The Journal of Animal & Plant Sciences, 27(1): 2017, Page: 207-218
ISSN: 1018-7081

HETEROTIC EXPRESSION FOR DRY POD YIELD AND ITS COMPONENTS IN CHILLI (*Capsicum annuum* var. *annuum*)

*N. Rohini and V. Lakshmanan

Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Periyakulam -625 604, Tamil Nadu, India.
*Corresponding author email: rohizna@gmail.com

ABSTRACT

Heterosis for dry pod yield and related characters in chilli was studied in full diallel crosses involving six genetically diverse inbreds. The hybrids and their potential parental lines differed significantly for all the characters, as evident from their highly significant mean square values. Considering the dry pod yield *per se* performance, the F_1 hybrids LCA 625 × K 1 (165.58 g), K 1 × Arka Lohit (157.25 g), Pusa Jwala × PKM 1 (156.54 g), PKM 1 ×LCA 625 (155.73), Pusa Jwala × K 1(147.40 g) and Arka Lohit × LCA 334 (143.10 g) were identified as best hybrids for further exploitation in breeding programme. These six F_1 hybrids could be exploited for table purpose due to higher weight and number of fruits along with high yield. Furthermore, these six hybrids exhibited higher magnitude of heterobeltiosis (104.42, 113.95, 140.83, 91.99, 126.77 and 93.38%) and standard heterosis over CO CH1 (18.12, 12.17, 11.67, 11.09, 5.15 and 2.08%) for dry pod yield per plant. Based on *per se* performance and heterosis, the F_1 hybrids LCA 625 ×K 1 and K 1 ×Arka Lohit were consistent which could be used for commercial exploitation after its critical evaluation.

Key words: Chilli, standard heterosis, heterobeltiosis, yield.

INTRODUCTION

Chilli (*Capsicum annuum* L.) is an important vegetable cum spice crop grown in almost all parts of tropical and sub-tropical regions of the world (Hazra *et al.,* 2011). It belongs to the family Solanaceae and originated from South and Central America, where it was domesticated around 7000 BC (Ince *et al.*, 2010). It has attained a status of high value crop in India and occupies a unique place among vegetables in Indian cuisine because of its delicate taste and pleasant flavor coupled with rich content of ascorbic acid and other vitamins and minerals. Chillies are low in sodium and cholesterol free, rich in vitamin A, C, E, a good source of potassium and folic acid. Fresh green chilli contains more vitamin C than citrus fruits and fresh red chilli has more vitamin A than carrot. It with bright colour and less pungency are preferred in Europe and in the West (Sharanakumar *et al*., 2011). Chillies are used in both green and dry forms in all culinary preparations.

Chilli has become on essential ingredient in India meals. India is largest producer of 11, 00,452 tonnes of dry chillies from an area of 9, 36,028 ha. Per capita consumption of chilli in the form of dry chilli is estimated 4.2 kg per annum (Indian Horticulture Database, 2014). India is the largest consumer and exporter of this crop. It consumes around 6.2 million tons of chillies, Almost 90% of chilli production is consumed indigenously while only 10 % is exported (Sonam *et al*.2015). Demand from the chilli powder producing sector constitutes to 30% of the total production in the country. Exports of chilies around 347,000 tonnes, which makes 29.20% of the total spices exported from the country. Chilli contributes on an average Rs. 35170 million GDP and creates employment of 20 million work day annually (Jagtap *et al*.,2015). Chilli extensively grown for dry chilli production but part of the crop harvested as green pods. Though India is the leading producer, the average yield of chilli is very low (1.11 tons ha^{-1} dry chilli) as compared to developed countries like USA, China, South Korea, Taiwan etc, where the average yield ranges from 3-4 tons ha^{-1}. Low productivity in chilli is mainly attributed to lack, of high yielding, pest and disease resistant varieties or hybrids. Only about 2.60% chilli area is under hybrids in India, while in the countries like Korea and Taiwan more than 90 percent area is covered by hybrids. The low productivity could be improved through hybridization since marked heterosis (3.8 to 71%) has been reported for yield and its yield components (Chaudhary *et al*., 2013)

The genus Capsicum is on often cross pollinated and natural cross pollination may go up to 50 per cent depending upon the extent of style exertion, time of dehiscence of anthers, wind direction and insect population (Murthy and Murthy, 1962; Hosmani, 1993). This accounts for considerable variation in fruit and yield parameters. India has the potentiality to increase the production in order to promote export besides meeting its domestic requirements.

Despite its economic importance, no major breakthrough has been made so far and a few old introductions are still recommended for commercial cultivation. So, there is need to develop high yielding good quality hybrids. Heterosis breeding creates variability and increases the chance of selection for qualitative and quantitative traits. The magnitude of heterosis provides a basis for determining genetic diversity and its guide to choice of parents. The popularity of F_1 hybrid cultivars is due to their vigor, uniformity and good horticultural traits including earliness and long shelf life expressed and therefore giving consistent stable yield. Diallel analysis is a biometrical tool that provides the estimates of genetic parameters regarding heterosis and combining ability. It gives additional information on presence or absence of epistasis, average degree of dominance and distribution of dominant and recessive genes in the parents. Application of diallel technique in a self pollinated crop for improving yield and quality may be appropriate (Griffing, 1956). Increased yield of chilli owing to the manifestation of hybrid vigor was observed earlier by Sathiyamurthy (2002), Rani (2002), Kumar (2005) and Karthik (2006). Patil (2012) evaluated 28 F_1 hybrids and recorded the highest yield per plant in cross Phule Mukta x AC-2 (1930 g).

Savitha (2011) reported highest fresh fruit (682.30 g) and dry pod yield per plant (170.23 g) in the hybrid CA 197 x Kashi Anmol. Munish (2012) observed the highest fresh fruit yield per plant in the hybrid LCA 436 x Pant C1 (615.23 g) and the highest dry pod yield per plant (70.59 g) in the same hybrid. Recently, Sharma *et al*. (2013) observed the highest fruit yield per plant in cross PRC 1 x Rani Sel 1 (1370.06 g).

The commercial hybrids are very common in chilli and selection of newer parents for higher magnitude of heterosis is a continuous process. Availability of F_1 hybrids in chilli suitable for both fresh and processed forms is much limited. Hence there is on immense need to develop hybrids in chilli for market type as in the form of dry pod. In view of this, it is essential to identify the lines possessing good fruiting and yield. Hence the present study is to undertaken to estimate the dry pod yield and its hybrid vigor in parents and 30 hybrids and to suggest the F_1 hybrids having high dry yield and yield contributing characters for evaluation of new chilli hybrids.

MATERIALS AND METHODS

The experimental work was carried out during the 2013-2014 at the experiment farm of Department of Vegetable Crop, Horticultural College and Research Institute, Periyakulam, Tamil Nadu Agricultural University, India. Six genetically diverse chilli inbreds viz., Arka Lohit (P_1), K1 (P_2), LCA 334 (P_3), LCA 625 (P_4), PKM 1(P_5) and Pusa Jwala (P_6) were crossed with each other in a complete diallel fashion to get 30 cross combinations. These 30 hybrids along with their parental lines and check genotype i.e. COCH1 were evaluated in a randomized block design with three replication. The seeds were sown in portrays on the first week of October and the plants were transplanted in the main field on the 2nd week of November. The main field was prepared to fine tilth and farm yard manure at 25 t/ha applied at the last plouging. Each plot consists of 5 rows and 4m length spaced at 60 x 45 cm. Standard cultural practices recommended for chilli were adopted uniformly for all the plots (CPG, 2013). The observations were recorded on fifteen horticultural traits viz., Plant height (cm), branches per plant, days to first flowering, days to 50 per cent flowering, fruits per plant, fruit length (cm), fruit girth (cm), individual fresh fruit weight (g), individual dry pod weight (g), pericarp weight (g), pericarp thickness (mm), seeds per pod, seed weight per pod (g), thousand seed weight (g), fresh fruit yield per plant (g) and dry pod yield per plant (g).

Statistical analysis: The mean data of all the hybrids and their parents for each character were tabulated and subjected to analysis of variance (Panse and Sukhatme, 1957).

Estimation of heterosis: Heterosis in F_1 hybrids was estimated for each trait based on all the criteria using the three mean values as detailed below

Relative heterosis (di) i.e. percentage of deviation of the F_1 hybrid from the respective mid parental value = ($F1$ – MP) / MP x 100

Heterobeltiosis (dii) i.e. percentage of deviation of the F_1 hybrid from the better parental value = (F1 – BP) / BP x 100

Heterosis over best parent (diii) i.e. percentage of deviation of the F_1 hybrid from the standard check hybrid for each trait = (F_1 – SV) /SV x 100

Where,

F_1 - mean value of the F_1 hybrid

$$MP \text{ – Mid parental value} = \frac{P1 + P2}{2}$$

Where, P_1 and P_2 are the mean values of the first and second parent respectively.

BP = mean value of the better of the two parents used in the respective cross combination and

SV = mean value of the standard check hybrid.

Test of significance: The standard errors for testing significance of heterosis were calculated as suggested by Snedecor and Cochran (1967)

$$SE_{MP} = \left[\frac{3EMS}{2r}\right]^{1/2}$$

$$SE_{HP \text{ or } BP} = \left[\frac{2EMS}{r}\right]^{1/2}$$

Where,
EMS = Error mean square obtained in the combined analysis for parents and the crosses.
r = number of replications
The 't' value was worked out as the deviation of F_1 from the mid parent or better parent or the best parent by standard error and tested against the table 't' value at error degrees of freedom for 5 and 1 per cent levels of probability.

RESULTS AND DISCUSSION

Analysis of variance showed highly significant differences among genotypes for all the characters. Significant difference among entries indicated that the parents and their F_1s were quite distinct from each other in respect of those characters (Table 1). The mean sum of squares of parental plant genotypes for all the characters was highly significant, which indicates that there was substantial variation in characters among the genotypes.

In any crop breeding programme, it is essential to select parents with good *per se* performance, so that the best performing hybrids could be developed. It is equally important to select hybrids of high performance to achieve specific objectives of any breeding programme. Dod *et al.* (1992) opined that *per se* performance should be given an equal importance while judging the hybrid combinations for exploitation of heterosis. The mean values for different characters revealed that the dry pod yield per plant and the yield contributing characters were found higher in desired direction with the hybrids as compared to parents and so possibility of considerable heterosis in the studied population (Table 2).

Plant height is an important component by which the growth and vigor of the plants are measured. The parents K 1 (83.25 cm), LCA 625 (74.40 cm) and LCA 334 (73.58 cm) recorded better values of plant height. Among the hybrids, the crosses Pusa Jwala × K 1 (100.7 cm), Arka Lohit × LCA 334 (91.20 cm), PKM 1 ×LCA 625 (88.45 cm) Pusa Jwala × PKM 1 (88.20 cm), and K 1 × Arka Lohit (86.50 cm) expressed better values of plant height. It is interesting to notice that both the tall and dwarf combinations had Pusa Jwala as one of the parents. In general, the hybrids involving Pusa Jwala or Arka Lohit as the female parent registered higher plant height. Identification of hybrids with better growth habit and spreading nature is advantageous and in such hybrids the fruiting would be greater due to continuous production of flowering truss in each node. The variation in plant height might have due to specific genetic make of different hybrids, inherent properties, hormonal factor and vigor of the crop. Such information on difference in plant height was noted to be available from the studies of Prasath and Ponnuswami (2008) and Patil *et al*. (2012). Branches per plant influence the yield to a significant extent. The primary branches as well as the secondary branches decide the spread of the plant. The number of branches was more in the parent Pusa Jwala (9.38) and LCA 625 (8.95), while the hybrids resulted by crossing these parents were above their parents. Pusa Jwala and LCA 625 would have contributed to better synthesis of cytokinin thereby helped to have architecture with more branches in its F_1 hybrids. The hybrids LCA 625 × K 1 (14.67), Arka Lohit × LCA 334 (13.50), K 1× Arka Lohit (12.20), Pusa Jwala × PKM 1 (12.20) and PKM 1 × LCA 625 (11.32) recorded more number of branches per plant. The variation in number of branches per plant might have been due to own genetic makeup and also due to plant height and hormonal factor confirming to reports of Chadchan (2008) and Munish (2012).

Days to first flowering and days to 50 per cent flowering are the two main attributes of earliness, which is manifested in the F_1 hybrids and most of the F_1 hybrids are grown for their early yield. The parents LCA 625 (62.92 & 69.51 days), PKM 1 (64 &71 days) and Arka Lohit (65.50 &70.33 days) exhibited very early flowering whereas, in hybrids, PKM 1 × LCA 625 (62 & 67days), PKM 1 × Pusa Jwala (62.6 & 67.93 days), K1 ×Arka Lohit (64 &67.50 days), K1 × LCA 625 (63 & 68 days) and K1× PKM 1 (64 & 68 days) were found to be earlier in flower production.. The lower temperature prevailed during early crop growth period in December month would have favoured the production of hormones like gibberellins which could have favoured early flowering. Supporting evidences in these aspects were available from results of Sood and Kumar (2010) and Sharma *et al.* (2013).

The selection for high yielding genotype should be based mainly on the number of fruits (Gill *et al*., 1973). Among six parents, LCA 625 (104.75), Arka Lohit (98.48) and K 1 (92.00) recorded more fruits per plant. In the present study, the hybrids LCA 625 × K 1 (195), PKM 1 × LCA 625 (188.05), Pusa Jwala × PKM 1 (178.50), Pusa Jwala × K 1 (176.43) and Arka Lohit × LCA 334 (173.80) revealed higher values for this trait. The variation in number of fruits per plant might have been due to fruit set percentage, genetic nature and their response to varying environmental conditions. Patil *et al.* (2012) reported that the number of fruits per plant is usually greater when cool temperature occur in the flowering period. Supporting evidences for increase in fruit number per plant could be obtained from the study conducted by Sitaresmi *et al*. (2010) and Sharma *et al*. (2013).

Fruit length decides the individual dry fruit weight and thereby the yield. The length was the highest in the parents LCA 625 (8.62 cm), Pusa Jwala (8.53 cm) and PKM 1 (8.00 cm).When Pusa Jwala was used as a female parent, the hybrids expressed better fruit length.

Table 1. Mean square for different characters in 6 × 6 diallel crosses in chilli.

Characters/Source	Replication	Genotypes	Error
Plant height	0.76	263.87**	0.57
Branches per plant	0.46	9.37**	0.52
Days to first flowering	2.33	19.02**	1.68
Days to 50 % flowering	1.25	20.79**	3.98
Fruits per plant	2.19*	2947.32**	0.59
Fruit length	0.41	2.84**	0.13
Fruit girth	0.01	0.378**	0.01
Fresh fruit weight	0.01	0.98**	0.03
Dry pod weight	0.00	0.03**	0.00
Seeds per pod	30.39	276.72**	16.06
Seed weight per pod	0.007**	0.01**	0.00
Pericarp weight	0.003**	0.006**	0.00
Pericarp thickness	0.005**	0.010**	0.00
Thousand seed weight	7.84**	0.89**	0.07
Fresh fruit yield per plant	39.31	87998.71**	8696.99
Dry pod yield per plant	0.68	3329.89**	16.28

Similarly, cross K1 x Arka Lohit exhibited maximum HB (- 8.33%, 42.86% and -4.33%) and SH (11.79%, 33.33% and 11.24%) for dry pod weight, pericarp weight and pericarp thickness. This cross also registered significant and desirable positive SH (13.97%) for fresh fruit weight. Cross combination Pusa Jwala × PKM 1 exerted highest heterosis for plant height (25.05%), fruits/ plant (96.15%), fresh fruit weight (65.86%), fresh fruit yield/ plant (248.72%) and dry pod yield/ plant (140.83%). The cross Pusa Jwala × K 1 manifested maximum BH for fruit girth (48.32%) and maximum plant height (22.06%) and fruit length (12.75%) over SH. For dry pod yield /plant 24 hybrids exhibited significant positive heterobeltiosis and five for standard heterosis. A large number of hybrids expressed greater amount of heterotic effects in desired direction for dry pod yield, fresh fruit yield, plant height, days to first and 50% flowering, number of fruits per plant, fresh fruit weight, seeds per pod and thousand seed weight.

The highest fruit length was recorded in the hybrids Pusa Jwala × K 1 (10.38 cm), K 1 × PKM 1 (9.58 cm), Pusa Jwala × PKM 1 (9.52 cm), PKM 1 × K 1 (9.40 cm) and PKM 1 × LCA 625 (9.37 cm). The parents have proved their potential in exhibiting their superiority in the respective hybrid combinations. The present results are in conformity with the findings of Sood and Kumar (2010), Patil *et al.* (2012) and Barhate *et al.* (2013). Fruit girth is equally important in deciding the individual fruit weight. High fruit girth leads to increased fruit yield. In parents, Arka Lohit (3.28 cm), PKM 1 (3.10 cm) and LCA 625 (3.07 cm) had fruit girth more than 3 cm, on the other hand, hybrids K 1 × Arka Lohit (3.97 cm), Pusa Jwala × K 1 (3.83 cm), K1 × Pusa Jwala (3.64 cm), Arka Lohit × LCA 334 (3.63 cm) and Pusa Jwala × PKM 1 (3.59 cm) had more fruit girth. The variation in fruit length and fruit girth might have due to genetic nature, environmental factor and vigor of the crop. Similar results for this trait were observed by Patel *et al.* (2010) and Barhate *et al.* (2013).

Fruit weight is the most important component that contributes directly to the yield in chilli. Among six parents, LCA 625 (3.07 & 0.78 g) and Arka Lohit (2.85 &0.75 g) registered the highest fresh fruit weight and dry pod weight. In case of hybrids, the crosses K 1 × Arka Lohit (4.32 & 0.92 g), Pusa Jwala × PKM 1 (4.10 & 0.88 g) , LCA 625 × K 1 (4.02 & 0.88 g), Pusa Jwala × K 1 (3.92 & 0.85 g), PKM 1 × LCA 625 (3.85 &0.83 g) and Arka Lohit x LCA 334 (3.81 & 0.84 g) registered higher values for this trait. The highest fruit weight in these crosses may be due to its hybrid vigor. The present results are in concurrence with the earlier findings of Chadchan (2008), Sitaresmi *et al.* (2010) and Sharma *et al*. (2013).

The number of seeds is important characters which influence the individual fruit weight. The parents LCA 625 (84), PKM 1 (82) and K1 (78) recorded higher seeds per pod. The cross combinations LCA 625 × K 1 (108.42), Pusa Jwala × PKM 1 (96.50), K 1 × LCA 625 (95), K 1 × Arka Lohit (93.30) and LCA 625 × PKM 1 (92.95) were found to be superior for number of seeds per pod. Seeds are also responsible for proper development of fruit shape. These results are in conformity with the findings of Sathiyamurthy (2002) and Reddy (2006). In chilli, pericarp tissue is a key component for both processing and dry market cultivars, especially when they are shipped for long distances. The parents LCA 625 (0.45 g) and Arka Lohit (0.42 g) recorded higher seed weight per pod and LCA 625 × K 1 (0.47 g), Arka Lohit × LCA 625 (0.47 g), Arka Lohit × K 1 (0.46 g), Arka

Lohit × PKM 1 (0.46 g) and K 1 × Arka Lohit (0.46 g) recorded higher values than the parents and these results are in conformity with the findings of Sathiyamurthy (2002), Kumar (2005) and Reddy (2006).

Pericarp weight is very closely related to productivity parameters. The highest value for pericarp weight was observed in the parents LCA 625 (0.33 g) and Arka Lohit (0.31 g). The superiority of these parents was reflected in the hybrids K 1 × Arka Lohit (0.47 g), PKM 1 × LCA 625 (0.40 g), LCA 625 × K 1 (0.37 g), K 1 × LCA 625 (0.36 g) and Pusa Jwala × K 1 (0.37 g). A similar result for this trait was recorded by Sitaresmi *et al.* (2010). Pericarp thickness directly favors enhanced shelf life by reducing the exchange of gases that indirectly accelerate many biochemical reactions towards softening of tissue. The parents LCA 625 (0.87 g), Arka Lohit (0.82 g) and Pusa Jwala (0.81 g) recorded the highest pericarp thickness among the parents of the study. The hybrids K 1 × Arka Lohit, (0.96 mm), LCA 625 × K 1 (0.92 mm), PKM 1 × Pusa Jwala (0.91 mm), K 1 × LCA 625 (0.91 mm) and LCA 334 × Arka Lohit (0.90 mm) exhibited the higher values of pericarp thickness. The parents LCA 625 and K 1 were proved to be better male and female parents while the parent Arka Lohit was proved to be better male parent in developing hybrids with better values of fruit pericarp thickness. Supporting results pertaining to performance of parents and corresponding hybrids were also reported by Rego *et al.* (2009), Sood and Kumar (2010) and Sharma *et al.* (2013).

Thousand seed weight decides the weight of the seeds, which is an alternative measure on the germinability and vigor of the seeds. The parents LCA 625 (5.73 g), Arka Lohit (5.52 g) and LCA 334 (5.32 g) had the highest thousand seed weight. The cross which held the first rank among the hybrids was LCA 625 × K 1 with a thousand seed weight of 7.03 g. Relatively higher values of thousand seed weight were recorded in K 1 × Arka Lohit (6.75 g), K 1 × PKM 1 (6.75 g) and PKM 1 × LCA 625 (6.52 g). Sathiyamurthy (2002) also recorded similar results for thousand seed weight in chilli.

Yield is a composite character and is dependent on many constituent traits. Any change in these constituent traits would reflect on total yield. Except PKM 1 all the parents recorded fresh fruit yield per plant of more than 200 g per plant and except K1 the entire parents recorded dry pod yield per plant of more than 50 g per plant. Based on their *per se* performance, the hybrids LCA 625 × K 1 (780.60&165.58 g), K1 × Arka Lohit (750.53 &157.25g), Pusa Jwala × PKM 1 (728.83 &156.54 g), PKM 1 × LCA 625 (720.60 &155.73 g) and Pusa Jwala × K 1 (687.23 &147.40 g) have been identified as the best F_1 cross combinations in the present investigation. The parents K 1, LCA 625 and PKM 1 contributed much as both female and male parents in developing better hybrids of higher fruit yield. The parent Pusa Jwala acted as best female parent and produced high yielding hybrid combinations. Grafius (1959), who had suggested that there could be no separate gene system for yield *per se* as yield is an end product of multiplicative interactions between its component characters. The variation in fruit yield per plant might have been due to fruit set percentage, number of fruits per plant, fruit length, fruit girth, genetic nature, environmental factor and vigor of the crop. The increased fruit yield of first generation hybrids obtained in the present study also correlates with the findings of Chadchan (2008) and Munish (2012). Considering the *per se* performance, LCA 625, Pusa Jwala and Arka Lohit were identified as best parents for further exploitation in breeding programme. Six promising hybrids K 1 × Arka Lohit, LCA 625 × K 1, Pusa Jwala x K 1, Pusa Jwala × PKM 1, PKM 1 × LCA 625 and Arka Lohit × LCA 334 were selected on the basis of *per se* performance.

Heterosis: Hybrid vigor is a direct property of heterozygosity and is due to superior gene content possible in a hybrid contributed by both the parents (Mather, 1955). Hybrid vigor, the phenomenon of heterosis, is the basis for improvement in crop yields achieved during 20^{th} century in many crops. The exploitation of heterosis is vital importance to face the challenges of providing novel traits like capsaicin and colour value besides food and nutritional security for an ever increasing human population. Rapid advances in plant breeding with regard to exploitation of heterosis have served in many ways to develop hybrids with increased yield per hectare along with good quality characters.

Mackey (1976) described genetic principles of expression of heterosis superior to the better parent, which may result from one or two of the following situations: (i) the accumulated action of favourable dominant or semi-dominant genes dispersed amongst two parents i.e. dominance; (ii) the complementary interaction of additive dominant on recessive genes at different loci i.e. non-allelic interaction or epistasis; (iii) favourable interaction between two alleles at the same locus i.e. intra locus or inter allelic interactions referred to as over dominance. It will be possible to recover homozygous lines as good as heterotic hybrids if either or both of the first two situations are the cause of heterosis, although the case with which such lines can be recovered will depend on linkage relationship of the genes involved and the ability to identify the recombinants as and when they arise. This will be particularly difficult with close linkage and when heterosis is expressed by a slight improvement in each of main yield components. If the heterosis is due

Table 2. Mean performance of parental genotypes and F_1 hybrids for various traits in chilli.

Parents and hybrids	Plant height (cm)	Branches / plant	Days to Ist flowering	Days to 50 % Flowering	Fruits / plant	Fruit length (cm)	Fruit girth (cm)	Fresh fruit weight (g)	Dry pod weight (g)
P_1 (Arka Lohit)	68.72	7.28	65.50	70.33	98.48	7.49	3.28	2.85	0.75
P_2 (K1)	83.25	8.53	68.00	72.55	92.00	7.83	2.58	2.42	0.54
P_3 (LCA 334)	73.58	7.00	70.63	76.39	86.52	6.56	2.72	2.35	0.62
P_4 (LCA 625)	75.40	8.95	62.92	69.51	104.75	8.62	3.07	3.21	0.78
P_5 (PKM1)	70.53	8.52	64.00	71.00	80.08	8.00	3.10	2.47	0.66
P_6 (Pusa Jwala)	62.80	9.38	67.75	72.00	90.85	8.53	2.30	2.32	0.72
Arka Lohit × K 1	73.28	9.20	64.0	70.67	127.67	8.05	2.85	3.38	0.80
Arka Lohit × LCA 334	91.20	13.50	68.0	71.33	173.80	8.50	3.63	3.81	0.84
Arka Lohit × LCA 625	60.47	9.00	67.0	70.33	132.85	7.43	3.29	2.90	0.83
Arka Lohit ×PKM 1	75.30	8.20	65.0	70.00	106.52	8.43	3.23	3.04	0.70
Arka Lohit × Pusa Jwala	84.06	8.63	67.0	73.00	125.50	6.16	2.95	2.63	0.68
K 1× Arka Lohit	86.50	12.20	64.0	67.50	175.03	8.41	3.97	4.32	0.92
K 1 × LCA 334	67.23	8.00	69.0	74.00	110.65	7.77	3.08	2.72	0.74
K 1 ×LCA 625	84.40	9.97	63.0	68.00	163.00	8.79	3.30	3.80	0.84
K 1 × PKM 1	71.86	8.50	64.0	68.00	138.43	9.58	3.50	3.81	0.82
K1 × Pusa Jwala	78.10	9.20	66.0	70.00	130.72	8.75	3.64	3.79	0.83
LCA 334 ×Arka Lohit	81.10	7.00	71.0	77.00	101.54	7.32	3.06	3.02	0.70
LCA 334 × K 1	77.53	8.13	69.0	74.00	98.00	8.38	3.05	2.85	0.69
LCA 334 ×LCA 625	60.03	8.30	68.0	74.00	108.35	7.76	3.20	2.76	0.66
LCA 334 × PKM 1	80.49	7.27	68.0	75.00	98.50	7.98	3.27	2.93	0.70
LCA 334 × Pusa Jwala	76.16	7.00	70.0	72.00	112.36	5.66	2.85	3.05	0.53
LCA 625 × Arka Lohit	66.98	10.32	65.0	69.00	132.00	8.27	2.57	3.32	0.76
LCA 625 × K 1	86.40	14.67	64.0	68.00	195.00	8.95	3.54	4.02	0.88
LCA 625 × LCA 334	68.93	8.07	68.0	75.00	123.00	8.48	3.21	2.98	0.67
LCA 625 × PKM 1	79.37	9.43	63.4	68.13	155.28	8.78	3.17	3.78	0.79
LCA 625 × Pusa Jwala	81.90	8.89	66.0	71.00	130.48	7.85	2.95	2.85	0.72
PKM 1 ×Arka Lohit	82.63	8.13	63.0	70.00	145.00	7.79	3.22	3.08	0.60
PKM 1 × K 1	85.80	9.65	62.9	69.00	165.35	9.40	3.51	3.50	0.74
PKM 1 × LCA 335	80.30	8.00	68.0	72.33	138.53	8.64	3.25	2.65	0.63
PKM 1 ×LCA 625	88.45	11.32	62.0	67.00	188.05	9.37	3.44	3.85	0.83
PKM 1× Pusa Jwala	74.60	10.00	62.6	67.93	154.19	8.46	3.32	3.82	0.78
Pusa Jwala ×Arka Lohit	58.13	9.73	65.0	68.33	145.15	7.45	3.17	2.48	0.62
Pusa Jwala × K 1	100.7	9.84	64.0	68.17	176.43	10.38	3.83	3.92	0.85

Th Rohini and Lakshmanan

Pusa Jwala × LCA 334	78.60	8.17	67.0	70.00	112.00	6.47	2.74	2.43	0.52
Pusa Jwala × LCA 625	78.32	7.82	62.4	69.49	148.76	7.95	3.06	3.21	0.73
Pusa Jwala × PKM 1	88.20	12.20	65.0	69.00	178.50	9.52	3.59	4.10	0.88
Parents mean	72.38	8.27	66.46	71.96	92.11	7.83	2.84	2.60	0.67
Hybrids mean	78.23	9.34	65.71	70.57	139.69	8.22	3.24	3.29	0.74
SE d	0.620	0590.	1.058	1.629	0.632	0.298	0.099	0.146	0.035
CD (P= 0.05)	1.236	1.178	2.111	3.249	1.260	0.595	0.199	0.292	0.071

	Seeds / pod	**Seed weight /pod (g)**	**Pericarp weight (g)**	**Pericarp thickness (mm)**	**1000 seed weight (g)**	**Fresh yield (g)**	**Dry yield (g)**
P_1 (Arka Lohit)	72.00	0.42	0.32	0.82	5.52	276.84	73.50
P_2 (K1)	78.00	0.25	0.28	0.69	5.15	221.64	49.68
P_3 (LCA 334)	70.00	0.36	0.26	0.71	5.32	201.50	55.18
P_4 (LCA 625)	84.00	0.45	0.33	0.87	5.73	332.45	81.11
P_5 (PKM1)	82.00	0.28	0.29	0.74	5.12	197.60	53.03
P_6 (Pusa Jwala)	68.00	0.39	0.29	0.81	4.26	208.80	64.80
Arka Lohit × K 1	73.10	0.46	0.34	0.85	5.65	420.94	98.28
Arka Lohit × LCA 334	87.50	0.43	0.35	0.88	5.71	657.20	143.10
Arka Lohit × LCA 625	82.43	0.47	0.34	0.86	5.61	379.92	102.28
Arka Lohit ×PKM 1	84.98	0.46	0.24	0.78	5.74	320.14	73.51
Arka Lohit × Pusa Jwala	78.75	0.44	0.31	0.83	5.62	327.61	85.63
K 1× Arka Lohit	93.30	0.46	0.47	0.96	6.75	750.53	157.25
K 1 × LCA 334	80.39	0.39	0.35	0.85	5.61	295.82	81.29
K 1 ×LCA 625	95.00	0.45	0.36	0.91	6.02	615.93	132.37
K 1 × PKM 1	87.45	0.30	0.33	0.84	6.75	525.73	110.85
K1 × Pusa Jwala	82.40	0.41	0.28	0.85	5.69	493.83	102.00
LCA 334 ×Arka Lohit	77.38	0.35	0.34	0.90	6.40	305.50	70.19
LCA 334 × K 1	83.43	0.33	0.36	0.79	5.81	279.67	66.53
LCA 334 ×LCA 625	80.00	0.36	0.30	0.83	5.60	295.10	70.85
LCA 334 × PKM 1	75.36	0.37	0.34	0.76	5.42	280.23	68.80
LCA 334 × Pusa Jwala	68.54	0.27	0.26	0.81	5.07	340.13	59.47
LCA 625 × Arka Lohit	91.63	0.43	0.33	0.88	6.51	435.33	99.27
LCA 625 × K 1	108.42	0.47	0.37	0.92	7.03	780.60	165.58
LCA 625 × LCA 334	87.58	0.35	0.32	0.83	5.76	360.13	81.83
LCA 625 ×PKM 1	92.95	0.45	0.34	0.87	5.89	526.40	120.67
LCA 625 ×Pusa Jwala	76.53	0.43	0.29	0.79	5.41	369.92	93.03
PKM 1 ×Arka Lohit	88.95	0.30	0.31	0.85	5.55	443.01	86.67

PKM 1 × K 1	86.43	0.29	0.31	0.79	5.84	575.22	121.48
PKM 1 × LCA 335	81.23	0.32	0.31	0.87	5.52	356.04	87.22
PKM 1 ×LCA 625	91.67	0.42	0.40	0.89	6.52	720.60	155.73
PKM 1× Pusa Jwala	89.63	0.39	0.36	0.91	6.25	585.50	125.72
Pusa Jwala ×Arka Lohit	68.54	0.24	0.30	0.88	5.30	358.94	89.23
Pusa Jwala × K 1	92.83	0.45	0.37	0.85	6.30	687.23	147.40
Pusa Jwala × LCA 334	62.47	0.27	0.25	0.76	5.42	272.16	58.13
Pusa Jwala × LCA 625	83.00	0.40	0.32	0.85	5.81	470.64	108.04
Pusa Jwala × PKM 1	96.50	0.42	0.34	0.80	6.21	728.83	156.54
Parents mean	75.66	0.35	0.29	0.77	5.18	239.80	62.88
Hybrids mean	84.27	0.38	0.32	0.84	5.89	465.29	103.96
SE d	3.272	0.010	0.009	0.022	0.229	8.299	3.294
CD (P= 0.05)	6.526	0.020	0.018	0.043	0.456	16.553	6.571

to inter allelic interactions of dominant types, it is not possible to fix such heterosis in homozygous condition in subsequent generations. The superiority of hybrids, particularly over better parent, is more useful in determining the feasibility of commercial exploitation of heterosis and also identifying the parental combinations capable of producing the highest level of transgressive segregants.

The range of heterosis, number of desirable significant heterotic crosses and best heterotic crosses over better parent and standard variety for 16 traits are presented in Table 3. Heterotic effects in negative direction are desirable for days to first flowering and days to 50% flowering. Hybrids Pusa Jwala ×LCA 625 (-8.19% and -8.37%) and PKM 1×LCA 625 **(**-7.46% and -6.94%) exhibited significant and the highest negative heterobeltiosis (HB) and standard heterosis (SH), respectively for days to first flowering and days to 50% flower initiation . A cross LCA 625 ×K 1 exhibited maximum significant SH for dry pod (18.12%) and fresh fruit yield (20%), branches per plant (22.12%), fruits per plant (13.37%), seeds per pod (25.63%), seed weight per pod (81.82%) and 1000 seed weight (11.71%) and HB for seeds per pod (29.09%). Similar finding were also reported by Patil *et al*. (2012), Chaudhary *et al*. (2013), Sharma *et al*. (2013) and Bhaumik *et al*. (2015).

The estimates and magnitude of various effects varied with cross combinations and characters. A comparative performance of the most six heterotic crosses for dry pod yield and yield components are presented in Table 4. The results revealed that crosses K 1×Arka Lohit, LCA 625×K 1, Pusa Jwala × K 1, Pusa Jwala ×PKM 1, K 1 × PKM 1 and Arka Lohit × LCA 334 exhibited higher percentages of heterobeltiosis. For Standard heterosis, the cross, K 1 × Arka Lohit, LCA 625 ×K 1, Pusa Jwala × K 1, Pusa Jwala× PKM 1, PKM 1× LCA 625 and Arka Lohit × LCA 334 depicted high heterotic effects. The crosses which had larger estimates of HB and SH for dry pod yield also exerted significant positive heterotic effects for number of fruits/ plant, fruit girth, fresh fruit weight. Therefore heterotic effects for dry pod yield were because of direct effects of number of fruits/ plant and could be outcome of interaction effects of other yield attributes likes fruit girth and fresh fruit weight. There was a reasonable ground to suggest that the heterotic expression for fruit yield per plant in all these six cross combinations was due to additive and additive × additive type of gene effects as the crosses involved one parent with best general combining ability. In such a situation the selection process could be deferred to later generations in order to exploit both additive and non-additive effects as suggested by Marame *et al*. (2009) and Sonam *et al*.(2015). Interestingly, cross combinations which showed the maximum better-parent heterosis for fruit yield per plant also exhibited significantly positive heterosis for number of fruits per plant, individual fresh fruit weight, individual dry pod weight, fruit girth and pericarp weight. Therefore, it appeared that better-parent heterosis for fruit yield per plant could ascribe mainly to heterosis observed for number of fruits per plant, individual fresh fruit weight, individual dry pod weight, fruit girth and pericarp weight. The nature and magnitude of better-parent heterosis helps in identifying the superior cross combinations and their exploitation to get better transgressive segregants. In the utilization of hybrid vigor in commercial crops, only that vigor in excess of the better parent is of significance**.**

Table 3. Range of heterosis, number of superior hybrids and significant hybrids in desired direction with three best heterotic hybrids over better parent (BP) and standard hybrid (SH) for 16 traits in chilli.

Characters studied	Heterosis over	Range of heterosis	Best heterotic hybrid	No. of hybrids
Plant height	BP	-20.39 to 25.05	Pusa Jwala × PKM 1	20
	SH	-29.54 to 22.06	Pusa Jwala × K 1	9
Branches per plant	BP	-25.37 to 92.86	Arka Lohit × LCA 334	6
	SH	-41.68 to 22.19	LCA 625 × K1	4
Days to first flowering	BP	-8.19 to 1.52	Pusa Jwala × LCA 625	18
	SH	-7.46 to 5.97	PKM 1 × LCA 625	16
Days to 50 % flowering	BP	-8.37 to 1.39	Pusa Jwala × LCA 334	13
	SH	-6.94 to 6.94	PKM 1 × LCA 625	18
Fruits per plant	BP	3.11 to 96.15	Pusa Jwala × PKM 1	30
	SH	-43.02 to 13.37	LCA 625 × K 1	6
Fruit length	BP	-33.67 to 21.43	Arka Lohit × LCA 334	6
	SH	-38.50 to 12.75	Pusa Jwala × 1	1
Fruit girth	BP	-21.65 to 48.32	Pusa Jwala × K 1	13
	SH	-24.85 to 16.08	K 1 × Arka Lohit	4
Fresh fruit weight	BP	-14.21to 65.86	Pusa Jwala × PKM 1	19
	SH	-36.06 to 13.97	K 1 × Arka Lohit	3
Dry pod weight	BP	-48.33 to -8.33	K 1 ×Arka Lohit	0
	SH	-36.99 to 11.79	K 1 × Arka Lohit	0
Pericarp weight	BP	-19.10 to 42.86	K 1 ×Arka Lohit	17
	SH	-31.43 to 33.33	K 1 × Arka Lohit	3
Pericarp thickness	BP	-24.33 to -4.33	K 1 ×Arka Lohit	1
	SH	-12.02 to 11.24	K 1 ×Arka Lohit	5
Seeds per pod	BP	-10.76 to 29.09	LCA 625 × K 1	12
	SH	-27.61 to 25.63	LCA 625×K 1	4
Seed weight per pod	BP	-44.53 to 81.82	LCA 625 ×K 1	14
	SH	-43.65 to 12.70	Arka Lohit ×LCA 625	8
Thousand seed weight	BP	-9.83 to 31.73	K 1 × PKM 1	11
	SH	-19.34 to 11.71	LCA 62× K 1	7
Fresh fruit yield /plant	BP	-11.23 to 248.72	Pusa Jwala ×PKM 1	29
	SH	-58.16 to 20.00	LCA 625 × K 1	5
Dry pod yield / plant	BP	-12.66 to 140.83	Pusa Jwala × PKM 1	24
	SH	-58.54 to 18.12	LCA 625 × K 1	5

Table 4. Manifestation of heterobeltiosis (BH) and standard heterosis (SH) of six top ranking crosses for different traits in chilli

F_1 hybrids	Plant height	Branches/ plant	Days to 1st flowering	Days to 50 % flowering	Fruits /plant	Fruit length	Fruit girth	Fresh fruit weight
Heterobeltiosis								
K 1 ×Arka Lohit	4.22**	35.56**	-5.88**	-7.53**	77.73**	5.17	21.04**	51.34**
LCA 625 × K 1	3.78**	62.96**	-5.88**	-6.28**	85.71**	-0.52	17.86**	34.88**
Pusa Jwala × K 1	20.96**	9.33	-5.88**	-6.05**	91.77**	15.30**	48.32**	61.85**
Pusa Jwala × PKM 1	25.05**	35.56**	-4.41**	-4.17	96.15**	5.78	15.81**	65.86**
K 1 ×PKM 1	-13.42**	10.78	-5.88**	-6.85**	50.47**	19.71**	12.90**	54.12**

Arka Lohit × LCA 334	23.95**	92.86**	-3.78**	-6.62**	77.35**	21.43**	21.11**	27.00**
Standard heterosis								
K 1 ×Arka Lohit	4.85**	1.64	-4.48**	-6.25**	1.76**	-8.58*	16.08**	13.97**
LCA 625 × K 1	4.78**	22.19**	-4.48**	-5,56**	13.37**	-2.72	3.41**	7.32**
Pusa Jwala × K 1	22.06**	-18.02**	-4.48**	-5.32**	2.58**	12.75**	11.89**	3.66
Pusa Jwala × PKM 1	6.91**	1.64	-2.99**	-4.17**	3.78**	3.44	4.97**	7.72*
PKM1 × LCA 625	7.21**	-5.67	-7.46**	-6.94**	9.33**	1.85	0.58	0.81
Arka Lohit × LCA 334	10.55**	12.14*	1.19	-0.93	1.05**	-7.64*	6.24*	2.44
F_1 hybrids	**Dry pod weight**	**Seeds / pod**	**Seed weight /pod**	**Pericarp weight**	**Pericarp thickness**	**1000 seed weight**	**Fresh yield**	**Dry yield**
Heterobeltiosis								
K 1 × Arka Lohit	-8.33**	19.62**	7.03**	42.86**	-4.33	22.28**	171.10**	113.95**
LCA 625 × K 1	-12.00**	29.07**	81.82**	30.23**	-8.00**	17.11**	135.12**	104.42**
Pusa Jwala × K 1	-15.00**	19.01**	76.62**	27.91**	-15.33**	22.17**	210.07**	126.77**
Pusa Jwala ×PKM 1	-11.67**	17.68**	48.24**	13.48**	-19.67**	21.07**	248.72**	140.83**
K 1 × PKM 1	-17.67**	13.10**	4.71	10.11**	-16.00**	31.73**	136.88**	109.13**
Arka Lohit x LCA 334	-16.00**	21.53**	20.37**	35.90**	-11.67**	-4.89	137.26**	93.38**
Standard heterosis								
K 1 ×Arka Lohit	11.79**	8.11*	8.73**	33.33**	11.24**	7.31	15.37**	12.17**
LCA 625 × K 1	7.32**	25.63**	11.11**	6.67**	6.98**	11.71**	20.00**	18.12**
Pusa Jwala × K 1	3.66	7.57	7.94**	4.76	0.16	0.61	5.64**	5.15*
Pusa Jwala × PKM 1	7.72**	11.82**	0.00	3.81	-1.32	-1.32	12.04**	11.67**
PKM 1 × LCA 625	0.81	6.22	0.00	15.25**	3.71	3.71	10.77**	11.09**
Arka Lohit LCA 334	2.44	1.39	3.17	0.95	-9.27*	-9.27*	1.03	2.08

Conclusion: Therefore, it can be concluded that heterosis breeding has an upper hand over the open pollinated cultivars as hybrids developed have the advantage of higher yields with uniform maturity, size and shape of the fruits**.** The results suggest that heterosis for fruit yield is obtained through components heterosis. Even the trifling hybrid vigor for individual yield components may have additive effects on yield. A perusal of *per se* performance, heterotic effect of hybrids revealed that hybrids LCA 625 × K 1 ranked first for all the approaches and found promising for commercial exploitation after its critical evaluation.

REFERENCES

Barhate, S.G., A.M. Musmade, M.N. Bhalekar and P.T. Patil (2013). Heterosis for green fruit yield and its contributing characters in chilli (*Capsicum annuum* L.). Bioinfolet, 10 :1506-1515.

Bhaumik, R., B. Patel, R. Patel, A. Parihar, Ramesh and P. Dixita (2015). Heterosis in CGMS and GMS based chilli (*Capsicum annuum* L.) green fruit yield, its components and quality traits. The Bioscan. 10:819-824.

Chadchan, D. (2008). Heterosis and combining ability in chilli. M.Sc. Thesis, University of Agricultural Sciences, Dharwad.

Chaudhary, A., R. Kumar and S.S. Solankey (2013). Estimation of heterosis for yield and quality components in chilli (*Capsicum annuum* L.). Afr. J. Biotechnol. 12: 6605-6610.

CPG (2013). Crop production techniques of horticultural crops. Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Page no: 69-71

Dod, V.N., P.B. Kale, R.V. Wankhade and B.J. Jadhao (1992). Heterosis in the intervarietal crosses of tomato (*Lycopersicon esculentum* Mill). Crop Res., 5: 134-139.

Gill, H.S., P.C. Thakur and T.C. Thakur (1973). Combining ability in sweet pepper (*Capsicum annuum* L. var. *grossum* Sandt.). Indian J. Agric. Sci., 43: 918-921.

Grafius, J.E. (1959). Heterosis in barley. Agron J. 51: 557-564.

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. Australian J. Biol. Sci. 9: 483-493.

Hazra, P., A.Chattopadhyay, K. Karmakar and Dutta (2011). Modern technology in vegetable production. New India Publishing Agency, New Delhi, India. p. 478.

Hosmani, M.M. (1993). Chilli crop (*Capsicum annuum*). Bharat Photo Offset Works. Dharwad.

Ince, A., M. Karaca and M. Onus (2010). Genetic Relationships within and Between Capsicum species. Biochem Genet. 48: 83-95.

Indian Horticulture Database (2014). National horticultural board. Ministry of Agriculture, Government of India.

Jagtap, P.P., U.S. Shingane and K.P. Kulkarni (2015). Economics of Chilli Production in India. Afr J. of Basic & Applied Sci, 4 : 161-164.

Karthik, M.N. (2006). Line x tester analysis for heterosis and combining ability in chillies (*Capsicum annuum* l.) for yield and quality traits. M.Sc. Thesis, Tamil Nadu Agric. Univ., Coimbatore, India.

Kumar, R. (2005). Heterosis and combining ability studies in chilli (*Capsicum annuum* L.) M.Sc. Thesis, Department of Genetics and Plant breeding, College of Agriculture, University of agricultural sciences, Dharwad.

Mackey, I. (1976). Genetics and evolutionary priniciples of heterosis. In: Heterosis of plant breeding, Proc.8th Congr. Eucarpia. Elsevier, P 17-33.

Marame, F.L., C. Dessalegne, Fininsa and R. Sigvald (2009). Heterosis and heritability in crosses among Asian and Ethiopian parents of hot pepper genotypes. Euphytica, 168:235-247.

Mather, K. (1955). The genetical basis of heterosis. Proc. Royal Soc. London, 144: 143-150.

Munish, S. (2012). Heterosis and gene action studies for fruit yield and horticultural traits in chilli (*Capsicum annuum* var. *annuum* L.). Ph.D. Thesis. Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya. Palampur. India.

Murthy, N.S.R. and B.S. Murthy (1962). Natural cross pollination in chilli. *Andhra Agric. J.* 9:161-165.

Panse, V.G. and P.V. Sukhatme. (1957). Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi. pp. 97.

Patel, M.P., A.R. Patel, J.B. Patel and J.A. Patel (2010). Heterosis for green fruit yield and its components in chilli (*Capsicum annuum* var. *longicum*) over environments. Elect. J. of plant breeding., 1: 1443-1453.

Patil, B.T., M.N. Bhalekar and K.G. Shinde (2012). Heterosis studies in chilli (*Capsicum annuum* L.) for earliness, growth and green fruit yield. Veg. Sci. 39: 73-75.

Prasath, D. and V. Ponnuswami (2008). Heterosis and combining ability for morphological, yield and quality characters in paprika type chilli hybrids. Indian J. Hort, 65: 441-445.

Rani, A. (2002). Studies on the development of F_1 hybrids in chilli (*Capsicum annuum* L.) with high yield and resistance to anthracnose disease. Ph.D. Thesis, Tamil Nadu Agric. Univ., Coimbatore, India.

Reddy, M.G. (2006). Heterosis and combining ability in chilli (*Capsicum annuum* L.). M.Sc. Thesis. Department of Genetics and Plant breeding, College of Agriculture, University of agricultural sciences, Dharwad.

Rego, E.R., M.M. Rego, F.L. Finger, C.D. Cruz and D.A. Casali (2009). Diallel study of yield components and fruit quality in chilli pepper (*Capsicum baccatum*). Euphytica, 168: 275-287.

Sathiyamurthy, V.A. (2002). Studies on the development of F_1 hybrids in chilli (*Capsicum annuum* L.) with high capsaicin, oleoresin and yield. Ph.D. Thesis, Tamil Nadu Agricultural University, Coimbatore, India.

Savitha, B.K. (2011). Studies on heterosis, combining ability and generation mean analysis for yield and thrips tolerance in chilli (*Capsicum annuum* L.). Ph.D. Thesis, Tamil Nadu Agric. Univ., Coimbatore, India.

Sharanakumar, H., M.K. Naik and M. Anantachar (2011). Drying characteristics of *Byadagi* chilli (*Capsicum annuum* L.) Using solar tunnel dryer. J. Agric. Food. Tech. 1: 38-42.

Sharma,V.K., S. Puneth and B.B. Sharma (2013). Heterosis studies for earliness, fruit yield and yield attributing traits in bell pepper. Afr. J. of Agric. Res. 8: 4088-4

Sitaresmi, T., S. Sujiprihati and M. Syukur (2010). Combining ability of several introduced and local chilli pepper (*Capsicum annuum* L.) genotypes and heterosis of the off springs J. of Agro. Indonesia, 38: 212-217.

Snedecor, G.W. and C.W.G. Cochran (1967). Statistical methods. The Iowa State University Press, IOWA, U.S.A.

Sonam S., S. Hussain, N. Jabeen and Padma Lay (2015). Heterosis studies for earliness, fruit yield and yield attributing traits in chilli (*Capsicum annuum* L.). The Bioscan. 10 : 813-818.

Sood, S. and N. Kumar (2010). Heterotic expression for fruit yield and yield components in intervarietal hybrids of sweet pepper (*Capsicum annuum* L. var. *grossum* Sendt.). SABRAO. J. of Breeding and Genet., 42: 106-116.