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RESEARCH ARTICLE

Identification of best heterotic cross combination for oil yield and its quantitative traits in basil (*Ocimum basilicum*).

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Abstract

Heterosis and inbreeding depression were studies for oil yield and its contributing traits were through generation mean analysis to identify the best heterotic cross combination. The improvement in oil yield is the prime objective of breeding programme of basil because it is oil as well as ornamental and medicinal crop thus, at the time of selection; oil yield received maximum attention of plant breeder for the selection of a genotype. From the present investigation, the cross C_3 (EC 388896 x IC 369247) showed significant and desirable heterobeltios and minimum inbreeding depression was recognized as the best heterotic cross for oil yield, fresh herb yield and dry herb yield. The cross C_2 (EC 387893 x IC 326711) exhibited significant and positive heterosis for all three types for plant height and showed significant standard heterosis for plant height, number of branches per plant, days to flowering, chlorophyll content, and oil content. However, at present time implication of heterosis breeding in basil for oil yield improvement is not possible but in future inclusion of lines with good combining ability in a national hybrid basil breeding programme may offer genetic improvement for higher oil yield and its component traits. These individual crosses may be exploited further in future in heterosis breeding programme for the improvement of oil yield and other contributing traits according to the objective of breeding programme.

INTRODUCTION

The word 'basil' was derived from the Greek word 'Basilica' which means the royal plant. Genus *Ocimum* is widespread over Asia, Africa and Central Southern America. Basil was probably first put to cultivation in India. Today, basil is cultivated in many Asian and Mediterranean countries; main exporters (for the European market) are France, Italy, Morocco and Egypt. There is also significant basil production in California It appears to have its center of diversity and origin in Africa, India and Indonesia. It was probably introduced in Europe by Greeks and Romans, coming from the commercial routes which crossed the Middle East. In England was introduced around the sixteenth century, whereas in America will be introduced in the seventeenth century. Heterosis measured as mean superiority of F_1s over their better parents or mid parent or the best commercial variety and thus, it is rated to be an important parameter in such studies. This phenomenon has extensively been exploited in cross-pollinated as well as self pollinated crops.

Heterosis breeding is the most successful approach amongst various technological options available for the improvement in crop productivity. Heterosis study can also be used for getting information about the increase or decrease of F_1s over better parent (heterobeltiosis). However, selection of superior parents represent the major step in development of high yielding new cultivars and the identification of superior hybrid combinations is another fundamental issue in hybrid breeding. The procedure has successfully been used on an extensive scale in India in various crops such as sunflower, soybean and medicinal crops. Moreover, the study of heterosis helps the breeders in eliminating the low productive cross combinations in F_1s generation itself. The rejection of crosses, which shows no heterosis, would helps the breeder to concentrate the attention on few but high productive crosses. Singh *et al*., (2004) suggested that especially heterosis over better parent (heterobeltiosis) can be useful for determining true heterotic cross combinations. The magnitude of heterosis particularly for yield having paramount importance and if the heterosis is practically and economically feasible, it can help to reach high oil levels and thereby higher output of oil in Indian basil. In fact, hybrid varieties will replace homozygous plant in many self-pollinated crops and heterozygous population in most cross pollinated crops in the next 25 years. The estimates of heterosis and inbreeding depression together provide information about the type of gene action involved in the expression of various quantitative traits. The high heterosis is followed by inbreeding depression; it indicates the presence of non-additive gene action (dominance and epistasis). The performance is the same in F_1 and $F_{2;}$ it reveals presence of additive genes. If the heterosis is negative in F_1 and there is increase in F_2, it again indicates presence of additive gene action. The genes with lack of dominance will not exhibit heterosis in F_1 but may show increase in performance in F_2 due to fixation of gene i.e. additive gene action. If some genes have dominance in one direction and some in other direction there will be no heterosis due to mutual cancellation effects of such genes. The production of new types of basil oils rich in specific chemical constituents that have application in new products will require a close relationship with both essential oil brokers and end-processors. The major objective of the present study was to identify the best cross combination in F_1 hybrids and to know the possibility of exploiting heterosis in hybrid breeding programme Dubey and Singh, (1968). The second aims of this investigation were to find out the relationship between high heterotic cross combination in F_{1s} and superior segregants in F_2 population. The combine study of heterosis and inbreeding depression can also give an idea about the genetic control of a particular character.

MATERIALS AND METHODS

The present investigation was conducted at the Research Farm, Department of Genetics and Plant Breeding (Formerly, Agricultural Botany), Ch. Charan Singh University, Meerut during 2007-09. Experimental material of this study was comprised of thirteen accessions of Basil namely, EC-388788, EC- 387893, EC-388896, EC-388887, EC-338785, EC-387837, IC-369247, IC-344881, EC-333322, IC-326711, IC-386833, IC-370846 and IC-326735, obtained from NBPGR, New Delhi. The parents were intercrossed to produce seven crosses, namely: (I) EC-388788 / IC-333322, (II) EC-387893 / IC-326711, (III) EC-388896 / IC-369247, (IV) EC-388887 / IC-386833, (V) EC-387837 / EC-338785, (VI) IC-369247 / IC-370846 and (VII) IC-344681 / IC-326735. All the agronomic practices were followed to raise a healthy and normal crop. The crosses were made between the selected parents on the basis of their mean performance in February- May, (2008). The observation were recorded on thirteen characters namely fresh herb yield (g), dry herb yield (g), oil content (%), days to maturity, plant height (cm), number of branches, days to flowering, leaf length (cm), leaf width (cm), leaf area (cm^2), number of inflorescence, length of inflorescence (cm) and chlorophyll content (%). Seeds of each cross were harvested and threshed, separately, which constituted F_1 seeds.

The essential oil was extracted from the air dried herb by hydro-distillation using Clevenger's apparatus for 2.30 hours. Chlorophyll content in the leaves of the parent and progeny was estimated by the method suggested by Arnon (1949). The extract was centrifuged at 1000Xg for a min and supernatant collected. Final volume was made up to 5ml and absorbance was read at A $_{645}$ NM and at $_{663}$ NM or spectrophotometer. Following formula was used for quantification of chlorophyll content. Mg total chlorophyll / gram tissue = 20.2 (A_{645}) +8.02 (A_{663}) *V/1000*W.
Where, A = absorption me at specific wavelength

V = final volume of chlorophyll extract in 80% acetone

W = fresh weight of tissue extracted.

The mean values of parents and F_{1s} cross combinations were used for the estimation of heterosis over standard parent, better parent and mid parent. The magnitude of heterosis was estimated by commonly used statistical software (INDOSTAT 7.5). Analysis of variance was performed to test the significance of difference among the genotypes for the characters studied, as suggested by Panse and Sukhatme, (1967). The percent increase or decrease of F_1 hybrids over standard parent, better parent and mid parent was calculated by using the formulae of Fonseca and Patterson (1968).

Standard heterosis (%) = $\frac{F1-SP}{SP} \times 100$

Heterobeltiosis (%) = $\frac{F1-BP}{BP} \times 100$

Average heterosis (%) = $\frac{F1-MP}{MP} \times 100$

F_1 = Mean performance of F_1 hybrid
SP = Mean performance of standard parent
BP = Mean performance of better parent
MP = Mean mid-parental value i.e. (P1+P2)/2

Test of significance

The 't' test was manifested to determine whether F_1s means were statistically different from standard parent, better parent and mid parent means. The heterosis was tested by least significant difference at 5 per cent and at 1 per cent level of significance for error degrees of freedom as follows the formulae suggested by Panse and Sukhatme (1961).
For testing heterosis over mid parent; SE (diff.) (MP) = 3Me/2r
For testing heterosis over standard check; SE (diff) (SC) = 2Me / r
Where,
Me = Error variance
r = Number of replications

Results and Discussion

Analysis of variance: The analysis of variance for all the thirteen traits recorded for 13 parents and F_1's in the study are presented in (Table 1). The mean squares due to treatment of all the traits were highly significant except to leaf length and chlorophyll content thereby suggesting the presence of sufficient genetic variability in the materials under study.

Estimates of heterosis and inbreeding depression

The estimates of heterosis over better parent (Heterobeltiosis), over the best cultivar (Cultivar- EC 388788) also called standard heterosis and mid-parent heterosis also called average heterosis and also inbreeding depression for thirteen traits in seven cross of basil are presented in (Table 1).

Plant height: The estimates of heterobeltiosis were positive significant in cross C_1 and C_2 while cross C_5 and C_6 showed negative significant. The range of heterobeltiosis varied from (-20.39) cross C_6 to (25.64) cross C_2. Positive heterobeltiosis for plant height were earlier reported by Kumar *et al*., 1999 and Radhika *et al*., 2001 in all crosses of sunflower. This may be due to inbreeding depression during inbreed line development which resulted in reduced plant height of inbreed lines**.** The range of standard heterosis varied from (-10.59) cross C_1 to (30.61) C_3. The estimates of positive significant standard heterosis in cross C_2, C_3 and C_5 whereas negative significant standard heterosis showed in cross C_1. Our findings are similar to other reporter who also found negative and positive heterosis (Prouda and Sachan 2003 and Goncearive Maria, 2008) it mean that negative and positive heterosis in hybrids could be expected whenever crossing two inbreed line and hybrid would always be taller than parent lines. The range of average heterosis varied from (-11.77) cross C_7 to (35.59) cross C_2. The estimates of positive significant average heterosis in cross C_1, C_2 and negative significant average heterosis showed cross C_7. In case of inbreeding depression the range varied from (-38.83) C_3 to (32.13) C_1, in which three crosses namely C_1, C_2 and C_3 exhibited highly significant inbreeding depression in which C_1 and C_2 highly positive and C_3 and C_7 highly negative significant inbreeding depression.

Number of branches: The estimation of heterobeltiosis was significant positive in three crosses C_4, C_2 and C_7. The range of heterobeltios varied from (-2.78) cross C_1 to (2.13) in cross C_4 and one cross showed significant negative heterobeltiosis in cross. The estimates of standard heterosis showed highly significant and positive in all seven crosses. The maximum range of standard heterosis (12.21) in cross C_4 to (49.25) in crosses C_6. It would be examined whether the positive heterosis in these crosses is really associated with oil yield and other contributing traits. The range of average heterosis varied from (-1.20) cross C_1 to (2.20) C_3, the estimates of maximum average was observed in cross C_3. Out of seven crosses only three crosses, namely C_2, C_6 and C_1 in significant inbreeding depression with range of (2.37) cross C_2 to (-1.63) cross C_1. The cross C_2 and C_6 showed negative significant and C_1 showed positive significant inbreeding depression. Therefore number of branches per plant is one of the major yields contributing trait, hence more number of branches per plant are desirable. The presences of significant positive heterobeltiosis and standard heterosis for branches per plant indicate that these crosses have potential of their use for developing high yielding genotypes. The presence of high levels of average heterosis indicates a considerable to embark on breeding of hybrid cultivars in basil species. In the present study those crosses showing non-significant heterobeltiosis, it is due to partial over dominance. Our finding are similar to earlier reports of Pourda and Sachan 2003; Satwinder *et al*., 2000; Jorgensen *et al*., 1995; Fary *et al*., 1997 and Hu *et al*., 1996 found high positive heterosis for number of branches and other yield contributing traits.

Days to flowering: The estimates of heterobeltiosis for this trait varied from (-7.07) cross C_6 to (6.20) cross C_4 percent. The crosses, C_2 and C_6 show negative significant and C_4 showed positive significant heterobeltiosis for days to flowering. The range of standard heterosis was observed from (-6.88) cross C_4 to (6.55) cross C_2. The estimates of standard heterosis showed significant in C_2 and C_4; including one cross, namely C_2 positive significant and cross C_4 show negative standard heterosis. Only one cross C_2 showed negative significant average heterosis as well as inbreeding depression. Days to flowering played an important role for the improvement of oil yield and its contributing traits in basil. The cross number C_2 is showing maximum heterobeltiosis out of seven crosses. Maximum negative significant heterosis for days to flowering were recorded in above cross (C_2) also reported by Kandhola *et al*., (1995). It means that hybrids normally flowered later than inbreed lines with some exception. The reason could be that hybrids had vigorous plant as compared to inbreed lines and weaker plants normally tended to flower earlier than vigorous plants.

Leaf length: The estimates of heterobeltiosis for this trait, one cross C_4 showed negative significant. The estimates of standard heterosis only five traits crosses, namely C_1, C_2, C_3, C_4 and C_5 showed negative significant and remaining crosses showed positive significant. The range of standard heterosis -18.84 crosses C_4 to (-11.11) cross C_5. The range of percent of average heterosis varied from (-0.65) cross C_2 to (0.590) cross C_5. Out of seven crosses, only two crosses namely, C_2 and C_5 were showed negative significant heterosis over mid parent. The estimate of inbreeding depression C_1 and C_2 were showed negative and C_3 were showed positive significant for this trait. Positive value of heterosis is desirable for this trait. Same this, our findings the positive heterosis for leaf length also reported by Shivani *et al*., (2011).

Leaf width: The estimates of heterobeltiosis were found non-significant in all cross combinations in F_1 generation. The range of standard heterosis varied from (-17.32) cross C_5 to (12.37) cross number C_2. All the seven crosses were exhibited significant heterosis over standard parent. There are three crosses, namely C_2, C_3 and C_7 showed positive significant and remaining crosses showed negative significant standard heterosis as percent for leaf width. In case of inbreeding depression C_1, C_2 showed negative significant and C_3 showed positive significant. Positive value of heterosis is desirable for this trait also earlier reported by Shivani *et al*., (2011).

Leaf area: Positive values of heterosis are desirable for this trait for the improvement of oil content (Singh *et al*., 2004 and Amin *et al*., (2014). The positive and significant heterobeltiosis were showed in crosses C_7, C_6 while the cross C_5 showed negative significant. The range of heterobeltiosis for this traits varied from (-3.20) cross C_5 to (2.54) cross C_7. The estimates of standard heterosis ranged from (-20.50) cross C_5 to (-1.190) cross C_6. All the seven crosses are showed significant standard heterosis except to cross C_2. Out of the seven crosses only five crosses C_5, C_7, $C_{4,}$ C_7 and C_6 showed negative significant and cross C_3 were showed positive significant for standard heterosis. In case of average heterosis only two crosses showed significant cross C_7 positive and cross C_5 showed negative significant. The estimates of inbreeding depression ranged varied from (-1.60) cross C_3 to (1.45) cross C_6 percent and that of only three crosses showed significant values for this traits, one cross C_6 showed positive and two cross C_7 and C_2 showed negative significant.

Number of inflorescence: The estimates of heterobeltiosis were significant in four crosses C_2, C_3, C_4 showed significant negative heterobeltiosis, while C_7 showed significant positive heterobeltiosis. The range of heterobeltiosis for this trait varied from (-199.00) cross C_4 to (2.47) cross C_7, it would be examined whether the positive heterosis in these crosses is really associated with oil content. In case of standard heterosis estimates were found the entire crosses showed negative significant. In case of mid parent heterosis four crosses were showed significant namely, C_1, C_2 showed positive significant and two crosses C_3, C_4 showed negative significant were estimates. Out of seven crosses, the cross C_4 are showed negative significant inbreeding depression in percent. Number of inflorescence is more important traits in yield and its attributes traits in basil. The large number of inflorescence is directly the yield and important for obtaining the high yield. The hybrids that showed heterosis for higher number of inflorescence, plant height and oil content have been used to develop productive hybrids varieties that ensure an increased inflorescence and essential oil production were earlier reported by Gonceariue Maria, (2008).

Length of inflorescence: The estimates of percent heterosis over better parent for this traits ranged from (-7.31) C_4 to (11.08) C_1 with the characteristics that all the crosses exhibited significant heterobeltiosis. The positive values of heterobeltiosis were observed in crosses C_1, C_2, C_5 and C_7, while remaining crosses namely, C_3, C_4 and C_6 showed negative significant. The estimates of standard heterosis varied from (-58.79) C_5 to (31.71) C_7 percent. Out of seven crosses, four crosses namely, C_1, C_2, $C_{3,}$ and C_5 showed significant negative and rest of three crosses C_4, C_6 and C_7 showed significant positive standard heterosis. Out of seven crosses, three crosses namely, C_1, C_2 and C_7 exhibited highly significant positive and two crosses C_3 and C_5 negative significant heterosis over mid parent. In case of inbreeding depression all the seven crosses, showed significant, C_1, C_2, $C_{3,}$ C_5, and C_6 showed positive significant and two cross C_4 and C_7 negative significant inbreeding depression. The positive value of length of inflorescence is directly effect on yield traits and the large number inflorescence obtained high yielding. Highly significant positive and negative heterosis (Standard heterosis, heterobeltiosis and mid-parent heterosis) and inbreeding depression for this trait have been earlier reported by Gonceariue Maria, (2008).

Days to maturity: Out of seven crosses, three crosses, namely C_2, C_3 and C_4 exhibited highly negative significant and the cross C_7 showed positive significant heterobeltiosis for this trait. In case of standard heterosis all the seven crosses showed highly negative significant. The range of standard heterosis varied from (–25.17) in C_7 to (-7.32) in C_3. The estimates of mid parent heterosis only four crosses, namely C_1, C_2, showed positive and C_3 and C_4 showed negative significant. For this trait all crosses did not show any significant except to cross C_4 showed highly negative significant inbreeding depression. The algebraic signs of heterobeltiosis and standard heterosis suggested that day to maturity of hybrids have increased compared to parent with longer maturity period but decreased when compared to commercial cultivar. Significant and positive heterosis for this trait was earlier reported by Singh, (2003).

Chlorophyll content: Out of seven crosses, only three crosses namely C_6 and C_7 positive and C_3 showed negative significant heterobeltiosis. The estimates of standard heterosis all crosses showed highly positive significant, the range of from (4.16) C_1 to (8.33) C_2 percent. The estimates of mid-parent heterosis only one cross C_3 showed negative significant results. The results for inbreeding depression same as above C_3 cross showed positive significant. The photochemical activity of isolated mesophyll chloroplasts and the content of photosynthetic pigments in leaves of plant were compared with the aim to him to find out the possible changes in the relationship between parents and hybrids, and determine the genetic base of heterosis in F_1 generation. Strong decrease in the content of chlorophylls was observed at low growth temperature. In present study all crosses showed highly significant positive standard heterosis for this trait. We know that the positive heterosis for this traits desirable. A positive heterotic effect in F_1 hybrids has been found for various photosynthetic characteristics by several reporters, Fousova and Avratovscukova, (1967)), Monma and Tsunoda, (1979)). The exact, causes of heterosis are still unknown. It has been speculated that heterosis could be associated with the possible ability of hybrids to better adapt to diverse, changing, and often unfavorable environments.

Fresh herb yield and Dry herb yield: The estimates of heterobeltiosis for fresh herb yield four crosses C_1, C_2, C_3 and C_7 showed highly positive significant and only one cross C_4 showed negative significant. In case of standard heterosis are not showing any significant in all the seven crosses. The estimates of mid parent heterosis in all the seven crosses, four crosses C_1, C_3 and C_7 showed highly positive and only one cross C_6 showed negative significant heterosis. In case of inbreeding depression six crosses C_1, C_2, C_4 and C_7 were showed positive and C_3 and C_5 showed negative significant. The estimates of heterobeltiosis for dry herb yield three crosses were significant C_1, C_3 showed positive and C_6 showed negative significant. All crosses did not show any significance in case of standard heterosis. In case of mid parent heterosis and inbreeding depression only three crosses showed significant out of seven crosses, two cross C_1 and C_3 showed positive and C_2 negative significant. Heterosis for forage yield is a common phenomenon in highly heterozygous cross pollination crops by Brummer, (1999). The heterotic effect observed for forage yield was of a similar magnitude to that typically observed in other forage crops. Similar finding to this result were also earlier reported by Knowles, (1920), Foster, (1971), Moutray and Frakes, (1973). In my present studied among all crosses some showed highly positive and other negative significant effect.

Oil content: The estimates of heterobeltiosis in four crosses namely C_1, C_3 and C_6 showed positive and C_4 showed negative significant. In case of standard heterosis all crosses showed highly positive significant. The range of standard heterosis varied from (24.67) C_4 and C_6 to (57.25) C_7 were estimates. In case of mid parent only one cross C_6 were showed positive significant and C_1, C_2, C_4 and C_7 showed positive significant and C_3, C_6 showed negative significant in case of inbreeding depression. The most important attribute of a cultivar from economic point of view is its yielding ability. Similar results were earlier reported by (Gupta. 1994 and Nation *et al.*, 1992) highly significant positive heterosis effect for oil content. Oil content is more important traits in basil also reported by (Kandhola *et al.* 1995; Kumar *et al.* 1999; Radhika *et al*. 2001 and Goncearіue 2004). The results of the present study also confirm the genetic causes of heterosis that predominance of non-additive gene effects lead to expression of heterosis as above traits which exhibited high degree of heterosis were found to show predominance of non-additive gene effects Exploitation of heterosis is considered one of the outstanding achievements of plant breeding. Utilization of heterosis through hybrid is more attractive than conventional plant breeding methods. Estimation of heterosis over the better parent (heterobeltiosis) may be useful in identifying true heterotic cross combinations basil breeders dealing with various aspects of hybrid basil found that the standard heterosis for oil yield.

Conclusion:

The improvement in oil yield is the prime objective of breeding programme of basil because it is an oil as well as ornamental crop thus, at the time of selection; oil yield received maximum attention of plant breeder for the selection of a genotype. From the result of present investigation, it may be concluded that cross C_3 showed significant and desirable heterobeltiosis and minimum inbreeding depression was recognized as the best heterotic cross for oil yield, fresh herb yield and dry herb yield. The cross C_2 exhibited significant and positive heterosis for all three types for plant height and showed significant standard heterosis for plant height, number of branches per plant, days to flowering, chlorophyll content, and oil content. These individual crosses may be exploited in heterosis breeding programme for the improvement of oil yield and other contributing traits according to the objective of breeding programme.

Table 1: Analysis of variance for thirteen quantitative characters in 13 parents and seven F_1s crosses in basil (*Ocimum basilicum*).

SOV	d. f.	PH	NB	DF	LL	LW	LA	NI	LI	DM	CH	FHY	DHY	OC
Replication	2	44.31	1.52	11.59	0.30	0.14	1.71	0.75	0.50	1.06	0 .04	18848.00	3966.00	.020
Treatment	40	633.5**	5.49**	40.4**	0.61	0.16	9.24**	391.30**	48.82*	100.04*	0.09	390958.40**	103503.00**	2.63**
Error	80	20.43	0.88	14.8	0.08	.030	0.27	0.94	0.36	2.17	0.03	9650.60	9887.36	0.04

PH = Plant height, NB = Number of branches, DF = Days to flowering, LL= Leaf length, LW = Leaf width, LA = leaf area, NI =Number of inflorescence, LI = Length of inflorescences, DM =Days to maturity, CH =Chlorophyll content, FHY = Fresh herb yield, DHY = Dry herb yield, OC =Oil content,

Table 2: Range of heterobeltiosis (HB), standard heterosis (SH), average heterosis (MP), inbreeding depression (ID) and number of desirable crosses for thirteen quantitative characters in seven crosses of basil (*Ocimum basilicum*).

Trait	Range of heterosis				Number of desirable crosses	
	HB	SH	MP	ID	HB	SH
Plant height	-2.10 - 25.64	-29 - 30.61	-2.81 - 35.59	-0.55 - 32.13	2	3
Number of branches	-0.50 - 1.83	12.21 - 49.25	-0.28 - 2.20	-0.03 - 1.63	3	7
Days to flowering	-0.42 - 6.20	-0.86 - 6.55	-0.40 - 5.58	-0.07 - 18.67	2	1
Leaf length	-0.08 - 0.51	1.20 - 18.84	-0.22 - 0.59	0.11 - 0.76	1	2
Leaf width	-0.02 - 0.51	-0.99 - 12.37	-0.15 - 0.41	0.07 - 0.32	1	2
Leaf area	0.22 - 2.54	0.14 - 5.00	-0.09 - 1.92	0.07 - 1.45	2	1
No. of inflorescence	-30.40 - 30.33	-25.55 - 31.26	-12.14 - 37.17	12.38 - 42.99	4	3
Length of inflorescence	-1.90 - 11.09	-58.79 - 31.71	0.47 - 11.75	-1.41 - 14.24	3	7
Days to maturity	-19.00 - 2.47	-25.17 - 9.74	-19.00 - 10.93	-22.50 - 1.87	1	……
Chlorophyll content	-8.13 - 3.00	1.38 - 8.33	-9.27 - 0.09	-0.05 - 1.00	2	7
Fresh herb yield	-183.33 - 177.33	15.56 - 153.32	-331.52 - 365.83	-981.67 - 70.00	4	…….
Dry herb yield	-230.00 - 460.00	38.50 - 131.72	-315 - 483.50	-370.00 - 350.00	2	…….
Oil content	-0.57 - 0.70	24.67 - 57.25	-0.05 - 1.30	-1.00 - 1.20	3	7

Table 3: Estimates of heterobeltiosis (HB), standard heterosis (SH), average heterosis (MP) and inbreeding depression (ID) for thirteen traits in seven crosses of basil (*Ocimum basilicum*).

	1.Plant height				2. Number of branches				3.Days to flowering				4.Leaf length			
Cross	HB	SH	MP	ID	HB	SH	MP	ID	HB	SH	MP	ID	HB	SH	MP	ID
C1	19.77**	-10.59**	28.27**	32.13**	-2.78**	42.06**	-1.20*	1.63*	1.50**	2.18	5.58	1.8	-0.18	-4.10**	-0.27	-0.66**
C2	25.64**	26.81**	35.59**	24.78**	1.83**	44.77**	0.28	-2.37**	-15.00**	6.55*	-14.93**	-18.67**	-0.28	-2.22**	-0.65*	-0.82**
C3	-2.10	30.61**	-5.70	-38.83**	1.28	39.34**	2.20**	-0.2	1.33	-0.86	0.4	-2.67	-0.17	-5.55**	-0.2	0.76**
C4	2.83	0.29	-5.57	2.00	2.13**	12.21**	1.00*	0.81	6.20*	-6.88*	3.47	1.46	0.51*	-18.84**	0.24	0.42
C5	-19.95**	20.00**	-7.75	0.55	1.27	18.45**	1.29**	0.03	3.37	2.09	1.37	0.46	-0.28	-11.11**	-0.59*	0.11
C6	-20.36**	0.95	-2.81	8.70**	0.5	49.25**	-0.65*	-1.87*	-7.07**	2.08	-4	-1.4	0.29	1.93**	0.22	0.22
C7	-4.53	4.09	-11.77**	-22.10**	1.77**	47.48**	1.13*	0.27	0.42	3.27	-0.02	-0.07	0.09	1.20**	0.31	-0.36
C.D. at 5%	7.23	7.23	8.88	7.23	1.5	1.5	0.55	1.5	6.15	6.15	7.54	6.15	0.45	0.45	0.55	0.45
C.D. at 1%	9.50	9.50	11.61	9.50	1.97	1.97	0.72	1.97	8.08	8.08	9.89	8.08	0.66	0.66	0.72	0.66
	5. Leaf width				6. Leaf area				7. Length of inflorescence				8. Days to maturity			
C1	-0.18	-4.10**	-0.27	-0.66**	-0.52	-3.21**	-0.10	0.07	11.08**	-15.63**	11.75**	14.24**	0.47	-8.40**	10.93**	0.78
C2	-0.28	-2.22**	-0.65*	-0.82**	0.22	0.14	-0.29	-1.43**	11.04**	-29.91**	7.60**	2.27**	-4.57**	-9.21**	4.68**	-0.20
C3	-0.17	-5.55**	-0.20	0.76**	-0.26	5.00**	-0.09	0.05	-3.83**	-1.22*	-1.85**	3.50**	-8.13**	-7.32**	-9.27**	1.00
C4	0.51*	-18.84**	0.24	0.42	0.03	-16.32**	-0.78	0.61	-7.31**	26.61**	-0.95	-1.41**	-19.00**	-8.93**	-19.00**	-22.50**
C5	-0.28	-11.11**	-0.59*	0.11	-3.20**	-20.50**	-3.20**	0.09	2.85**	-58.79**	-1.68*	1.81**	-0.37	-9.74**	0.98	1.30
C6	0.29	1.93**	0.22	0.22	2.50**	-1.19*	-0.21	1.45**	-1.90**	1.83**	0.47	3.01**	0.07	-9.74**	0.33	1.87
C7	0.09	1.20**	0.31	-0.36	2.54**	-20.14**	1.92**	-1.60**	4.09**	31.71**	4.03**	-3.11**	2.47*	-25.17**	1.90	0.17
C.D. at 5%	0.45	0.45	0.55	0.45	0.83	0.83	1.01	0.83	0.90	0.90	1.54	0.90	2.35	2.35	2.88	2.35
C.D. at 1%	0.66	0.66	0.72	0.66	1.08	1.08	1.31	1.08	1.23	1.23	1.76	1.23	3.09	3.09	3.78	3.09
	9. No. of inflorescence				10 Chlorophyll content				11. Fresh herb yield				12. Dry herb yield			
C1	0.47	-8.40**	10.93**	0.78	0.05	4.16**	-0.04	0.06	185.00**	18.75	365.83**	570.00**	460.00**	100.59	472.12**	350.00**
C2	-4.57**	-9.21**	4.68**	-0.20	-0.08	8.33**	-0.07	0.04	170.00**	85.26	116.67	493.00**	-83.33	44.07	-315.00**	-370.00**
C3	-8.13**	-7.32**	-9.27**	1.00	-8.13**	6.94**	-9.27**	1.00**	1743.33**	15.56	1388.33**	-981.67**	560.00**	101.79	483.50**	-314.67**
C4	-19.00**	-8.93**	-19.00**	-22.50**	-0.02	2.77**	-0.04	0.02	-183.33**	120.	160.00	247.28**	50.33	131.72	112.17	-107.89
C5	-0.37	-9.74**	0.98	1.30	-0.01	2.77**	-0.04	0.02	-147.28	153.32	160.00	-247.28**	-55.24	60.71	-107.55	9.30
C6	0.07	-9.74**	0.33	1.87	0.91**	8.33**	0.06	-0.05	133.67	76.49	-311.52**	-69.29	-230.00**	38.50	-192.50	-46.67
C7	2.47*	-25.17**	1.90	0.17	3.00**	8.33**	-0.01	0.02	760.00**	132.28	225.00*	131.67**	106.62	69.75	190.00	160.00
C.D. at 5%	2.35	2.35	2.88	2.35	0.27	0.27	0.33	0.23	157.21	157.21	192.54	157.21	159.12	159.12	194.89	159.12
C.D. at 1%	3.09	3.09	3.78	3.09	0.36	0.36	0.44	0.36	206.62	206.62	253.04	206.62	209.11	209.11	243.25	209.11
	13. Oil content															
C1	0.69**	25.00**	-0.40	0.85**												
C2	-0.10	49.02**	-0.32	1.20**												
C3	0.70**	45.45**	0.04	-0.74**												
C4	-0.57**	24.67**	-0.05	0.71**												
C5	0.26	26.29**	-0.43	0.37												
C6	0.44**	24.67**	1.30*	-1.00**												
C7	-0.23	57.25**	-0.33	0.32*												
C.D. at 5%	0.32	0.32	1.23	0.32												
C.D. at 1%	0.41	0.41	1.63	0.41												

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