-493.

Gupta, R., K.R.Khanna, H.G.Singh and A.S.Gupta (1978). Status Report On Opium Poppy (Papaver somniferum Linn.). All India Workshop on Opium Poppy (ICAR) 11th to 13th April, Udaipur .

Herisset, A (1967). Evolution of the cultivation of the opium poppy in Anjou (Fr).Pl.Med.Phytother.,1(1):35-41.

Hirishi, N.J(1960). Cytogenetical studies on Papaver somniferum L and Papaver setigerum DC and their hybrid . Genetica,31(10-2):1-130.

Hirosi, T(1923). Plant breeding experiments with the opium poppy (Jap). Rep.Imp.Hyg.Lab.,19:289-327.

Hlavackova, Z(1955). Poppy breeding for increased morphine content . (Czech). Preslia,27:368-382.

Hlavackova, Z(1959). Crossing of poppies aimed at a heightening of the morphine content in dry poppy heads(Czech). Roslt. Vyroba,32(4):521-536.

Hlavackova, Z(1972). Investigation of the inheritance of the plant height and seed weight in poppy (Papaver somniferum L) (Czech). Genet. Slecht.(Praha),. 8(2):87-93.

Horowtiz, B (1930). Studies on opium poppy (Papaver somniferum L) (Pol) Pamietniki Panstwowego Instytutu Naukowego Gospodarstwa Wiefsklegow Pulawoch. 11(1):159-217.

Hurst, C.C(1907). Mendelian characters in plants and animals. Int.Conf.Genet., 3rd report.Hort.Soc. 114-128.

Ivanova, R.M (1972). Use of experimental mutagenesis in breeding of papaver somniferum L (Rus.). Genetika. 8(1):30-37.

Jablonski, M. (1967). The influence of spaces between the rows and thinning methods on poppy yield (Pol). Pamieln. Pulawski. 25:205-223.

Jatasra, D.S and R.S.Paroda (1979).Heterosis and combining ability for synchrony traits in wheat. Indian J.Genet., 39(3):521-528.

Kasaeva, M.A(1929). Hybridization experiments between Papaver somniferum and P. bracteatum. Acad.Sci.Ukraine . Bull.Cl.Sci.Phys.Math. 4(4):220-233.

Kasaeva, M.A(1930). Hybridization experiments between Papaver somniferum L and Papaver bracteatum Lindl.(Russ). Trudy. Ussesojuzn . Sezd.Gen.Selek.Semenov.Plemenn. Zhivotnov. 2:295-306 .

Kawatani, T and H.Asahina (1959). External character and alkaloids of the artificial interspecific F_1 hybrid between Papaver orientale L and P.somniferum L. Jap.J.Genet., 34(1):353-362.

Keskova, E.S (1963). Intravarietal and intervarietal hybridization in the oil poppy . (Rus). Agrobiologija. 4:619-622.

Khanna, K.R. and A.S.Murty (1973) : Proc. 5 AGRAO Cong.

Khanna, K.R and U.P.Singh (1975) . Correlation studies in Papaver somniferum L. and their bearing on yield improvement. Pl.Medica. 28:92-96.

Kohoutova, Z (1953). Poppy breeding with regards to oil content (Czech). Preslia. 25:97-106.

Kopp, E and E.Kotilla (1955). Experiments on improving the alkaloid poppy (Rum). Stud.Cercet.Sti.(Cluj)Ser.2, 6 (3/4):57-60.

Kopp,E(1957) (Rum). Pharmazie. 12:614-620.

Kopp,E., E.Kotilla., K.Crado and S.Matyas (1961). Further attempts at breeding a poppy variety rich in alkaloids (Ger). Pharmazie. 16(4):224-231.

Korhoda,J and I.Miczulska (1962). A trial of taking advantage of heterosis in breeding and seed production of poppy (Pol). Pamietn. Pulawski. 5:5-14.

Leake, H.M and B.R.Parshad (1920) . A preliminary note on the flower colour and associated characters of opium poppy. J.Genet. 10(1):1-22.

Legg,P.D., J.F.Chaplin and G.B.Collins (1969); J.Hered. 60:213.

Lorinz, G and P.Tetenyi (1963). Result of our experiments in interspecific hybridization in Papaver.(Hung).Herba. Hung. 2:127.

Lorinz, G and P.Tetenyi (1966). Distant hybridization between Papaver somniferum and P.orientale. (Rus).Herba. Hung. 5(1):95-105.

Michalski,T (1959). Polyploidization of medicinal poppies, Papaver somniferum L. (Pol). Bull.Inst.Roslin. Leczniczych . 5(1):63-67.

Miczulska, I (1967). Heterosis effect in hybrids of certain varieties of poppy (Papaver somniferum L). (Pol). Roczn.Nank.Roln., Ser.A, Roln. 93:197-204.

Miyake,K and Y.Imai (1927). Inheritance in Papaver somniferum. Proc.Imp.Acad. Japan. 3(3):168.170.

Moresz, S(1960). Increasing morphine content of poppy with controlled self pollination. (Hung). Herba.Hung. 5(2/3):127-130.

Morice, J and J.Louarn (1971). Study of morphine content in the oil poppy (Papaver somniferum L). (Fr).Ann.Amelior Pl. 21(4):465-484.

Mraz,F(1964). A method for determining the share of the "Health effect of heterosis" in yield effect.(Czech). Rostl. Vyroba.10:909-912.

Naicvevska C. and .Popovska,C.(1967). Bull.Sci.Cong.Acad.Yougosl. 12:144-145.

Nigam,K.B., S.K.Jain and M.C.Chaurasia (1979). Evaluation of genetic variability in opium poppy (Papaver somniferum L) in Madhya Pradesh, JNKVV.Res.J. 13(1-4):98-99.

Nigam, K.B(1980 a). Release proposals of two opium poppy varieties for Madhya Pradesh . Proc.IV All India Workshop on M&AP. (ICAR), Madurai .

Nigam, K.B., G.S.Rawat, M.C.Chaurasia and S.K.Jain (1980 B). Salient acheivements and recommendation in opium poppy for Madhya Pradesh . Proc.IV All India Workshop on M&AP (ICAR), Madurai.

Nigam, K.B., S.K.Parikh, K.L.Sethi and R.Gupta (1982). Genetic variability in opium poppy(Papaver somniferum L) in Madhya Pradesh. JNKVV.Res.J. 76(2).

Nigam,K.B. and D.B.Dhumale (1982). A new mutant in opium poppy. JNKVV.Res.J. (In press).

Panse, V.G.and.P.V.Sukhatme (1954). Statistical methods for Agricultural Workers. Pub.ICAR. New Delhi.

Pirovano, A (1927). Result of hybridization between Papaver somniferum L and P.bracteatum .(Ital).Ann.Bot. 17(4):171-174.

Remussi,C(1959). Mutations induced by X-ray treatment (Span). Raviata.Argent.Agron. 26 (3-4):108-109.

Saini,H.C and U.S.Kaicker (1982). Combining ability analysis for opium yield in opium poppy (Papaver somniferum L). South. Indian .Hort. 30(1):32-36.

Sarkany,S., B.Dance and I.Sarkany kiss (1959). Studies on heterosis effects in poppy hybrids (Ger).Ann.Univ. Sci.Budapest Rolando Lvotvos Sect.Biol.2:211-237.

Schroder,H (1966). The influence of mineral fertilization and location on the morphine content and other qualitative and quantitave character of poppy (Papaver somniferum L) (Germ). Pharmazie. 21 (10):635-641.

Singh Daljit (1973). Diallel analysis for combining ability over several environments. Ind.J.Gent. 33 (3) II:469-482.

Singh, U.P and K.R.Khanna (1970). Male sterility in opium poppy (Papaver somniferum L). Sci. & Cul. 36:554-556.

Singh,U.P and K.R.Khanna (1975). Heterosis and combining ability in opium poppy . Indian J.Genet. 35(1).

Sosa Bourdenil,C., P.Lecat and A.Sosa (1963). The inheritance of pigmentation in Papaver somniferum L. Compt. Rend.Hebd.Sceances Aced.Sci. 256:2683-2685.

Tetenyi,P., G.Lorincz and E.Szabo (1961). Investigation on intrespecific chemical differences in opium poppy. Characterization of hybrids of Papaver somniferum L x P.orientale L. (Ger).Pharmazie 16(8):426-433.

Ved Kaj Henriken (1970). Experiement with strains of opium poppy (Papaver somniferum L) 1965-1969 (Ger). Saertryk AF Tiosskrift for plan lsqvl. 74:475-480.

Volovo, E.N.(1941). Polyploids in Papaver somniferum L induced by treatment with Colchicine . Compt.Rend.(Dokl) Acad.Sci.URSS . 31(3):261-263.

Von H.Bohm (1965). (Germ). Planta medica 13:235.

Von H.Bohm (1970). English Summary : Planta Medica (Stuttgart) B.d. 19 Heft. 2:94-109.

Voskerusa,J.(1960). English Summary. Pharmazie. 15:552-558.

Watson, D.J.(1958). The dependence of net assimilation rate in leaf area index. Ann.Bot.NS:22:37-54 .

Yasui,K(1937). Cytogenetical studies in artificially raised interspecific hybrids of Papaver VII. Papaver somniferum L x P.bracteata Lindl. Cytologia 8 (2): 331-342.

Zeschke, M.(1962). The genetic variability of the alkaloids content of Papaver somniferum L (Ger). An gew.Bot. 36 (314): 185-192.

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