THE EFFECT OF EARLINESS GENE *efl-1* ON CHICKPEA (*Cicer arietinum* L.) TRAITS

BY

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B.Sc.(Ag.)

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CERTIFICATE

Mr. GARINE RAGHU, has satisfactorily prosecuted the course of research and that the thesis entitled **"THE EFFECT OF EARLINESS GENE *efl-1* ON CHICKPEA (*Cicer arietinum L.*) TRAITS"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by him for the degree of any university.

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Place :Hyderabad

CERTIFICATE

This is to certify that the thesis entitled **"THE EFFECT OF EARLINESS GENE *efl-1* ON CHICKPEA (*Cicer arietinum L.*) TRAITS"** is submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE** of the Acharya N.G. Ranga Agricultural University, Hyderabad is a record of the bonafide research work carried out by **Mr. GARINE RAGHU** under our guidance and supervision. The subject of the thesis has been approved by the student's advisory committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All the assistance and help received during the course of investigations have been duly acknowledged by the author of the thesis.

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ABSTRACT

Inheritance of days to first flowering and maturity, node number and correlations among traits were studied in crosses of three extra-early flowering chickpea lines ICCV 2, ICCV 93929 and Harighantars. The experimental material involved the three parents, three one way F_1 crosses among them and F_7 and F_8 recombinant inbred lines (RILs) developed from the three crosses. The experiments were carried out at the International Crops Research Institute for Semi-Arid Tropics, Patancheru, near Hyderabad, A.P., India during *rabi* 1999.

The F_1 generation of the cross ICCV 2 x ICCV 93929 flowered earlier than the mid parental value, ICCV 2 x Harighantars equal to the mid parental value and Harighantars x ICCV 93929 later than their mid parents. The distributioin of flowering time for the recombinant inbred lines indicated transgressive segregation for the trait. This suggested that some genes for days to flowering were different. However, the values were still within the extra-early range. Therefore, it appears that the recessive allele *efl-1* is present in all the three parents. Its effect is modified by other minor genes towards earlier or later flowering.

The gene *efl-1* is found to have a positive effect on seed size as seed size showed a low positive correlation with days to first flowering. In the present study highest seed size was recorded on the RILs that flowered on 28 days to first flowering in all the three crosses under study.

The effect of *efl-1* on yield among all the three crosses was found differently, as the highest yields were recorded on 38 days to first flowering in ICCV 2 x Harighantars, 37 days to first flowering in ICCV 2 x ICCV 93929 and 30 days to first flowering in Harighantars x ICCV 93929, this may be due to minor genes that are interacting with *efl-1* allele.

Gene(s) governing node to first flower and maturity received a positive effect from *efl-1* because in all the three crosses under study flowering node and flowering time are positively correlated.

The node number at which the first flower appears is an important flowering characteristic along with flowering time. This trait exhibited a negative correlation with yield. In the present study the optimum node number at which highest yield recovered was observed to be lying between 14 to 16

Positive correlations of days to first flowering with days to 50 per cent flowering, days to first pod formation and days to maturity were obtained in three crosses in both F_7 and F_8 generations Node number at which first flower appears is negatively correlated with the yield in the crosses ICCV 2 x Harighantars, and ICCV 2 x ICCV 93929.

DECLARATION

I, **GARINE RAGHU**, hereby declare that the thesis entitled **"THE EFFECT OF EARLINESS GENE *efl-1* ON CHICKPEA (*Cicer arietinum L.*) TRAITS"** submitted to Acharya N.G. Ranga Agricultural University for the degree of **MASTER OF SCIENCE IN AGRICULTURE** is a result of original research work done by me. I also declare that the thesis or part thereof has not been published earlier elsewhere in any manner.

Date: 6/8/2001

Place: Hyderabad

(GARINE RAGHU)

LIST OF ABBREVIATIONS

%	:	percentage
cm	:	centimetre
DFF	:	days to first flowering
DM	:	days to maturity
g	:	gram
ha	:	hectare
hr	:	hour
kg	:	kilogram
m	:	metre
°C	:	degree centigrade
RIL	:	recombinant inbred line
SE	:	standard error

INTRODUCTION

CHAPTER I

INTRODUCTION

The two groups of plants of the greatest importance to world agriculture belong to the plant families Graminae and Leguminosae. Grain legumes or pulses refer to leguminous plants producing dry edible seeds, through fresh pods, fresh seeds, green leaves, shoots, flowers and tuberous roots of the same plant may also be edible.

Pulses enjoy the distinction of being protein rich food. These are valuable in cereal based diets because of their complementary pattern and profile of amino acids to cereal proteins. They are especially important as food in those regions where animal proteins are scarce or where poverty, religious or ethnic preferences preclude the consumption of meat.

Pulses have also played a crucial role in agricultural production throughout history. This is obviously due to their capacity to fix atmospheric nitrogen with rhizobia by using solar energy collected through plant photosynthesis. They play an important role in dry farming, fertility restoration and crop rotations.

Among pulses chickpea (*Cicer arietinum* L.) is the third most important food legume crop in the world after dry beans (*Phaseolus vulgaris* L.) and peas (*Pisum sativum* L.). Chickpea is grown annually on 12.3 million hectares with a production of 9.24 million tonnes globally (FAO, 2000). India, Pakistan, Turkey and Iran together account for 88 percent of world's chickpea production and 87 per cent of chickpea area (FAO, 2000).

India is the largest producer of chickpea in the world. It produces 67 percent of total chickpea amounting to 6.7 million tonnes. India also stands first in total chickpea area under cultivation that is 65 per cent of wold area under this crop (FAO, 2000). Even though India ranks first in area and production of chickpea, its productivity is low. The causes for unstable productivity of chickpea are numerous (Kumar *et al.*, 1990). The major ones are drought, foliar and root diseases, pod borer and cold. The productivity of chickpea can be hastened and stabilized by developing extra short duration (80-90 days) varieties that escape end-of-season drought. (Kumar *et al.*, 1985). Keeping in view of the paramount significance of thwarting the crop duration, more research is needed in this novice area.

The progress in breeding of any crop depends on variability and the efficiency of the selection criteria. Suitable selection criteria in a segregating population depends upon the nature and magnitude of association between characters. Correlation is an important statistical technique for identifying useful characters influencing yield and undesirable association between the component characters. This emphasizes the importance of correlation studies.

Expeditious pragmatic approach is needed in this vital area of genetics of flowering time and significance of flowering node to reduce the crop duration in chickpea.

Therefore, the present investigation was carried out with the following objectives.

1. To study the inheritance of early flowering and maturity
2. To study the significance of node number on which the first flower appears to crop maturity
3. To study the phenotypic correlation between selected traits with earliness genes

REVIEW OF LITERATURE

CHAPTER II

Review of literature

Chickpea (*Cicer arietinum L.*) is the third important grain legume in the world and number one pulse crop in India (FAO, 2000). Its seed yield is low compared to cereals and even other legumes like field pea and soybean. Genetic efforts to improve its seed yield require better understanding of its adaptation. Nearly 90 percent of the crop is grown rainfed in post rainy season. Therefore, matching the crop duration with the availability of soil moisture is important. In the following pages literature on inheritance of flowering, crop growth measured through number of nodes to first flowering and correlations among traits is reviewed as follows.

2.1 Inheritance of time of flowering.

2.2 Significance of flowering node.

2.3 Correlation coefficients.

2.1 Inheritance of time of flowering

The world germplasm for chickpea exceeding 17,000 accessions has been evaluated at ICRISAT Patancheru, near Hyderabad for many traits (Pundir *et al*. 1988). Kumar (Personal communication) selected three accessions that took approximately the same number of days to flowering at Patancheru.

Kumar and Rao (1996) reported transgressive segregation for days to first flowering and indicated that more than one gene was responsible for this trait in ICCV 2X ICCV 93929 cross.

Kumar and Van Rheenen (2000) reported a major recessive gene *efl-1* for early flowering ICCV 2. It's dominant allele *EFL-1* delayed flowering by three weeks in JG 62.

In chickpea only two research articles reported on genes for earliness and the effect of temperature and photoperiod on them (Orr *et al* 1999, Kumar and Van Rhennen 2000 and Kumar and Abbo 2001). However, it is well studied in other crops like pea, cowpea, lentil, pigeon pea, dry beans, soybean etc.

The review presented here under is a collection from all these crops.

Sachaik and Probst (1958) worked on effects of environmental factors on flower production in soybean, by studying two varieties of soybean, Clark (Indeterminate growth type) and Midwest (determinate growth type), and reported that days to appearance of first flower and length of flowering period increases with increase in temperature and reduced photoperiods.

Coyne and Wattson (1964) studied the inheritance of time of flowering trait in three crosses of *Phaseolus vulgaris* L involving early x late parents . They reported different patterns of inheritance for time of flowering, in the cross white seed Tender green x Bush Blue Lake OSC949-1864, time of flowering determined primarily by one major gene, lateness being dominant to earliness. In the cross GN 1140 x Nebraska # 1 selection, time of flowering was controlled by two major genes, earliness being dominant over lateness. In case of the third cross white seeded Tender green x GN Nebraska # 1 selection the flowering was governed by 3 genes ; lateness being dominant over earliness.

Coyne (1970) studied the inheritance of date of flowering in beans in the cross GN 1140 x PI 165078, and reported that date of flowering is governed by a single major gene with late flowering being recessive. The symbol '*fd*' was assigned to the recessive gene.

Genetics of flowering in pea was studied by Murfet (1971) among eight pea cultivars representing three distinct classes ED (early developing), EI (early initiation) and L (late) and reported that, these class differences are controlled by three dominant major genes *S1*, *E* and *S2*.

Ojomo (1971) studied the inheritance of flowering date in cowpeas (*Vigna unguiculata* (L.) Walp.) by crossing an exotic early flowering cultivars to the local late flowering cultivar and reported that, flowering date was governed by two major gene pairs, early flowering being dominant over late flowering.

Gibbori *et al.* (1978) studied four quantitative traits in peanuts (*Arachis hypogea* L.) by analyzing F_2 data from a 9 x 9 diallel cross and reported a bi-directional dominance for the trait days from sowing to first flower.

Sidhu (1981) studied the genetic architecture of six characters in pigeonpea and observed that, days to 50 percent flowering and maturity, plant height and seed size were governed predominantly by additive gene effects, whereas seed yield and pod number showed non-additive gene action.

Leyna *et al.* (1982) studied the changes in patterns of inheritance of flowering time of dry beans in different environments and reported that only one gene governed time of flowering trait under low night temperatures, while more than one gene was activated under high night temperatures.

Venkateswarlu (1982) studied genetics of flower initiation in *Pisum sativum* L. in a diallel with F_1 and F_2 generations .He reported both additive and non-additive gene effects, however additive gene effects were predominant.

Waldia and Singh (1987) reported the inheritance pattern of dwarfing genes in pigeonpea [*Cajanus cajan* (Linn.) Millsp.] by crossing 3 *tall indeterminate* varieties to a dwarf variety and assigned symbols *T1T1T2T2 for tall and t1t1t2t2* for dwarf types based on the segregation ratios of their F_2 population.

Govil *et al.* (1989) estimated variability with change in environment among 45 varieties of chickpea representing 20 countries. They reported that, amongst the 11 characters they studied, days to flower trait showed high heritability and genetic advance indicated the usefulness of this character.

In order to make more biologically plausible modeling of crop phenology, for reliable prediction of time of flowering, Summerfield *et al.* (1991) worked on six annual crops, soybean, cowpea, various Asiatic *Vigna* spp., chickpea, lentil and barley and formulated various physiological models which described the photo thermal response of time of flowering (f) and explained the linear and non-interacting effects of photoperiod (p) and temperature (T) on rate of progress towards flowering (1/f).

Kornegas *et al.* (1993) studied the inheritance of photoperiod response in common beans by selecting 5 lines from each of two gene pools (Andean and Mesoamerican bean) and mated them in all possible combinations within a group, days to flowering (DTF) of F_1, F_2 and random F_3 lines were studied under two environments differing mean temperature. They reported that photoperiod sensitivity was inherited as two dominant genes *(AA BB)*, while the neutral response was conditioned by recessive epistasis *(aabb or aaBB*). An intermediate response occurs when the first gene was dominant and second gene was recessive *(AAbb)*, under both the environments.

Wallace *et al.* (1993) while studying the F_8 generation of a cross involving a photoperiod sensitive and photoperiod insensitive parent in bean, observed that photoperiod gene interacted with day length to control (aerial biomass, harvest index and days to maturity) all physiological components of yield.

Erskine *et al.* (1994) developed of a model to predict time of flowering in lentil. They evaluated the predicted model with a world collection of 369 accessions and reported that mean pre-flowering values of photoperiod and temperature combined to account for 90.5 percent of variance of 1/f (reciprocal of days to first flower initiation).

Lawn *et al.* (1995) worked on reliable prediction of time of flowering, by examining the variation in time from sowing to flowering (f) among 44 cultivars of soybean, mungbean, blackgram, rice bean, cowpea, chickpea, lentil and barley by growing in upto 21 diverse environments obtained by making one or more sowings at each of six locations, spanning tropical, sub-tropical and temperate climates in Australia. They evaluated the utility of simple linear models, relating to rate of development (1/f) towards flowering to mean photoperiod and temperature. They reported that these models were highly efficient, explaining most (86.7%) of the variation observed across species, cultivars and environments. They described the applications of these physiological models in crop improvement for genotype characterization, adaptation and to predict the time of flowering of individual genotypes in specific environments.

Jha *et al.* (1997) analyzed the nature of gene action and combining ability in chickpea using line x tester analysis involving six lines and four testers. Genetic analysis of some selected quantitative traits indicated additive gene action for days to first flower, primary branches, secondary branches, pods per plant, seeds per pod and dominant gene effects for days to maturity and plant height, and for 100-seed weight and yield both additive and dominance gene effects

Srinivasan *et al* (1998) worked on cold tolerance during early reproductive growth of chickpea and reported that the two early maturing breeding lines they used, showed good pod set in cold spells but seed growth in them was limited Basing on their studies they suggested that pod set can occur at night temperature of 0-5°C if the day time temperature exceeds 20°C Seed development required a higher threshold temperature than pod set

Or *et al* (1999) studied the F_2 populations derived from crosses between an early flowering breeding line desi with weak photoperiod response and a late-flowering high yielding kabuli variety with a strong photoperiod response, and obtained a ratio of 3 1 late flowering to early flowering and reported that this segregation is in consistent with a major photoperiod response gene *(Ppd)* affecting time to flowering

Sarkar *et al* (1999) worked on F_1, F_2 and F_3 populations of various crosses in lentil and reported that early flowering trait was determined by a single recessive gene *(Sn)* and the occurrence of early flowering transgressive segregants in F_2 population is attributed to interaction of Sn and minor genes for earliness However, they did not provide allele test evidence for naming *Sn* gene

Kumar and Van Rheenen (2000) studied the inheritance of time of flowering trait in chickpea (*Cicer arietinum* L) and proposed a single recessive gene controls the time of flowering and designated it as *efl-1*, by studying recombinant inbred lines (RILs) from an extra short duration variety ICCV 2 and short duration variety JG 62.

Kumar and Abbo (2001) reviewed the literature on flowering genes of chickpea and observed that these played a major role in adaptation of cultivars in different regions. They reported major success for early maturing cultivars as much of this crop is cultivated rainfed where end of season drought is often faced. They suggested that much more research is required before this trait is well understood.

From the above studies the inheritance of time of flowering is reported to be monogenic in chickpea Or *et al*. (1999) and Kumar and Van Rheenen (2000). However ,it is likely that more genes may be discovered when more studies are carried out like in field peas.

In case of other related legume crops monogenic, digenic, trigenic control of the trait is reported. Monogenic inheritance was proposed by Coyne (1970) and sarkar *et al.* (1993) in bean and lentil respectively. Digenic inheritance was proposed by Ojomo (1971) and Kornegas *et al* (1993) in cowpea and common bean respectively. Trigenic inheritance was proposed by Coyne and Watson (1964) , Waldia and Singh (1987) in bean, pea, and pigeon pea respectively.

2.2 Significance of node to first flower.

The number of nodes formed before flowering is characteristic of differences between varieties (Reid and murfet 1977, Mcdaniel *et al;* 1996). Many plants do not respond to photoperiods appropriate for time of flowering until they reached a critical number of nodes. (Sachs1999.)

The review presented here under enable us to establish the effects of photoperiod and temperature on node to first flower and association of the latter to time of flowering in chickpea and other related crops.

Paton (1968) studied photoperiodic and temperature control of flowering initiation in a late pea cultivar 'Greenfeast' .He reported that when grown in different photoperiod and temperature regimes, the leaf requirement is lowest in continuous light and low temperature and concluded that the action of temperature and photoperiod was independent.

Marn (1969) investigated photo-dependant response in pisum by exposing 4 strains (G_1, G_2, K and I) to two levels of light intensity and two levels of growth temperature and a long photoperiod (18 h). He reported that growth temperature has no influence on the number of nodes to flower but it had a marked influence on the number of days to flower.

Murfet (1971) recognized six phenotypic classes in Pisum while working on flowering behavior of twelve pea cultivars under short and long photoperiods, and reported the action of 3 major genes for flowering and named them as *E*, S_2 and S_1 and found that *E* is epistatic to S_2 in terms of flowering nodes.

Collins and Wilson (1974) observed node at which first flower occurs (NF) .They studied the interrelation between node of flowering, rate of node production and time of flower initiation. They reported that NF should not be treated as a prime determinant of flower initiation but merely as the node at which the first flower initiation occurs.

Paton (1978) investigated the node of flowering (NF) in 'Greenfeast' a *P sativum* L cultivar and reported that the number of green foliage leaves appears to be a direct determinant of time of flower initiation (TI)

Mehra *et al* (1986) studied the gene action of selected traits plant height, trunk height, node to first effective branch on main stem and total number of nodes on main stem in a 7 x 7 single diallel cross of pigeon pea and reported non-additive genetic control of these traits They suggested that selection should be deferred to advance generations to obtain desirable recombinants

From the above studies it was reported that node at which first flower appears is not influenced by growth temperature Marn (1969) and it can be influenced by temperature as reported by Paton (1968) However it was reported that node at which the first flower appears is a direct determinant of time of flower initiation (TI) Paton (1978)

The number of nodes to first flowering indicates the magnitude of vegetative growth that a plant variety attains However the speed at which these nodes are formed and their internode length will also influence the over all size of an individual Early flowering varieties like ICCV 2 produce first flower at around 15-17 nodes and later flowering varieties like JG 62 at 22-24 nodes (Jagdish Kumar unpublished information) However, ICCV 2 has faster early growth and attains sufficient vegetative mass before flowering

2.3 Correlations

Correlation coefficient is an important statistical tool for determining association among characters In a breeding program selection for one trait is influenced by closely associated traits Therefore, it is useful to know these relationships

Seed yield is a complex character. For augmenting the yield, the role of component characters is well appreciated. Therefore, understanding interrelationship between seed yield and its components, and among the components themselves is necessary to select for these traits.

A review of literature for correlation of seed yield with yield contributing traits is presented here under.

Reddy and Rao (1988) analyzed 50 F_2 chickpea populations derived from inter varietal crosses and reported that seed and pod number per plant were positively associated with yield per plant. Plant height had significant positive association with 100-seed weight. Number of pods per plant was positively associated with number of seeds per plant. Plant height and 100-seed weight showed non-significant association with yield.

Sharma and Maloo (1988) observed in 21 chickpea varieties that grain yield was significantly correlated with number of pods per plant for both planting dates (28 November and 14 December; r = 0.7 and r = 0.7, respectively) with the number of primary branches per plant (r = 0.5) and 100-seed weight (r 0.7) for earlier planting dates. They also reported that days to flowering showed strong positive correlation with days to maturity, and days to maturity exhibited negative and significant correlation with 100-grainweight in case of second sowing at both genotypic and phenotypic levels.

Ali (1990) conducted studies on six advanced lines of desi chickpea, compared with two check cultivars and found positive association of grain yield with plant height and grain mass. He suggested to consider longer duration of flowering, late maturity and large grain mass while selecting genotypes for grain yield.

Uddin *et al.* (1990) investigated correlation derived from the data of fifty four genetically diverse chickpea lines and reported that yield per plant had significant positive correlations with pods per plant, 100-seed weight and primary branches per plant.

Lal *et al.* (1993) reported in chickpea genotypes that seed yield was positively and significantly correlated with pod number and plant height and negatively correlated with 100-seed weight. Plant height showed significant negative correlation with branch number, pod number had significant negative correlation with 100-seed weight. They suggested pod number and plant height as important characters for seed yield.

Rao *et al.* (1994) studied 44 varieties of *Cicer arietinum* and reported that seed yield was positively correlated with primary branches, secondary branches, 100-seed weight and pods per plant.

Singh and Rheenen (1994) crossed two chickpea accessions JG 62 and MS 24. They evaluated them along with their F_1s and F_2s and backcross progenies and observed that seeds per pod was positively correlated with seed yield in segregating generations ($r = 0.18$).

Bhattacharya *et al.* (1995) studied the association of yield and yield components under soil moisture stress and non-stress environments in chickpea by taking twelve genetically different chickpea genotypes and reported that, under non-stress conditions, seed yield is mainly influenced through extent of biological yield followed by effective node number per plant and number of seeds per plant, while under stress conditions maximum association was observed for biological yield followed by plant height, harvest index and days to 50% flowering.

Sandhu and Mangat (1995) computed correlations between seed yield and other traits in 32 genotypes of chickpea and reported a significant positive association between yield and days to flowering.

Mathur and Mathur (1996) worked on genotypic and phenotypic correlations for grain yield and yield contributing characters in 34 varieties of chickpea and reported that yield showed a positive correlation with 1000-gtain weight but negatively correlated with days to flowering.

Manjare *et al.* (1997) studied 22 chickpea genotypes and reported that grain yield per plant has positive correlation with number of pods per plant, number of branches per plant, 100-seed weight and number of grains per pod.

Qayyum *et al.* (1997) worked genetical estimation of productivity and plant geometry in chickpea by studying seven genotypes and reported that days to maturity exhibited negative correlation with yield and a significant positive correlation with days to first pod development.

Arora and Jeena (1999) reported a positive correlation between days to 50 percent flowering and days to maturity.

Or *et al.* (1999) studied the phenotypic correlations between days to first flower, pod number and mean grain weight among F_2 populations derived from crosses between early flowering (desi) x late flowering (abuli) cultivars and revealed a strong association in the characters studied.

Rahman and Uddin (2000) evaluated the performance of 28 chickpea cultivars for yield, flowering and other selected traits under need-based watering and water stress conditions and reported that yield has highest correlation (r = 0.90) with pod number followed by harvest index (r = 0.75).

From the above studies the traits under study exhibited different types of character associations. Over all seed yield appears to be positively correlated with seed number, pod number and secondary branches. However positive associations of seed yield with long flowering and maturity indicates that longer distribution cultivars should produce more yield. While this may be theoretically feasible, in practice, the longer duration cultivars often suffer end of season drought and may actually yield lower.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The present investigation was carried out with a view to determine the inheritance of number of days to flowering and maturity, significance of node to first flowering and to study the character association (correlation) among days to first flowering and other selected traits in F_7 and F_8 recombinant inbred lines of three crosses of chickpea. The experiment was conducted during *rabi* season, 1999 at ICRISAT, Patancheru, A.P. This location has an altitude of 545 m above the mean sea level and lies at a latitude of 17°32' N and a longitude of 78°16' E. The weather data during the crop growth period are given in Appendix 1.

3.1 MATERIALS

3.1.1 Experiment I

This experiment was conducted in the field during 1999/00.The material for investigation comprised of F_7 generation of the crosses, ICCV 2 x Harighantars, ICCV 2 x ICCV 93929 and Harighantars x ICCV 93929. The original cross was made during the year 1991-92 *rabi* at ICRISAT, Patancheru, A.P., and the generations were advanced to F_7. Details of the three parents are presented in Table 1.

Table 1: Characteristics of the parents under study.

Character	ICCV2	Harighantars	ICCV 93929
Origin	India	India	India
Accession No.,	12968	5810	
Growth habit	Semi erect	Semi spreading	Semi erect
Flower color	White	Pink	Pink
Reddish pigment	No anthocyanin	Low anthocyanin	Low anthocyanin
Seed type	Kabuli	Desi	Desi
Seed shape	Owl's head	Angular	Angular
Seed coat color	Cream	Black	Yellow brown
Seed surface	Smooth	Rough	Rough
Maturity	Extra-early	Extra-early	Extra-early
Special features	-		Cold tolerant

3.1.2 Experiment II

This experiment was conducted in a glasshouse at ICRISAT, Patancheru .The material used for the study consisted of F_8 generation of the cross ICCV 2 x ICCV 93929 representing a population of 89 RILs and two parents.

3.2 METHODS

3.2.1 Experiment I

The F_7 seeds and the parents were sown in an unreplicated block at a wider spacing of 60 x 20 cm with single seed per hill. The sowing was done on 12 October 1999. All recommended package of practices were followed to raise a healthy crop.

3.2.2 Experiment II

The F_8 seeds from the cross ICCV 2 x ICCV 93929 were sown on 3 March 2000, in a glasshouse at ICRISAT, Patancheru, A.P. The number of treatments was 91, and these were sown in 3 replications in a typical RBD (Randomised Block Design). All necessary measures were taken to raise a healthy crop.

3.3 COLLECTION OF DATA

Data recorded on F_7 generation RILs during 1998/99 *rabi* season taken from chickpea breeding unit ICRISAT, Patancheru.

During 1999/00 *rabi* data were recorded on F_8 generation RILs of the three crosses, on 7 selected traits as follows.

3.3.1 Days to first flowering

Number of days taken by RILs from sowing to first appearance of flower.

3.3.2 Number of nodes to first flower.

Node number at which the first flower appeared from the base of the plant.

3.3.3 Days to 50 percent flowering

Number of days taken from sowing to 50 percent flowering.

3.3.4 Days to pod formation

Number of days taken for the appearance of first pod.

3.3.5 Days to maturity

Number of days taken for the maturity of the line, when more than 90 percent plants turned yellow or brown.

3.3.6 Yield (kg/ha)

Yield was recorded for the entire plot and converted to kg/ha.

3.3.7 Seed size (g)

Weight of 100 seeds is obtained by the formula

$$\frac{\text{Seed yield (g)}}{\text{Total number of seeds}} \times 100$$

3.4 STATISTICAL ANALYSIS

The data were subjected to the following analysis with the help of standard statistical procedures,:

3.4.2 Analysis of variance

3.4.3 Phenotypic correlations

3.4.1 Analysis of variance

The data were subjected to following statistical analysis.

Difference among genotypes for various characters were tested for significance by using analysis of variance technique on the basis of model proposed by Panse and Sukhatme (1957).

$$Y_{ij} = m + g_i + V_j + e_{ij}$$

Y_{ij} = Phenotypic observation in i^{th} genotype and j^{th} replication.
m = general mean
g_i = effect of i^{th} genotype
V_j = effect of j^{th} replication
e_{ij} = Random error.
The analysis of variance for each character was carried out as indicated below.

Source	d.f	S.S	M.S.S.	F.
Replication	r-1	mr	m'r	m'r/m'e
Treatments	t-1	mt	m't	m't/m'e
Error	(r-1)(t-1)	me	m'e	
Total	rt-1			

Where r = number of replications.

T = number of treatments (RILs)

m'r, m't, m'e stand for mean square due to replications, treatments and error respectively.

3.4.2 Correlation coefficients

Changes in one variable may be accompanied by changes in another and that a relation exist between the two, which indicates a correlation between the two variables. Correlation coefficient (r) is a measure of the degree of closeness of the linear relationship between two variables.

Simple correlation coefficients among days to first flower, days to first pod formation, days to maturity and other yield attributing traits were worked out using the formula suggested by Panse and Sukhatme (1967).

$$\text{Correlation coefficient (r)} = \frac{\sigma xy}{\sigma x \, . \, \sigma y}$$

$$\sigma xy = \frac{\Sigma f(X - \overline{X})(Y - \overline{Y})}{N} = \frac{\Sigma f.dx.dy}{N}$$

σxy = mean product moment or the covariance between x and y

σx = standard deviation of x

σy = standard deviation of y

dx + dy = deviations

$$\sigma x = \frac{\sqrt{\Sigma fdx^2}}{N} \qquad \sigma y = \frac{\sqrt{\Sigma fd^2}}{N}$$

Significance correlation coefficient $\quad t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$

'r' is the estimate obtained from 'n' pairs. The significance of correlation was tested by referring to the standard 't' table values given by Snedecor and Cochran (1968) at 5 per cent and 1 per cent levels of significance.

RESULTS

Chapter -IV

RESULTS

An experiment was conducted on chickpea (*Cicer arietinum* L.) during the *rabi* (post - rainy season) 1999-2000 to (i) study the inheritance of days to flowering, and maturity (ii) determine the significance of node number at which the first flower appears to crop maturity , and (iii) compute correlations among traits. The studies were carried out on, parents,F_1, F_7 and F_8 recombinant inbred lines (RILs) of three crosses namely ICCV 2 X Harighantars, ICCV 2 X ICCV 93929 and Harighantars X ICCV 93929 and on F_9 generation RILs of the cross ICCV 2 X ICCV 93929. All the parents are extra-short duration types that flower around 28.0 days after sowing at ICRISAT research farm at Patancheru, near Hyderabad, A.P.

The data were recorded for 7 characters namely node at which first flower appears (flowering node), days to first flowering, days to 50% flowering, days to first pod formation, days to maturity, 100-seed weight and seed yield. The results are described under the following headings.

4.1 Inheritance of early flowering and maturity

4.2 Significance of flowering node to crop maturity.

4.3 Correlation coefficients among the selected traits.

4.1 INHERITANCE OF EARLY FLOWERING AND MATURITY

The inheritance of number of days to flowering and maturity studied on parents and F_8 generation of the three crosses of chickpea namely ICCV 2 X Harighantars, ICCV 2 X ICCV 93929, and Harighantars X ICCV 93929. Three experiments were carried out to record the number of days to first flowering on the cross ICCV 2 X ICCV 93929. There were field experiments during 1999/00 and 2000/01 and glass house experiments in 2000.

The numbers of days taken from sowing to first flowering were recorded on the parents and F_7 and F_8 generations of the three crosses included in this study. The F_7 RILs were grouped according to their number of days to first flowering as those earlier than the parents, equal to the parents and later than the parents. This distribution is shown in (Table 2). The results indicate that 6 to 20 % RILs flowered earlier to the parents, 12 to 30% along with the parents and 65 to 80% later than the parents.

4.1.1 ICCV 2 X ICCV 93929

Field experiment (1999-00)

ICCV 2 flowered in 28 $\pm$ 0.2 days and ICCV 93929 in 27 $\pm$ 0.3 days. Their F_1 flowered in 26 $\pm$ 0.2 days, earlier than either parent. Classification of RIL values according to the number of days to flowering indicated that about 20% of these flowered earlier than the parents, 12% with the parents and 68% were later than the parents (Table 2). This indicated that the two parents although flower in about the

Table 2: Percentage distribution of RILs of the three chickpea crosses for number of days to first flowering 1999/00 field experiment.

Category	ICCV 2 X Harighantars	ICCV 2 X ICCV 93929	Harighantars X ICCV 93929
Earlier	10	20	6
Equal	10	12	30
Later	80	68	64
Range	26-63	28-58	28-63
P_1	28±0.2	28±0.2	29±0.2
P_2	29±0.2	27±0.3	27±0.3
Mean RILs	37.3	33.5	37.2

Table 3: Means, CV and ranges for days to first flowering and days to maturity for the cross ICCV 2 X ICCV 93929

Generation	Trait	Mean ± SE	CV. (%)	Range
F_7	DFF	36± 0.46	12.36	28-58
F_8	DFF	31 ± 0.55	17.1	20-52
F_7	DM	91 ±0.42	4.3	85-107
F_8	DM	85±0.46	5.1	76-107

Table 4 : Classification of ICCV 2 X ICCV 93929 RILs for days to first flowering days to maturity generation wise.

Classification	Generation	#RILs	Mean ± SE
Trait: DFF			
Early	F_7	17	30.0 ± 0.20
	F_8	13	24.0 ± 1.2
Like Parents	F_7	11	32.3 ± 0.34
	F_8	19	27.0± 0.11
Late	F_7	63	38.0 ± 0.44
	F_8	59	34.0 ± 0.55
Trait: DM			
Early	F_7	12	86.5 ± 0.22
	F_8	11	79.0 ± 0.5
Like Parents	F_7	31	89.0 ± 0.10
	F_8	13	82.0 ± 0.30
Late	F_7	48	93.0 ± 0.55
	F_8	63	87.0 ± 0.50

same number of days, carry some different genes that complement for earlier and later flowering than the parents (Figure. 1).

Glasshouse experiment 2000

The data from the glasshouse experiment that was sown in a typical RBD design with three replications were subjected to analysis of variance (Tables 6,7).

Field experiment 2000/01

The data collected from the *rabi* 2000 field experiment showed that the two parents took 29 $\pm$ 0.2 days to first flower with an over all mean of 35 $\pm$ 0.5 days .

4.1.2 ICCV 2 X Harighantars:

The two parents ICCV 2 and Harighantars took about 28 0.2 and 29 $\pm$ 0.2 days to flowering. The F_1 flowered slightly later than the mid parental value. The mean values for F_7 and F_8 recombinant inbred lines were much higher than the mid parental value (Table 10).

Classification of RIL values according to the number of days to flowering indicated that about 10% of these flowered earlier than the parents, 10% with the parents and 80% were later than the parents (Table 2). This indicated that the two parental lines although flowered in about the same number of days, carry genes that complement to produce transgressive segregants for this trait (Figure 5).

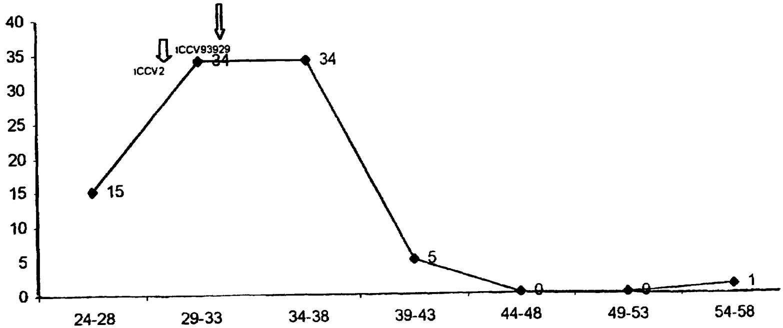

Figure 1: Frequency distribution of RILs for days to flowering of the cross ICCV 2 X ICCV 93929 based on mean values of two generations

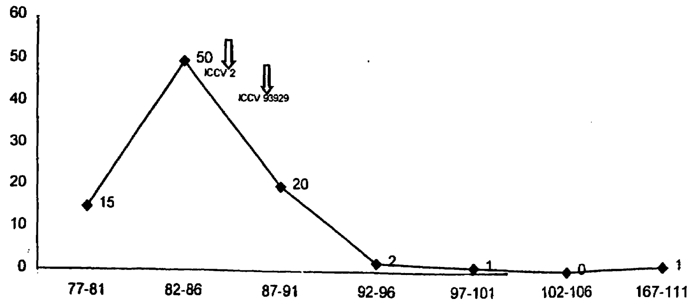

Figure 2: Frequency distribution of RILs for days to maturity of the cross ICCV 2 X ICCV 93929 based on mean values of two generations.

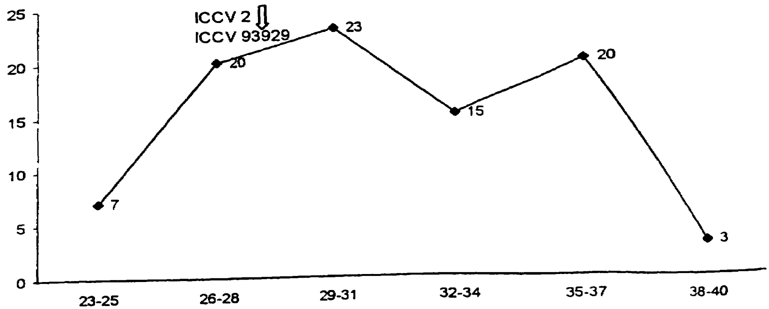

Figure 3:Frequency distribution of RILs for days to flowering of the cross ICCV 2 X ICCV 93929 2000/01 field data.

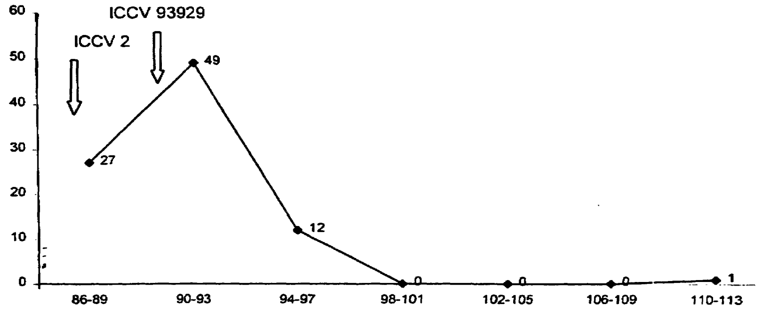

Figure 4: Frequency distribution of RILs for Days to maturity of the cross ICCV 2 X ICCV 93929 for 2000/01 field data.

Table 5: Classification of RILs based on means of two generations for DFF and DM

Trait	# RILs Early	# RILs like parents	# RILs late	Range	Parents (days)	
					ICCV2	Harighan tars
DFF	15	14	60	24-55	29	30
DM	9	12	68	81-107	85	86

Table 6: ANOVA Table on variate days to first flowering of the cross

ICCV 2 X ICCV 93929 Glasshouse experiment 2000.

Source of variation	d.f	S.S	M.S.	V.R.	F.PR
REP stratum	2	28.161	14.081	4.86	
Treat	90	5941.201	66.013	22.80**	< 0.01
Residual	180	521.172	2.895		
Total	272	6490.535			

Table 7: ANOVA Table on variate node to first flowering of the cross

- ICCV 2 X ICCV 93929 2000 Glasshouse experiment.

Source of variation	d.f	S.S	M.S.	V.R.	F.PR
REP stratum	2	11.93	5.96	2.5	
Treat	90	300.2	33.3	14.03**	< 0.01
Residual	180	420.12	2.4		
Total	272	3442.2			

Table 8: Segregating RILs for DFF and DM based on *rabi* 2001 field experiment Of the cross ICCV 2 X ICCV 93929

Trait	# RILs Early	# RILs like parents	# RILs late	Range	Parents (days)	
					ICCV2	ICCV 93929
DFF	25	11	52	23-39	29	29
DM	0	62	27	86-110	91	86.0

Table 9: Segregating RILs based on *rabi* 2001 field data of the cross ICCV 2 X ICCV 93929.

Classification	# RILs	Mean + SE
Trait: DFF		
Early	**25**	**26.7± 0.3**
Like parents	**11**	**29± 0.07**
Late	**52**	**33± 0.34**
Trait: DM		
Early	**0**	**0**
Like parents	**62**	**89 ± 0.15**
Late	**27**	**94± 0.64**

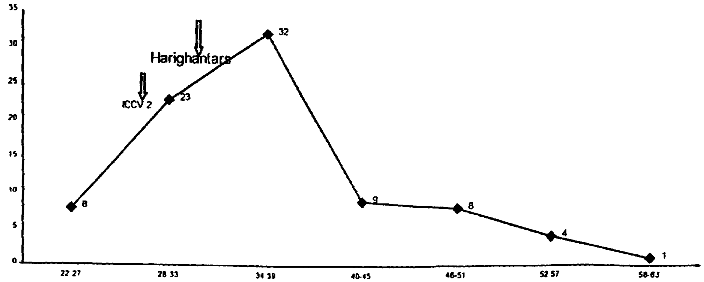

Figure 5: Frequency distribution of RILs for days to flowering of the cross ICCV 2 X Harighantars based on mean values of two generations.

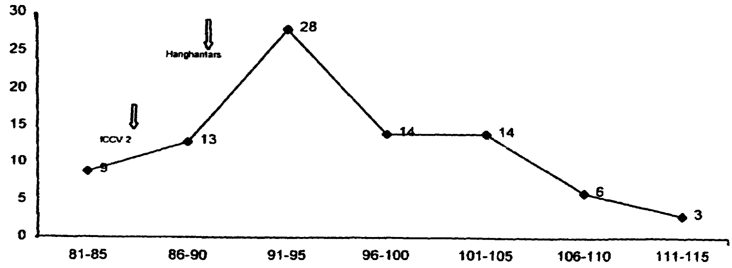

Figure 6: Frequency distribution of RILs for days to maturity of the cross ICCV 2 X Harighantars based on mean values of two generations.

4.1.3 Harighantars X ICCV 93929

Harighantars and ICCV 93929 flowered in 29 and 27 days and their F_1 flowered much later. Classification of the RILs according to the number of days to flowering showed that about 6% lines flowered earlier, 30% equal to, and 64% flowered later than the parents (Table 2).

This indicates that this cross has relatively more complementation towards later flowering than either of the other two crosses (Figure 7). Therefore, the two parents Harighantars and ICCV 93929 carry different genes for determination of flowering than the other two crosses.

Inheritance of days to maturity

The number of days from sowing to maturity were recorded on parents, F_1 and F_7 and F_8 generations of the three crosses involving a diallel among ICCV 2, ICCV 93929 and Harighantars. The results are given in the following sections.

ICCV 2 x ICCV93929

The two parents matured in 85 and 86 days. The mean value for the RILs was 85 days (Table 3). The CV's and ranges for days to maturity were generally lower than those for days to flowering, indicating that heat and lower moisture affected the expression of this trait. The distribution for days to maturity also indicated similar pattern as for days to flowering (Figure 2). This suggests that the same genes may be determining this trait as for days to flowering.

Table 12: Classification of Harighantars X ICCV 93929 RILs basing on means of two generations for DFF and DM .

Trait	#RILs Early	#RILs Like parents	#RILs Late	Range	Parents	
					ICCV2	Harighan tars
DFF	9	9	67	22-63	30.5	28.5
DM	9	11	65	81-144	90.0	86.0

Table13: Means, CV and ranges for days to first flowering and days to maturity for the cross Harighantars X ICCV 93929

Generation	Trait	Mean $\pm$ SE	CV. (%)	Range
F_7	DFF	39 $\pm$0.4	23.2	28-63
F_8	DFF	35.4 $\pm$ 0.38	28.5	24-58
F_7	DM	95 $\pm$ 1.01	6.23	85-107
F_8	DM	93 $\pm$1.01	10.75	97-107

Table 14 : Classification of Harighantars X ICCV 93929 RILs for days to first flowering and days to maturity generation wise.

Classification	Generation	#RILs	Mean ± SE
Trait: DFF			
Early	F_7	5	28.0 ± 0.20
	F_8	11	25.5 ± 1.2
Like Parents	F_7	28	31.25 ± 0.34
	F_8	32	28.0± 0.13
Late	F_7	63	43.05 ±1.06
	F_8	54	42.4 ± 1.30
Trait: DM			
Early	F_7	0	0
	F_8	48	84.2 ± 0.53
Like Parents	F_7	25	87.2 ± 0.10
	F_8	0	0
Late	F_7	74	97.3 ± 0.52
	F_8	51	102.0 ± 0.78

Table15: Classification of Harighantars X ICCV 93929 RILs basing on means of two generations for DFFand DM.

Trait	#RILs Early	#RILs Like parents	#RILs Late	Range	Parents	
					Harighantars	ICCV93929
DFF	8	20	68	27-61	29	30
DM	10	14	72	82-114	85	86

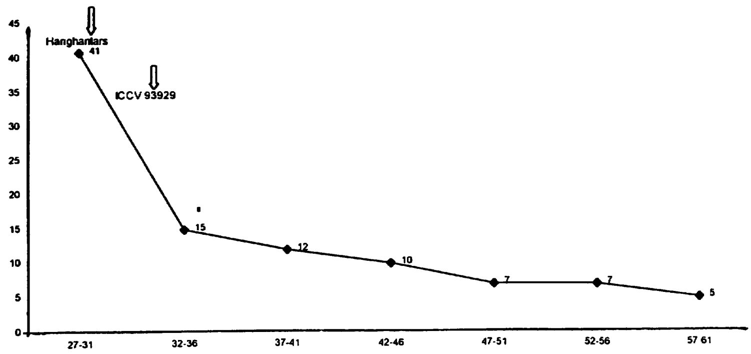

Figure 7: **Frequency distribution of RILs for days to flowering of the cross Harighantars X ICCV 93929 based on mean values of two generations.**

ICCV 2 x Harighantars

ICCV 2 took 90 and Harighantars 86 days to maturity whereas the RILs took a mean of 95 days (Table 10). The coefficients of variation and ranges for days to maturity were lesser than the corresponding values for days to flowering. This suggests that increasing temperatures and reduced moisture availability in the season may force longer duration plants to mature relatively early.

The distribution for days to maturity (Figure 6) indicated similar pattern as number of days to flowering. This suggests that the genes controlling the two traits are probably the same.

Harighantars x ICCV 93929

Harighantars matured in 85 days and ICCV93929 in 86 days. The RILs matured in 93 days (Table13). Here again the CV% and ranges for this trait were lower than those for days to flowering indicating an influence of rising temperatures and low moisture in later stages of growth.

The distribution for days to maturity indicated similar pattern as that for days to flowering (Figure 8). Most of the RILs matured later than the parents suggesting an epistatic interaction among the genes contributed by the two parents.

4.2 Number of nodes and days to first flowering:

The node number at which the first flower appears indicates the level of vegetative growth before initiation of reproductive stage. The node number to first

Table 10: Means, CV and ranges for days to first flowering (DFF) and days to maturity (DM) for the cross ICCV 2 X Harighantars.

Generation	Trait	Mean $\pm$ SE	CV. (%)	Range
F_7	DFF	39 $\pm$ 4.2	20.51	26-63
F_8	DFF	35 $\pm$ 3.75	25.1	23-56
F_7	DM	97 $\pm$ 10.0	1.62	85-108
F_8	DM	93 $\pm$ 9.9	10.7	77-120

Table 11: Classification of ICCV 2 X Harighantars RILs for days to first flower and to maturity generationwise.

Classification	Generation	#RILs	Mean $\pm$ SE
Trait: DFF			
Early	F_7	9	28.2 $\pm$ 0.36
	F_8	12	21.0 $\pm$ 0.59
Like Parents	F_7	12	31.9 $\pm$ 0.34
	F_8	10	27.0$\pm$ 0.16
Late	F_7	64	41.6 $\pm$ 0.88
	F_8	63	33.5 $\pm$ 0.98
Trait: DM			
Early	F_7	6	86.3 $\pm$ 1.65
	F_8	14	80.4 $\pm$ 1.37
Like Parents	F_7	30	92.6 $\pm$ 0.44
	F_8	02	84.0 $\pm$ 0.00
Late	F_7	49	100.5 $\pm$ 0.34
	F_8	69	96.0 $\pm$ 1.10

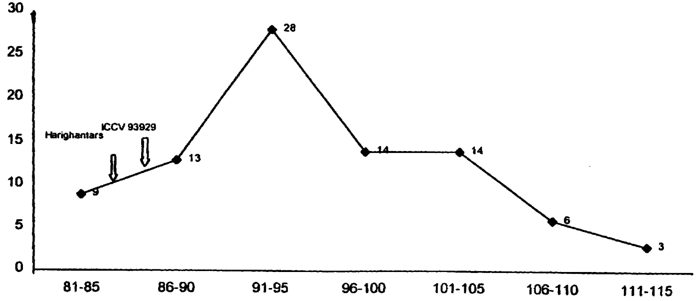

Figure 8: Frequency distribution of RILs for days to maturity of the cross Harighantars X ICCV 93929 based on mean values of two generations.

flower was recorded on parents and RILs of the three crosses studied. The results are given under the following headings.

4.2.1 ICCV 2 X ICCV 93929

ICCV 2 produced its first flower at node number 15 ± 0.2 and ICCV 93929 14 ± 0.3. The mean node number to first flower for the RILs was 16 ± 0.3. The range was 13 to 24 (Table 16). About 11% RILs produced their first flower at lower nodes than the mid parental value, 41% equal to the mid parental value and 48% at higher number of nodes.

The regression of number of nodes to first flower and days to first flowering showed almost a linear relationship (Figure 9). Thus early flowering lines in general produced their first flower at a lower node than those that flowered later. However, exceptions occurred. Some lines that took 35 to 40 days to first flower, produced their flower at about the same number of nodes as those that flowered early.

4.2.2 ICCV 2 X Harighantars

ICCV 2 produced first flower at node number 15 ± 0.3 Harighantars at 16 ± 0.2 .The RILs produced first flower from node number 12 to 35 with a mean of 17.5 ± 0.4 (Table 17). About 9% lines produced the first flower at lower nodes than the parents (13.7 ± 0.26) 47% at the same level as parents (15.6 ± 0.07) and 44% at higher nodes than the parents (20.6 ± 0.74).

The regression of number of nodes to first flowering on days to first flowering indicated that the two traits show almost a linear distribution (Figure 12). This suggested that generally early flowering lines flowered at lower nodes than those

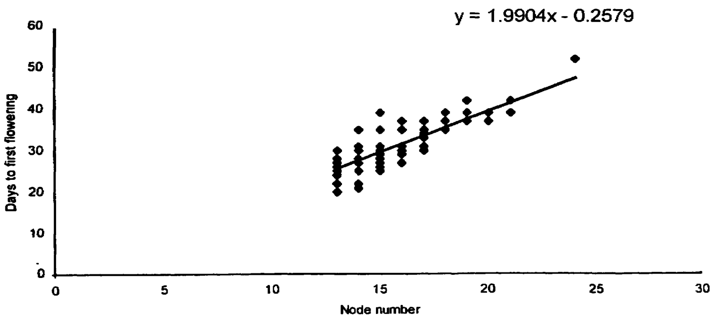

Figure 9: Distribution diagram of flowering node and flowering time of the cross ICCV 2 X ICCV 93929

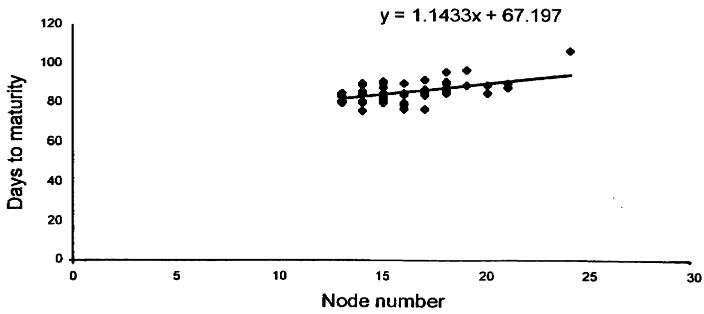

Figure 10: Distribution diagram of flowering node and days to maturity of the cross ICCV 2 X ICCV 93929

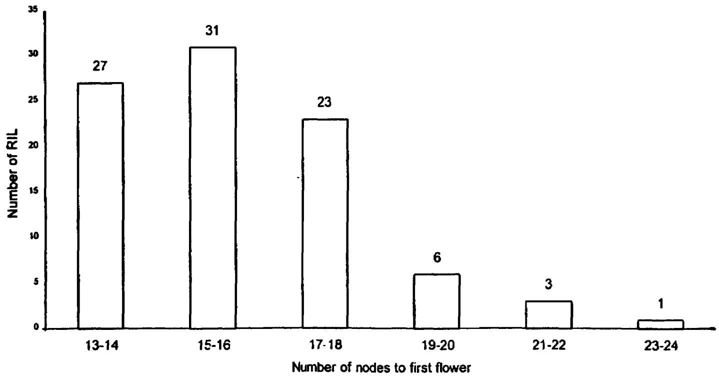

Figure 11: Frequency distribution of RILs for node to first flower for the cross ICCV 2 X ICCV 93929

Table 16: Number of nodes to first flower for RILs of ICCV 2 X ICCV 93929 in 1999/00.

Class	#RILs	Mean ± S.E
Early	10 (11%)	13 ± 0.01
Like parents	37 (41%)	14.5 ± 0.1
Late	42 (48%)	18± 0.26

Table17: Number of nodes to first flower for RILs of ICCV 2 X Harighantars in 1999/00.

Class	#RILs	Mean ± S.E
Early	8 (9%)	13.7 ± 0.26
Like parents	40 (47%)	15.6 ± 0.07
Late	37 (44%)	20.6 ± 0.74

Table 18: Number of nodes to first flower for RILs of Harighantars X ICCV 93929 in 1999/00.

Class	#RILs	Mean ± S.E
Early	4 (4%)	11.75 ± 0.25
Like parents	38 (40%)	13.5 ± 0.1
Late	54 (56%)	10.5± 0.05

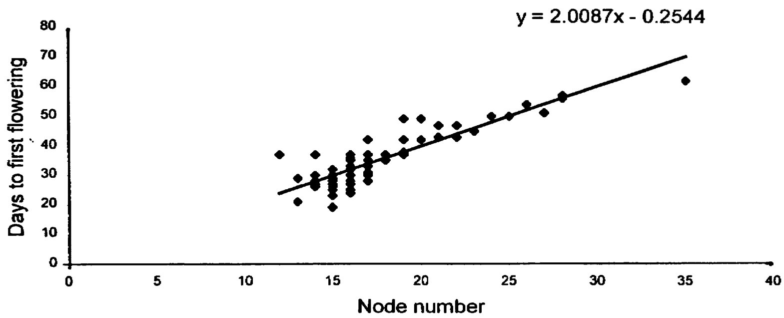

Figure12: Distribution diagram of flowering node and flowering time of the cross ICCV 2 X Harighantars

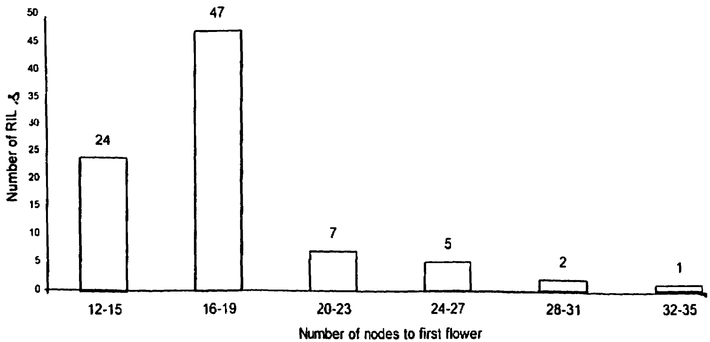

Figure 14: Frequency distribution of RILs for node to first flower for the cross

ICCV 2 X Harighantars

which flowered later. However, some exceptions occurred. Some lines that flowered relatively late produced their first flower at lower nodes than those that flowered very early.

4.2.3 Harighantars X ICCV 93929:

Harighantars flowered at node number 16 ± 0.2and ICCV 93929 at 14 ± 0.3. Their RILs ranged from node number 11 to 31 with a mean of 16.9 ± 0.6 (Table 18). About 4% of the RILs flowered at a lower node, 40% at about the mid parental value and 56% at a higher node number .

The regression of number of nodes to first flower on days to first flower showed almost linear distribution, however, the scatter of the values was much wider than that in the first two crosses (Figure 15). It appears that there were quite a few lines that flowered between 35 to 47 days, produced their first flower at relatively lower node number.

Number of nodes to first flowering and days to maturity:

The number of nodes at which the first flower was borne and the numbers of days taken to maturity were recorded on parents and the RILs of the three crosses (Figures 10,13 &16). Generally the lines that produced their first flower at relatively lower nodes matured early. However, regression values of maturity on node number indicated that Harighantars produced wider ranges with either parent than did the other two parents. The distribution of individual values was more widely scattered for Harighantars crosses.

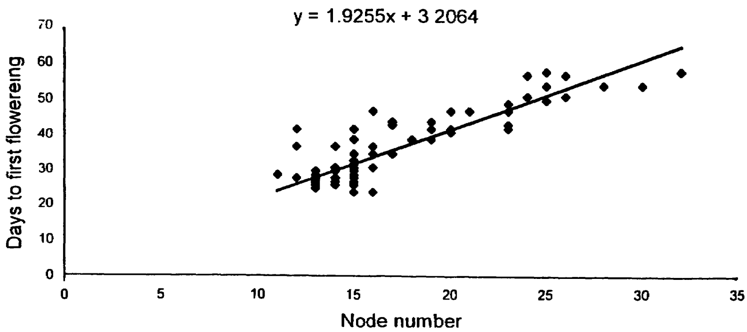

Figure 15: Distribution diagram of flowering node and flowering time of the cross Harighantars X ICCV 93929

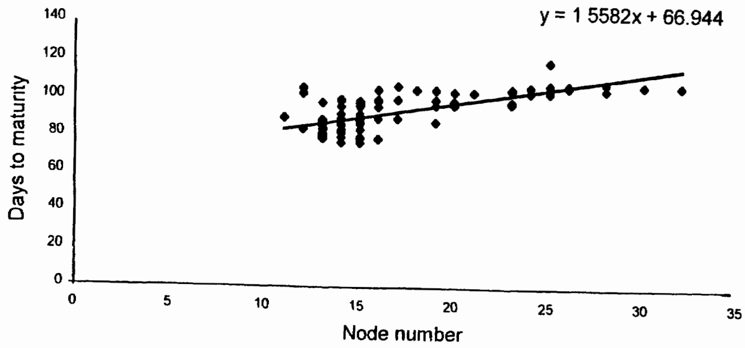

Figure 16: Distribution diagram of flowering node and days to maturity of the cross Harighantars X ICCV 93929

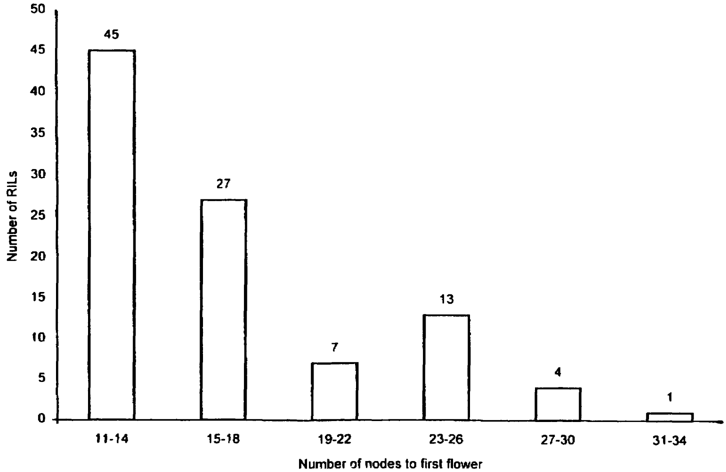

Figure 17: Frequency distribution of RILs for node to first flower for the cross Harighantars X ICCV 93929

In the cross Harighantars X ICCV 93929 a number of RILs that produced their first flowers at 12 to 32 nodes, matured about the same time. It appears that there is an opportunity to select lines that flower at relatively lower nodes and mature late, such lines could produce relatively higher seed yields under favourable conditions.

4.3 CORRELATION COEFFICIENTS

Phenotypic correlation coefficients among days to first flowering, days to 50% flowering, days to first pod formation, days to maturity, Yield, 100 seed weight and number of nodes to first flower were computed for the F_7 and F_8 generations of the three crosses, in this study.

4.3.1 ICCV2 X ICCV 93929

Days to first flowering: The trait showed positive correlation with days to 50% flowering (0.978**/0.981**), days to first pod formation (0.879**/0.973**) and days to maturity (0.69**/0.749**) in F_7 and F_8 generations, respectively.

In F_8 generation the trait exhibited positive correlation with flowering node (0.836**) and yield (0.267**).

Days to 50% flowering: This trait showed

positive correlation with days to first pod formation (0.897**/0.981**), days to maturity (0.713**/0.772**) and days to first flower (0.978**/0.981**) in both the generations respectively.

In F_8 generation the trait exhibited positive correlation with flowering node (0.818**) and significantly positive correlation with yield (0.25*).

Days to first pod formation:

The days to first pod formation exhibited positive correlation with days to first flower (0.879**/0.973**), days to 50% flowering (0.897**/0.981**) and days to maturity (0.638**/0.761**) both the generations respectively.

In F_8 generation, the trait exhibited positive correlation with flowering node (0.818**) and significantly positive correlation with yield (0.231*).

Days to maturity:

This trait observed a positive correlation with days to first flower (0.69**/0.749**), days to 50% flowering (0.713**/0.772**) and days to first pod formation (0.638**/0.761**) and positive correlation with seed size (0.228*/0.259*) in both the generations respectively.

The trait in F_8 generation exhibited a positive correlation with flowering node (0.585**).

Seed size

Character association of the trait seed size, witnessed a positive correlation with days to maturity (0.258**/0.259**) in both the generations and found non significant for all other traits under study.

Yield

Table 19 Correlation coefficients among various traits in the cross ICCV2 x ICCV 93929

	DFF	DF50	DFP	DM	Seed size	Yield	Node number
DFF	1.000						
	1 000						
DF50	0.978**	1.000					
	0 981**	1 000					
DFP	0.879**	0.897**	1.000				
	0 973**	0 981**	1 000				
DM	0.690**	0.713**	0.638**	1.000			
	0 749**	0 772**	0 761**	1 000			
Seed size	0.109*	0.114*	0.109*	0.228*	1.000		
	0 054	0 061	0 08	0 259*	1 000		
Yield	-0.069	-0.067	-0.077	-0.066	0.044	1.000	
	0 266**	0 251*	0 231*	0 148*	-0 003	1 000	
Node number	0 836**	0 818**	0 818**	0 585**	0 075	-0 230*	1 000

(Numbers in bold letters represents F_7 generation)

*, ** Significant at 5%, 1% level of significance respectively

The trait yield exhibited a positive correlation with days to first flower (0.266**) and positive correlation with flowering node (0.23*), days to 50% flowering (0.251*) and days to first pod formation (0.231*), in F_8 generation.

In F_7 generation the trait yield found non-significant correlation with all other characters.

Flowering node

In F_8 generation, the trait exhibited a positive correlation with days to first flowering (0.836**), days to 50% flowering (0.818*), days to first pod formation (0.818**) and days to maturity (0.585*), and flowering node exhibited a positive correlation with yield (0.23).

4.3.2 ICCV 2 X Harighantars

Phenotypic correlation coefficients were computed for days to first flowering (DFF) and other yield contributing characters, studied in F_7 and F_8 generation RILs. (Table20.)

Days to First Flower: In this cross, days to first flower showed positive correlation with day to 50% flowering (0.987**/0.985**), days to first pod formation (0.987**/0.976**) and days to maturity (0.857**/0.850**) with in each generation, whereas in F_7 generation days to first flower showed negative correlation (-0.369**) with yield, and positively correlated with seed size (0.238*).In F_8 generation days to first flower showed positive correlation with node number at which first flower appears (0.868**).

Days to 50% flowering: In this cross, days to 50% flowering showed positive correlation with days to first flowering, days to first pod formation and days to maturity, in both the crosses. In the F_7 generation of this cross, days to 50% flowering showed negative correlation with seed size (-0.296**) and yield (-0.310**). In F_8 generation, days to 50% flowering showed positive correlation with seed size (0.259*).

Days to first pod formation (DFP): In this cross days to first pod formation showed positive correlation with days to first flower, days to 50% flowering, days to maturity in both the generations.

In F_7 generation days to first pod formation showed negative correlation with seed size and yield. In F_8 generation days to first pod formation showed highly significant positive correlation with seed size and node number at which first flower appears (flowering node).

Days to maturity (DM): In this cross days to maturity showed highly significant positive correlation with days to first flower, days to 50% flowering, days to first pod formation, in both the generations.

In F_7 generation days to maturity showed highly significant negative correlation with seed weight and yield.

In F_8 generation days to maturity showed highly significant positive correlation (0.763**) with flowering node, and positive correlation (0.24*) with seed size.

Seed size: In this cross seed size had shown significant positive correlation with days to 50% flowering , days to maturity in both the generations.

In the F_7 cross of ICCV2 x Harighantars, seed size had showed significant positive correlation with days to first flower and days to first pod formation (0.238*, 0.22*), whereas in F_8 generation of this cross, seed size had shown positive correlation with days to first flower (0.293**) and days to first pod formation (0.293**) and positive correlation with flowering node (0.259*).

Yield: In F_7 generation of the cross yield showed negative correlation with days to first flower (-0.369**), days to 50% flowering (-0.366**), days to first pod formation (-0.3764**) and days to maturity (-0.355**).

In F_8 generation of the cross yield had shown negative correlation with flowering node (-0.298**).

Flowering node: In F_8 generation of the cross, the trait node number at which first flower appears (flowering node) had shown positive correlation with days to first flower (0.868**), days to 50% flowering (0.86**), days to first pod formation (0.858**) and days to maturity (0.763**), flowering node had shown significant positive correlation with seed size (0.259*) and negative correlation (-0.298**) with yield.

Table 20: Correlation coefficients among various traits in the cross ICCV2 x Harighantars

	DFF	DF50	DFP	DM	Seed size	Yield	Node number
DFF	**1.000**						
	1.000						
DF50	**0.987****	**1.000**					
	0.985**	1.000					
DFP	**0.987****	**0.980****	**1.000**				
	0.976**	0.971**	1.000				
DM	**0.857****	**0.871****	**0.863****	**1.000**			
	0.850**	0.864**	0.827**	1.000			
Seed size	**0.238****	**-0.296****	**0.220***	**0.228***	**1.000**		
	0.293**	0.253**	0.293**	0.240**	1.000		
Yield	**-0.369****	**-0.366****	**-0.374****	**-0.355****	**-0.193**	**1.000**	
	-0.112	-0.110	-0.095	-0.183	0.013	1.000	
Node number	0.836**	0.860**	0.858**	0.763**	0.259**	-0.298**	1.000

(Numbers in bold letters represents F_7 generation)

*, ** Significant at 5%, 1% level of significance respectively

4.3.3 Harighantara X ICCV 93929

Days to first flowering

In this cross the trait days to first flowering exhibited a correlation with days to 50% flowering (0.983**/0.96**), days to first pod formation (0.981**/0.986**) and days to maturity (0.862**/0.844**) in both the generations respectively In F_8 generation, the trait days to flowering found positive correlation with seed size (0.22*) and positive correlation with flowering node (0.899**).

Days to 50% flowering

The character association study of the trait days to50% flowering study, revealed a positive correlation with days to first flowering (0.983**/0.96**), days to first pod formation (0.985**/0.96**) and days to maturity (0.895**/0.89**) in both the generations respectively.

However the trait days to 50% flowering showed positive correlation with flowering node (0.857**), in F_8 generation.

Days to first pod formation

The trait days to first pod formation exhibited positive correlation with days to first flowering (0.981**/0.986**), days to 50% flowering (0.985**/0.96**) and days to maturity (0.876**/0.859**) in both the generations respectively.

The trait, in F_8 generation exhibited a positive correlation with flowering node (0.89**) and a positive correlation with seed size (0.206*).

Days to maturity

The trait, found to have positive correlation with days to first flowering (0.862*/0.844*), days to 50% flowering (0.895**/0.89**), days to first pod formation (0.896**/0.859**) in both the generations respectively.

In F_8 generation of the cross, the trait exhibited a positive correlation with flowering node (0.73**).

Yield

Yield is found to have a non-significant correlation with all the characters under study in both the generations.

Seed size

In F_7 generation of the cross, the trait seed size is found non-significant, however in F_8 generation seed size exhibited a positive correlation with days to first flowering (0.22*) and days to first pod formation (0.206*).

Flowering node

The trait, flowering node is found to have a positive correlation with days to first flowering (0.899**), days to 50% flowering (0.857**), days to first pod formation (0.89**),and days to maturity (0.73**) in F_8 generation.

Over the three crosses days to first flowering showed high and consistent positive correlation with days to 50% flowering, days to first podding, days to maturity and number of nodes to first flowering. Days to 50% flowering was highly and positively correlated with days to podding, days to maturity and number of nodes to first flowering. Days to first podding was highly and positively correlated with days to maturity and number of nodes to first flowering. Days to maturity had high positive correlation with node number. Seed size showed low positive relationship with most of the traits. Seed yield generally recorded low correlations varying from negative to positive with other traits.

Table 21: Correlation coefficients among various traits in the cross Harighantars x ICCV 93929

	DFF	DF50	DFP	DM	Seed size	Yield	Node number
DFF	**1.000**						
	1.000						
DF50	**0.983****	**1.000**					
	0.960**	1.000					
DFP	**0.981****	**0.985****	**1.000**				
	0.986**	0.960**	1.000				
DM	**0.862****	**0.895****	**0.896****	**1.000**			
	0.844**	0.890**	0.859**	1.000			
Seed size	**0.116**	**0.108**	**0.085**	**0.07**	**1.000**		
	0.220*	0.185	0.206*	0.144	1.000		
Yield	**0.129**	**0.12**	**0.11**	**0.028**	**0.106**	**1.000**	
	-0.001	-0.04	-0.007	-0.131	-0.023	1.000	
Node number	0.899**	0.857**	0.890**	0.730**	0.16	0.141	1.000

(Numbers in bold letters represents F_7 generation)

*, ** Significant at 5%, 1% level of significance respectively

DISCUSSION

CHAPTER V

DISCUSSION

Genetic studies were carried out on number of days to first flowering and maturity and nodes to first flowering and correlation studies were made on three crosses of chickpea, namely ICCV 2 X Harighantars, ICCV 2 X ICCV 93929 and Harighantars X ICCV 93929. Correlation coefficients were computed among the traits days to first flowering, 50% flowering, first pod formation, maturity, node to first flowering, seed size and yield. The results are discussed under the following headings.

5.1 Inheritance of early flowering and maturity.

5.2 Significance of flowering node to crop maturity.

5.3 Correlation coefficients.

5.1 Inheritance of early flowering and maturity

In breeding suitable varieties for crop plant it is important that its phenology matches the environmental conditions of the region where it is grown. In irrigated agriculture, the crop environment can be modified to some degree to allow crop varieties to express their potential productivity. However, in crops like chickpea that are cultivated on residual soil moisture, the crop phenology needs to be modified to the environmental conditions where these are grown. As the end of season drought is almost always a major factor in determining the crop productivity, it is important that the crop flowering and maturity duration match the availability of moisture in the soil. Therefore, fast and early growth, optimal crop canopy, relatively early flowering and maturity are important characteristics in determining crop productivity.

The number of days taken from sowing to first flowering is a major component for adaptation in crop plants. This trait is determined by the genotype, temperature and photoperiod. In the present study the temperature and photoperiod were the same within each experiment, therefore the differences among individual treatments reflect their genetic constitution.

In the three crosses that involved extra early flowering parents. ICCV 2, Harighantars and ICCV 93929, the three F_1s showed slightly different behaviour from each other although they still flowered within the extra early range. These therefore, appear to carry the same major gene for flowering. However, as these differ slightly from each other, they appear to carry additional minor genes that are different from each other and influence flowering and maturity to some extent.

Kumar and Van Rheenen (2000) reported in a cross of ICCV 2 X JG 62 recessive gene *efl-1* controlled extra early behaviour of ICCV 2. In the present study, its crosses with Harighantars and ICCV 93929 also produced extra early F_1s although these differed slightly from each other. Therefore, those two parents also appear to carry the *efl-1* allele.

Similarly Orr *et al.* (1999) designated a recessive allele *ppd* for early flowering in Harighantars (ICC 5810) when they studied its cross with a long duration cultivar Hadas. Thus the cross ICCV2 x Harighantars have both the recessive alleles *efl-1* and ppd. Their F_1 differed only slightly from the mid parental value. It therefore, appears that the two alleles probably have similar effect on flowering and may indeed be the same allele. One more cross Harighantars x JG 62 needs to be studied to definitely state whether *ppd* and *efl-1* are indeed the same allele.

Since the F_1 behaviour as well as the magnitudes and distribution of the RILs produced for the three crosses indicated slight difference, they may carry minor genes that confer earlier or later flowering. The epistatic interaction between genes for early flowering produced more later flowering segregants than the early flowering ones.

From the cross ICCV 2 x ICCV 93929 , Kumar and Rao (2001) isolated super early genotype ICCV 93929 earlier than the two parents indicating that some minor genes from between them complemented to produce earlier flowering than either of the two parents.

5.2 Significance of flowering node to crop maturity

The node number at which the first flower appears is an important flowering characteristic of chickpea as it determines the amount of vegetative growth attained before fruiting initiates. It was clearly established in pea, that flowering time is determined above all by node number (Murfet 1971). By the time that flower initiation takes place the metabolism of the plant is strongly geared towards reproduction (Murfet and Reid 1985). Days to first flowering and days to maturity, though exhibited positive association with the node number at which the first flower appears, the distribution diagram of the two traits with flowering node exhibited few RILs that lie away from the regression line. This discrepancy could be attributed to the interaction of genes governing those traits. Flowering characteristics of RILs has important implications for seed yield, since setting of the flowering potential is the first step in the determining final yield potential. Flowering node i.e the node number at which the first flower appears is thus considered as an important flowering characteristic along with flowering time. In the present investigation among the three crosses studied barring the cross Harighantars X ICCV 93929, in the other two crosses, flowering node exhibited a significant negative correlation with yield. If the flower initiation occurs at a lower node the photosynthetical assimilates flow towards reproductive organs mainly leading to higher yields, as chickpea is an indeterminate crop.

The comprehensive idea that can be formed from the present investigation is that if the plant flowers relatively at a lower node, the reproductive period of the plant is long even though that is early maturing type and resulting in higher yields under favourable conditions, but from the present investigation it was observed that if the plant flowers below a certain threshold node number yield of the plant is getting affected. This threshold number is lying between node number, 14 to node number 16 in the three crosses studied. Highest yield was recorded on node number 19 in the cross ICCV 2 X Harighantars where as highest yield were recorded on node numbers 16 and node number 14 in ICCV 2 X ICCV 93929 and Harighantars X ICCV 93929, respectively. Though the heighest yield was recorded on node number 19 in the cross ICCV 2 X Harighantars that RIL was found to be late maturing. Significance of flowering node to crop maturity could be revealed by the occurance of strong positive character association among flowering time, days to maturity and flowering node. The present investigation also witnessed a significant negative character association between flowering node and yield. As drought is a major reducer of yield, it is always desired to have genotypes that flower at lower nodes i.e early flowering so as to escape terminal drought stress and to achieve a sustained yield.

5.3 Correlation coefficients

Correlation coefficients indicate of the association between traits under consideration. These furnish a realistic basis for the allocation of weightage to each of the contributing components in deciding upon a suitable selection criteria for the genetic improvement of complex characters like seed yield and help in selection for simultaneous improvement of these characters.

In the present investigation correlation coefficients were computed between seed yield and six other traits in three crosses of chickpea.

Cross I: ICCV 2 x ICCV 93929

Phenotypic correlation studies were carried out in F_7 and F_8 generations of this cross.In this during F_8 generation yield had showed a positive association with days to first flowering (Ali, 1990; Sarvaliya and Goyal, 1994; Sandhu and Mangat, 1995; Qayyum, 1997) and days to first pod formation (Qayyum, 1997) and yield showed a non significant relationship with days to maturity (Bhanabota *et al.*, 1994). in F_7 generation yield was found non significant with all the traits under study.

In this cross days to first flower showed a positive association with days to maturity (Sharma and Maloo, 1988) and days to 50 per cent flowering showed a positive association with days to maturity (Arora and Jeena, 1994) in both F_7 and F_8 generations.

The positive association of yield to traits under study in this cross, emphasizes the importance of genotypes with late flowering and late maturity with higher grain mass to achieve higher yields in the crop.

Cross II: ICCV2 x Harighantars

Phenotypic correlation studies were carried out in the F_7 and F_8 generation of this cross.In this cross yield showed low positive association with days to first flowering (Ali,1990; Sarvaliya and Goyal, 1994; Sandhu and Mangat, 1995; Qayyum, 1997) and a negative association with days to 50 per cent flowering (Rahman and Parth, 1988), days to maturity (Qayyum *et al.*, 1997) in F_7 generation. In F_8 generation of the cross yield exhibited a non significant correlation with all the parameters under study excepting the node number, wherein yield showed positive association with node number (Bhattacharya *et al.*, 1995).

In this cross days to first flower showed a positive association with days to maturity (Sharma and Maloo, 1988) and seed size (Rao, 1994) in both F_7 and F_8 generations. In this cross, in both F_7 and F_8 generations days to 50% flowering showed a positive association with days to maturity (Arora and Jeena, 1994).

In this cross,the negative association of seed yield to days to maturity, days to 50 per cent flowering indicates the selection of the genotypes that flower early and having smaller flowering period with lower grain mass, during moisture stress conditions.

Cross III: Harighantars x ICCV 93929

Phenotypic correlation coefficients were carried out for both F_7 and F_8 generation of the cross.In this cross yield showed a non significant association with all the traits under study (Bhambota *et al.*, 1994) in both the generations. In F_8 generation of the cross, days to first flowering showed a positive association with seed size (Rao, 1994) and days to maturity (Sharma and Maloo, 1988) in both the generations. Days to 50 per cent flowering showed a positive association with days to maturity (Arora and Jeena, 1994) in both the generations.

In this cross, in F_8 generation node number showed a positive association with all the traits under study.

In this cross, it can be inferred that the genotypes that flower on larger node and that matures late with higher grain mass will contribute to higher yields.

SUMMARY

CHAPTER VI

SUMMARY

Genetic studies on flowering time, flowering node and character associations among selected traits were carried out in three crosses of chickpea (*Cicer arietinum* L.) at the International Crops Research Institute for the Semi - Arid Tropics (ICRISAT), Patancheru, A.P., during the *rabi* season 1999-2000.

The investigation was done on parents, and F_7 and F_8 generation RILs (Recombinant Inbred Lines) of three crosses; ICCV 2 x Harighantars, ICCV 2 x ICCV 93929 and Harighantars x ICCV 93929, wherein all the three parents are of extra - short duration types and flowers around 28 days after sowing at ICRISAT, Patancheru, near Hyderabad. The parent ICCV 93929 is a cold tolerant line.

The parental and F_7 seeds were sown in the post-rainy season, on 12th October, 1999. Sowing was done on deep vertisols on ridges 60 cm apart in an unreplicated block with plant to plant spacing of 20 cm within a row. Normal agricultural operations were done and plant protection measures were taken to grow a healthy crop.

The crosses ICCV 2 x Harighantars and Harighantars x ICCV 93929 produced F_1 that flowered later than mid parental value, and the cross ICCV 2 x ICCV 93929 produced F_1 that flowered earlier than the mid parental value. The cross ICCV 2 x ICCV 93929 indicated that one or more gene(s) between them complemented to produce earlier flowering than either of the two parents. In the

three crosses that involved extra-early flowering parents ICCV 2, Harighantars and ICCV 93929, the three F_1's showed slightly different behaviour from each other although they still flowered within the extra early range. In the present study, the cross ICCV 2 x Harighantars has both the recessive alleles *efl-1* and *ppd*, though it is not established whether *ppd* and *efl-1* are indeed the same allele.

The F_1 behaviour as well as the magnitudes and distribution of the RILs produced for the three crosses indicated slight differences indicating that these may carry minor genes that confer earlier or later flowering than the parents.

The inheritance of days to maturity indicated that the genes controlling days to flowering and days to maturity are probably the same, since the distribution for days to maturity indicated similar pattern as to number of days to flowering, this pattern was evident in all the three crosses under study.

The studies on significance of node number at which the first flower appears, indicated a linear relationship among flowering node, flowering time and days to maturity, though the distribution of individual values was more widely scattered for Harighantars crosses. The present investigation also indicated a low negative character association between flowering node and seed yield. Basing on the data collected from the three crosses under study for node to first flower, the threshold node number for sustainable yield was node number 14 to 16.

Correlation studies have indicated a strong positive association of seed yield with days to first flowering in two crosses. Such associations suggest a possible role of these traits in yield improvement. Strong positive associations were also observed among days to first flowering, days to 50% flowering, days to maturity and node to first flowering. Node to first flower and yield was found to have a strong negative character association.

Future studies should be taken up on various other crosses like Harighantars X JG 62 so as to establish whether the allele *efl-1, ppd* are the same or different and the flowering node is also to be studied in various other crosses under different environments so as to establish the genetic nature of that trait and its character associations are to be formulated.

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APPENDIX

Weather Data recorded at ICRISAT, Patancheru

Latitude 17 53°N Longitude 78 27°E Altitude 545m

Weekly Weather Data for the crop growth period

Year	Std Week	Rain (in mm)	Evap (in mm)	Max Temp (in°C)	Min Temp (in°C)	Rel Humidity1 at 07:17 (in%)	Rel Humidity2 at 14:17 (in%)	Wind Velocity (in Kmph)	Solar Radiation (in mj/ m²)	Bright Sunshine (in Hrs)
1999	40	0 3	33 1	30 31	20 71	89 57	63 71	8 64	14 92	8 8
1999	41	5 7	34 6	31 19	19 87	93 85	53 14	8 05	14 61	7 78
1999	42	17 6	33 4	30 44	17 42	95 14	51 14	4 68	17 02	7 57
1999	43	14 8	34 39	30 8	17 85	89	48 85	4 29	16 24	8 57
1999	44	0	40 5	30 82	14 68	87 85	37 14	6 47	18 02	8 97
1999	45	0	32 3	31 31	15 63	88 83	38 66	4 08	17 34	9 2
1999	46	0	42 2	29 92	10 34	80 28	27 14	4 02	18 71	10 07
1999	47	0	38 5	28 11	11 14	79 57	33 85	4 29	15 79	7 78
1999	48	0	34 2	29 75	10 47	88 42	31 28	4 28	16 95	9 29
1999	49	0	25 4	28 43	10 68	89 16	34	4 25	15 84	9 16
1999	50	0	35 6	27 77	9 22	87 62	30 75	3 73	15 88	9 32
1999	51	0	33 89	27 69	9 32	85 57	32 85	4 65	16 07	9 47
1999	52	0	35 19	28 21	10 81	96	35 87	5 21	14 79	9 71
2000	1	0	32 5	27 18	8 94	86	31 42	4 44	15 22	9 81
2000	2	0	37 59	29 32	11 18	86 57	28 85	6 3	16 27	9 74
2000	3	0	40 7	31 52	12 91	87 14	28 85	5 62	15 17	9 29
2000	4	0	42 7	31 15	12 [illegible]	90 28	28 42	5 82	17 94	9 7
2000	5	0	39 89	31 09	11 [illegible]	88	26 14	5 89	18 5	10 31
2000	6	0	46 39	32 51	15 59	86 71	30 28	7 21	17 55	9 74
2000	7	0	44 8	31 34	15 97	79	36 57	7 37	16 54	8 67
2000	8	0	47 6	30 8	17 57	77	38 28	11 94	15 98	7 91
2000	9	57 8	46 4	31 11	14 6	74 25	37 12	6 31	18 41	8 83
2000	10	0	59 09	34 35	14 64	69 28	17 42	6 62	22 05	10 51
2000	11	0	62 2	35 25	15 08	61	15 85	5 4	22 15	10 55
2000	12	0	69 79	35 84	16 95	70 71	21 85	7 29	21 57	10 34
2000	13	0	69 39	36 01	17 48	62 57	17 28	6 82	20 47	9 81
2000	14	0	77 9	38 08	19 88	69 85	19 42	9 42	21 71	10 27
2000	15	0	73 59	40 15	21 44	54	18 28	7 18	21 04	9 47
2000	16	0	75	38 34	20 37	55 85	19 85	8 98	21 19	8 95
2000	17	0	98 39	40 52	20 9	35 71	16	9 02	23 95	10 64
2000	18	86 29	92 5	40 97	21 27	56	25 57	9 64	23 3	10 17
2000	19	14 3	49 8	34 71	20 45	67	40	6 34	20 55	9 05
2000	20	3 79	76 4	36 61	22 05	60 71	32 57	13 71	24 28	10 32

Year	Std Week	Rain (in mm)	Evap (in mm)	Max Temp (in°C)	Min Temp (in°C)	Rel Humidity1 at 07:17 (in%)	Rel Humidity2 at 14:17 (in%)	Wind Velocity (in Kmph)	Solar Radiation (in mj/ m²)	Bright Sunshine (in Hrs)
2000	21	18 19	65 6	35 41	22 45	70	39 85	11 55	20 67	8 22
2000	22	12 6	64 59	35 54	21 8	78 28	43 85	11 45	22 52	9 45
2000	23	46 09	35 29	30 54	20 75	86 71	67 85	13 61	13 2	3 77
2000	24	30	44 89	31 98	20 32	82 85	59 71	12 9	16 84	6 32
2000	25	61 6	33 8	30 3	20 18	87 14	63 14	9 15	12 81	1 41
2000	26	239 09	37 5	29 91	19 95	86 71	63	11 14	14 22	4 45
2000	27	22 8	25.89	29 51	20 09	91 28	70 57	11 19	14 49	3 52
2000	28	44 89	22 39	27 47	19 78	89 57	76 85	18 14	10 42	2 38
2000	29	0 3	31 1	28 62	19 24	87 42	65 57	15 99	13 91	4 48
2000	30	2 39	33 39	31 11	19 59	81	54 14	7 48	18 65	6 97
2000	31	12	36 2	32 22	20 12	82 71	55 42	6 25	20 68	7 34
2000	32	105 8	21	27 58	19	91 42	78 42	10 55	10 28	2 15
2000	33	34 79	28 39	29 75	19 85	89 71	65 14	8 3	15 91	5 59
2000	34	517 3	12 69	27 45	19 5	93 28	77 57	12 32	9 62	1 67
2000	35	7 7	18 89	27 65	19 18	92	76 14	14 01	10 65	1 68
2000	36	14	26 8	29 44	18 8	89 28	62 28	8 09	16 97	6 27
2000	37	0	35 6	30 97	17 98	79 24	53 14	5 88	20 81	8 3
2000	38	117 2	27 89	31 05	18 89	93 71	63 42	5 08	16 41	6 97
2000	39	2 79	30 29	31 31	18 91	89 57	55 42	6 09	19 58	8 51
2000	40	0	33 7	32 08	18	89 14	42 42	2 98	19 54	9 27
2000	41	1 79	24 79	31 64	20 24	93 85	57 57	3 11	16 58	7 35
2000	42	16 19	29 5	31 05	19 65	89 57	50 14	3 97	15 12	5 85
2000	43	0	36 2	32 81	17 51	88	35 71	2 75	18 57	9 59
2000	44	0	30 69	30 6	17 31	90 71	38 57	3 78	15 65	8 21
2000	45	0	36 29	30 75	16 32	90 57	37 85	3 97	16 6	9 38
2000	46	0	36 8	29 67	13 92	90 28	36 14	4 91	17 55	9 9
2000	47	0	32 5	30 21	14 24	90 57	34 42	4 21	15 94	8 84
2000	48	3 09	32 6	29 38	16 25	85 14	39 71	3 72	13 19	6 89
2000	49	0	36 89	29 18	10 39	80 42	25 14	3 84	16 67	9 19
2000	50	0	36 6	29 39	9 65	85 28	20 42	3 98	17 41	10 35
2000	51	0	38 79	28 85	9 11	89 57	23 28	4 09	17 02	10 01
2000	52	0	41 39	28 52	10 57	89 12	27 87	5 55	16 43	10 01