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Research Article

Generation mean analysis for quantitative traits in basil *(Ocimum basilicum* L.*)*

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Abstract
To study the nature and magnitude of gene effects for yield and its components in basil (*Ocimumbasilicum* L.), generation mean analysis with following seven crosses of different accession was carried out: EC-388788/IC-333322, EC-387893/IC-326711, EC-388896/IC-369247, EC-388887/IC-386833, EC-387837/EC-338785, IC-369247/IC-370846 and IC-344681/IC-326735.Generation mean analysis with three parameter model with $\chi 2$ test indicated that additive-dominance model was inadequate for all the traits in all the crosses used to estimate the gene effects.The analysis showed the presence of additive, dominance and epistasis gene interactions.In addition to digenic and higher order of interaction, additive and dominance effects were also important for improvement in contributing traits to yield. Duplicate type epistasis played greater role than complimentary epistasis. This suggested that duplicated type of gene action was present confirming the importance of dominance effects. The study revealed the importance of both additive and non-dominance types of gene action for all the traits studied. Thus, considerable non-additive genetic effects observed in this study suggest that selection in advanced generation may be more appropriate.

Key words:
Ocimum basilicum L., quantitative trait, joint scaling test, gene effects, generation mean analysis

Introduction

The genus*Ocimum* belonging to the *Lamiaceae* family is characterized by great variability for both morpho and chemo types (Lawrence**,**1988). Cross-pollination leads to a large number of subspecies, varieties, and forms (Guenther,1949). Among all the species, *Ocimumbasilicum* (basil or sweet basil) is economically important and is cultivated and utilized throughout the world. The aromatic leaves are used fresh or dried as a flavouring agent for foods, confectionery products and beverages. Traditionally, the plant has been employed in folk medicine for its carminative, stimulant and antispasmodic properties. In ayurvedics, the traditional Indian medicine, basil is used as a remedy for many diseases. In India it is pretty common to plant basil in order to check the celebrity of a soil: the good growing of the plant makes a place or soil good. The leaves are used during religious ceremonies dedicated to God Vishnu, in particular the ones in favour of family wellness. The essential oil, mainly used in food industries and perfumery possesses antimicrobial activity (Prasad *et al*., 1985) and some of its components, such as 1, 8-cineole, linalool, and camphor, are known to be biologically active (Morris *et al*., 1979). Camphor and 1, 8-cineole also seems to be involved as agents in allelopathic reactions (Rice, 1979). Based on chemical composition, several chemo types of basil, like methyl cinematic, methyl chavicol, eugenol and linalool rich have been identified (Pareek*et al*., 1982). Basil essential oil finds diverse uses in perfumery, pharmaceutical, cosmetics, and food and flavour industries (Duglas, 1969). The plant is reported to be of great medicinal value and finds use in Indian Systems of Medicine and Aromatic Plant. The economically important parts of *Ocimum* are mainly leaves and the tender parts of the shoots, which yield essential oils. The essential oil of basil contain heterogeneous group of aromatic compounds having immense value as flavours and fragrance.Tulsi leaf, when eaten, can control thirst, and so was invaluable to weary travellers (Lal*et al*., 2008, 2013 and Lal, 2014). The basil proves to be beneficial in cardiac disease also and reduces the level of cholesterol and calories, thereby reducing the chance of heart risk. The leaves of basil have also proven to act as an anti- stress agent. Even a healthy and normal person can chew the leaves of basil in order to remove stress. Chewing the leaves of basil can cure the mouth ulcers and infection. Blood is purified with the help of its leaves. The herb also proves to be great in healing the insect stings and bites. The fresh juice must be applied to the affected parts. Even the paste of its fresh roots can be applied for immediate effect indeed to be of great value as a medicinal and aromatic plant.

For genetics of the crop, the breeding method to be adopted depends mainly on the nature of gene action involved in the expression of quantitative traits. The presence or absence of epistasis can be detected by the analysis of generation mean using the joint scaling test, which measures epistasis accurately whether it is complementary (additive x Additive) or duplicate (Additive x Dominance) and (Dominance x Dominance) at the digenic level. The objective of this research was to obtain information on the nature of gene action in basil to provide a basis for evaluation of selection methods for the improvement of the basil population.

Material and Methods

Thirty accessions of (*Ocimumbasilicum* L), 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 National Bureau of Plant Genetic Recourses, New Delhi were used in the present study. The experiments involved the six basic generations (the P_1 and P_2 parent the F_1 and F_2 generations, and BC_1 and BC_2) of seven crosscombinations. The combinations used were EC-388788/IC-333322, EC-387893/IC-326711, EC-388896/IC-369247, EC-388887/IC-386833, EC-387837/EC-338785, IC-369247/IC-370846 and IC-344681/IC-326735. The experiment was conducted at the research farm of Department of Genetics and Plant Breeding, Ch.Charan Singh University campus Meerut, India during 2009. All the six basic generations, i.e. P_1, P_2, F_1, F_2, B_1 and B_2 were planted in a randomized block design with three replications and a plot size of 32.20 x 22 m. The data on quantitative traits like,plant height, leaf area, number of inflorescence, length of inflorescences, days to maturity, fresh herb yield,dry herb yield and oil content were recorded on 5 randomly selected plants in each of P_1, P_2 and F_1 generations, 15 plants each of B_1 and B_2 and 30 plants of F_2 generations. The estimates of generation mean analysis with three parameter model as suggested by Jinks and Jones (1958) and Joint Scaling test (Cavalli, 1952) were carried out to estimate the presence or absence of non-allelic interaction. Six parameter model suggested by Hayman (1958) was used to estimate variance components to fit the models.The essential oil was extracted from the air dried herb by hydro-distillation using Clevenger’s apparatus for 2.30hrs.

Results and discussion

The analysis of variance for all the eight traits recorded for 13 parents $F_{1'}$s, $F_{2's}$, $B_{1's}$ and $B_{2's}$ in the study are presented in (Table 1). The mean squares due to treatment of all the eight traits were highly significant thereby suggesting the presence of sufficient genetic variability in the materials under study. The mean of six generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) for each trait and their corresponding weights were used to estimates various gene effects for oil content and its contributing traits. Joint scaling test was applied to test the adequacy of additive-dominance model and estimates three parameters m (mean) d (additive effect) and h (dominance effect). In case the additive-dominance model was not found adequate, the data were analysed for estimation of six parameters m (mean), d (additive effect), h (dominance effect) and digenic interaction effects i.e. i (additive x additive). j (additive x dominance) and l (dominance x dominance). Significant joint scaling test indicated the presence of non-allelic interaction and non-significance indicated the absence of non-allelic interaction. In such cases 6- parameter model was used to estimates the additive, dominance and epistasis effects. The estimates of gene effects obtained using 6-parameter model for the 13 traits in seven crosses are presented in (Table 2).

The additive, dominance and epistatic types of gene interaction in each cross for different trait were found to be different from each other. The dominance x dominance [l] interaction was larger than the additive x additive [i] and additive x dominance [j] effects put together, while for the main effects the dominance component (h) was greater than the additive [d] components. The dominance [h] and dominance x dominance [l] effects were in the opposite direction, suggesting that duplicate-type epistasis occurred in most cases and indicating predominantly dispersed alleles at the interacting loci (Jinks, and Jones**,** 1958). Dominance gene effects were found to be relatively more important, as indicated by the fact that in all cases the dominance [h] values were higher than additive [d] values.

For plant height, 6-parameter model was used in all seven crosses. All the gene effects were significant for this trait in five crosses namely, EC-388788/IC-333322, EC-387893/IC-326711, EC-388896/IC-369247, EC-387837/EC-338785 and IC-369247/IC-370846. The additive gene effects were significant in all crosses except to cross IC-344681/IC-326735, whereas dominance gene effect were significant in six crosses EC-388788/IC-333322, EC-387893/IC-326711, EC-388887/IC-386833, and EC-387837/EC-338785; positive significant and negative significant in cross EC-388896/IC-369247 and EC-387837/EC-338785 respectively. All the three types of non-allelic gene interactions were significant and positive in crosses, EC-388788/IC-333322 and IC-369247/IC-370846. It is clear that [i] indicate additive x additive, [j] indicate the additive x dominance and [l] indicate that dominance x dominance non- allelic interactions. For this trait, all the significant values were found positive h, j and i whereas 'l' was negative in all crosses except EC-388788/IC-333322 and IC-369247/IC-370846. The dominance gene effects were negative and non-significant for plant height. However significant and non-significant positive and negative estimates were recorded for plant height. A comparison of the generation mean analysis data in (Table 2**)** indicates that estimates of the additive gene effect [d] were greater in magnitude than their corresponding dominance effects [h] for plant height in crosses EC-388896/IC-369247 and IC-369247/IC-370846. Therefore additive genes are the most important factor contributing to the genetic control of this trait. Further, in situations where additive gene effects moderate indicated fixable gene effect and therefore early selection among the segregating population could be rewarding.

Since, significant estimates of 'h' and l had opposite signs, duplicate type of epistasis was indicate in four crosses; EC-387893/IC-326711, EC-388887/IC-386833, EC-387837/EC-338785, and IC-369247/IC-370846. The breeding implication is that difficulties might be encountered in the process of evolving varieties with improved plant height. Significant estimates of 'h' and l had same signs complimentary or recessive epistasis was indicated in only two crosses EC-388788/IC-333322 and EC-388896/IC-369247. Over dominance showed in all crosses for plant height. The magnitudes of dominance and non-dominance and non-allelic interactions were higher than the additive gene effects in all crosses except EC-387893/IC-326711 and EC-388896/IC-369247. For these traits dominant effects together with non allelic gene interaction type of epistasis are predominant.

Non-fixable gene effects were higher than the fixable gene effects to environment indicating a greater role of non-additive gene effects in the inheritance of these traits, which suggested that this trait can be improved through recurrent selection. These finding are agreement with those earlier reported by(Singh, and Paroda,1987;Singh, and Nanda,1989). Moreover epistasis in this trait was of duplicate type which further confirms the complex nature of this trait thereby suggested that difficulty would be encountered in selecting for this trait as also reported by (Ketata*et al*., 1976, Srivastava*et al*., 1980, Ramesh *et al*., 2012 and Ganesh, and Sakila, 1999)

The leaf area trait for the three crosses EC-388887/IC-386833, EC-387837/EC-338785 and IC-369247/IC-370846, showed a significant and pronounced additive, dominance and non allelic interactions. And all crosses showed additive and dominance type of gene effect except to EC-387893/IC-326711 for additive and EC-388896/IC-369247 for dominance type of gene effect. non opposite signs of [h] and [l] parameters in two crosses EC-387837/EC-338785 and IC-369247/IC-370846 indicated the duplicate type of interaction and cross EC-388887/IC-386833 same sings (i.e. positive or negative) of [h] and [l] parameters showed complimentary or recessive type of epistasis. Both additive and dominance gene effects as well as non-allelic interaction were found significant in three crosses, EC-388887/IC-386833, EC-387837/EC-338785 and IC-369247/IC-370846. However, additive gene effect was non- significant in cross EC-387893/IC-326711 and dominance gene effect was non-significant in cross EC-388896/IC-369247. In general, the magnitudes of non-additive effect were higher than additive gene effect in most of the crosses. Similar results were obtained Walton,(1969 and 1972).

In case of the number of inflorescence, all the gene effects were significant in all crosses. The magnitudes of non-additive effect were higher than that of additive gene effect. All the crosses exhibited complimentary type of epistasis for this trait except cross EC-388896/IC-369247 which showed duplicate type of epistasis. The non fixable gene effect were higher than fixable gene effects indicating a greater role of non-additive gene effects for this trait, which suggested that this trait can be improved through recurrent selection. These results confirm the findings of**(**Pathak *et al*., 2000, Kumar*et al*., 1994 and Noshin*et al*., 2003) who also reported the involvement of additive type of gene action for this trait.

For length of inflorescence in all the seven crosses, additive and non-additive gene effects were found significant in all crosses except EC-387837/EC-338785. The non-additive (dominance and non-allelic interaction) type gene effect was found significant in all crosses. The crosses EC-387893/IC-326711, EC-388896/IC-369247 and EC-387837/EC-338785 showed duplicate type of interaction and cross EC-388788/IC-333322 showed complimentary type of epistasis for this trait. The non-additive gene effects were predominant for this trait.

For the trait days to maturity, additive gene effects were found significant in only two crosses. EC-

388887/IC-386833 showed negative and IC-369247/IC-370846 showed positive significance. Dominance gene effects significant in all the seven crosses except to EC-388896/IC-369247 and EC-388887/IC-386833. All the types of gene effects were found in cross IC-369247/IC-370846. Among non-allelic interaction additive x additive with positive signs in cross EC-387837/EC-338785 and IC-369247/IC-370846, additive x dominance with positive significant in EC-388788/IC-333322, EC-388896/IC-369247and IC-369247/IC-370846, negative significant showed in EC-388887/IC-386833. In all significant cases the magnitudes [h], [i] and [l] were higher than that of additive gene effects. For this trait, both additive and non-additive gene effects were predominant. Duplicate type of epistasis was observed in two crosses except toEC-388788/IC-333322 and IC-369247/IC-370846, while EC-387893/IC-326711 showed in complimentary type of epistasis.

In case of the fresh herb yield all types of gene effects were found significant in only three crosses, EC-387893/IC-326711, EC-388887/IC-386833 and EC-387837/EC-338785. Additive type gene effect were found significant in crosses, EC-387893/IC-326711 , EC-388887/IC-386833 , EC-387837/EC-338785 , IC-369247/IC-370846 and IC-344681/IC-326735, dominance gene effect were observed in significant in crosses namely,EC-388788/IC-333322 , EC-387893/IC-326711 , EC-388896/IC-369247, EC-388887/IC-386833 and EC-387837/EC-338785 . All types of non-allelic gene interactions were significant in all the crosses except toEC-388788/IC-333322. Duplicate type of interaction showed in cross EC-388887/IC-386833, EC-387893/IC-326711 and EC-388896/IC-369247 and EC-388887/IC-386833 showed complimentary types of epistasis.

For the trait dry herb yield, all types of gene effects were found in only one cross EC-388788/IC-333322. Additive and dominance were found significant in crosses, EC-388788/IC-333322 and EC-387837/EC-338785. For this trait [i] type interaction was significant in crosses, EC-388788/IC-333322 , EC-387893/IC-326711 , EC-388896/IC-369247, EC-388887/IC-386833 and EC-387837/EC-338785 , [j] type of interaction were observed significant in EC-388788/IC-333322, EC-388896/IC-369247, EC-388887/IC-386833 and IC-344681/IC-326735 and (l) type of gene interaction were found in EC-388788/IC-333322 , EC-387893/IC-326711 , EC-388896/IC-369247, IC-369247/IC-370846 and IC-344681/IC-326735. In all the significant cases the magnitudes of [h], [i], [j] and [l] were higher than that of additive gene effects. In crosses EC-388788/IC-333322, EC-387893/IC-326711 and IC-344681/IC-326735 showed complimentary type of epistasis and duplicate type of epistasis showed in EC-388896/IC-369247, EC-387837/EC-338785 and IC-369247/IC-370846.

For oil content six parameter models was used in three crosses, EC-387893/IC-326711 , EC-388896/IC-369247 and EC-387837/EC-338785 and rest of crosses used in 3-parameter models. EC-388788/IC-333322, EC-388887/IC-386833, IC-369247/IC-370846 and IC-344681/IC-326735 showed non-allelic interaction was absent. Although the best approximation of additive and dominance effects can be obtained from the three parameter additive-dominance model because these effects are unbiased due to absence of epistasis. The three parameter models was found not to be sufficient to explain the genetic control of oil content in three crosses, therefore the six parameter model was fitted to determine the type and magnitude of gene effects involved in the inheritance of oil content. The results of the six parameter model analysis indicated that dominance, additive x additive and dominance x dominance effects contributed significantly to the inheritance of trait. The cross EC-388896/IC-369247 showed complimentary and cross EC-387837/EC-338785 showed duplicate type of epistasis. This suggested that duplicate type of gene interaction were present confirming the importance of dominance effects as reported by Grewal,(1988).In conclusion, considerable non additive genetic effects were observed in this study suggesting that selection in advanced generation may be more appropriate because effective selection in early generation of segregating material can be achieved only when additive gene effects are substantial and environment effects are small. In all the three crosses dominance gene effect were observed positive significant except to EC-387837/EC-338785 which showed negative significant. A negative estimate of dominance might be due to epistatic gene action in the cross combination. Additive gene effects were found significant in all three crosses. Cross EC-387837/EC-338785 showed positive significant and EC-387893/IC-326711 and EC-388896/IC-369247were showed negative significant. The additive effects and gene interaction dominance x dominance [l] or other type digenic complementary gene interaction can be exploited effectively by selection for the improvement the traits.

Generation mean analysis showed that dominance, additive x additive and dominance x dominance gene action play a role in the inheritance of oil content. Similar results were found byDani and Kohel**(**1989) who determined that dominance, additive x additive and dominance gene effects play a significant role in the inheritance of oil content. The negative additive, additive x additive and dominance x dominance estimate shows the gene pairs responsible for oil content are in dispersive form (Mather, and Jinks, 1977). The different types of gene effects estimated provided a test for gene action and are useful for analyzing the genetic architecture of a crop so as to further improve desirable traits. The estimates obtained from each cross may be unique to that cross and may not be applicable to the parental population. Additive genetic variance formed the major part of the genetic variance for the important yield components and oil content. Therefore genetic improvement in the fresh herb and dry herb yield per plant trait would be easier through indirect selection for a component trait such as the oil content trait than through direct selection for fresh and dry herb yield itself.

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Table.1. Analysis of variance for eight quantitative characters of 13 parents, 7 F_1s, 7F_2s, 7 B_1s, and 7 B_2s of seven crosses in basil (*Ocimumbasilicum*).

Source of variation	**d.f**	**PH**	**LA**	**NI**	**LI**	**DM**	**FHY**	**DHY**	**OC**
Replication	2	44.31	1.71	0.75	0.50	1.06	18848.00	3966.00	.020
Treatment	40	633.5**	9.24**	391.30**	48.82*	100.04*	390958.40**	103503.00**	2.63**
Error	80	20.43	0.27	0.94	0.36	2.17	9650.60	9887.36	0.04

Acronyms:PH = Plant height (cm),LA = leaf area (cm^2), NI =Number of inflorescence, LI = Length of inflorescences (cm), DM =Days to maturity, FHY = Fresh herb yield, DHY = Dry herb yield (g), OC =Oil content (%)

Table 2.Generation mean analysis in seven crosses of basil (*Ocimum basilicum* L.)

Crosses	M	d	h	**χ2**	m	d	h	i	j	l	Type of epistasis
					Plant height						
C_1	76.25** ± 0.64	3.81**±0.63	6.48**±1.18	86.90	90.06**±0.84	-13.03**±0.81	51.99**±2.72	23.72**±2.53	4.53**±0.91	24.54**±4.28	C
C_2	111.30**±0.64	2.00**±0.63	0.06±1.18	13.06	91.22**±0.36	-20.85**±0.82-	121.19**±2.27	-63.89**±2.05	22.99**±0.75	-16.14**±3.39	D
C_3	100.83**±0.64	7.25**±0.63	15.33**±1.18	31.42	111.73**±0.39	26.60**±0.37	-69.59**±2.18	86.32**±2.21	22.99**±0.75	-16.14**±3.39	C
C_4	93.23**±0.64	-6.49**±0.63	-7.18**±1.18	67.97	89.33**±0.34	9.05**±0.37	97.70**±2.43	103.27**±2.31	0.65±0.57	-187.41**±3.57	D
C_5	119.04**±0.64	7.52**±0.63	-14.78**±1.18	156.65	88.63**±0.61	-35.02**±0.84	53.35**±7.76	61.10**±7.74	-22.82**±0.41	-104.49**±8.30	D
C_6	89.91**±0.61	1.64**±0.63	0.08±1.18	11.55	91.80**±0.61	19.93**±0.73	-36.41**±2.86	33.59**±2.85	2.35**±0.77	107.62**±3.91	D
C_7	85.62**±0.64	4.48**±0.63	7.61**±1.18	17.97	108.46*±11.2	-8.63 ±8.71	2.16±4.85	13.93**±4.84	-1.39±9.67	-92.97±57.67	….
					Leaf area						
C_1	5.74*8±0.64	-1.03±0.63	1.29±1.18	6.67	8.80**±0.13	-0.57*±0.26	-1.53**±0.83	-1.43*±0.74	-0.15±0.42	3.33**±1.39	
C_2	9.98**±0.64	1.68**±0.63	0.31±1.18	8.71	8.83**±0.09	-0.44±0.41	-2.81**±1.00	-2.52**±0.90	0.50±0.52	-0.80±1.91	….
C_3	10.45**±0.64	0.90±0.63	-0.91±1.18	9.33	8.07**±0.35	1.17**±0.40	-0.70±1.63	-0.63±1.62	1.61±0.91	1.61±2.16	….
C_4	7.49**±0.64	--0.30±0.63	-0.54±1.18	8.57	6.09**±0.11	-2.03**±0.33	16.37**±0.89	17.15**±0.89	-1.22**±0.41	30.30**±1.59	C
C_5	9.79**±0.64	0.68±0.63	-0.18±1.18	8.31	6.65**±0.32	-6.62**±0.41	7.54**±0.15	10.74**±1.52	-6.62**±0.50	-14.72**±2.23	D
C_6	7.85**±0.64	-0.47±0.63	0.87±1.18	12.88	7.51**±0.58	1.35**±0.43	-5.48**±2.54	-5.52**±2.49	-1.63**±0.45	16.76**±2.99	D
C_7	8.22**±0.64	-0.14±0.63	1.56±1.18	16.56	10.27**±0.24	-1.16**±0.75	7.29**±1.85	5.37**±1.86	5.37**±1.80	-0.84±0.76	….
					Number of inflorescence						
C_1	91.37**±0.64	19.83**±0.63	1.38±1.18	25.71	82.34**±0.56	24.53**±1.21	66.74**±3.20	29.57**±3.10	31.30**±1.20	38.40**±5.38	C
C_2	103.00** ±0.64	-1.78**±0.63	-1.78±1.18	56.97	82.40**±0.83	15.00**±0.81	27.76**±3.76	8.39*±3.70	18.50**±0.92	30.86**±4.83	C
C_3	96.05**±0.64	10.29**±0.63	18.38**±1.18	67.19	89.60**±0.83	21.50**±0.77	49.96**±0.37	44.60**±3.60	21.43**±0.92	-98.33**±4.79	D
C_4	90.49**±0.64	-2.81**±0.63	1.58±1.18	30.71	93.86**±0.83	14.43**±0.61	31.38**±2.11	21.48**±1.78	11.04**±0.80	88.01**±3.58	C
C_5	88.80**±0.64	6.40**±0.63	-14.62**±1.18	44.83	90.26**±0.58	-25.66**±0.80	24.27**±2.90	28.59**±2.83	-14.55**±0.83	50.40**±4.17	C
C_6	94.12**±0.64	5.14**±0.63	-1.60±1.18	139.95	101.10**±0.57	9.66**±0.55	55.15**±2.60	44.30**±0.26	18.48**±0.58	74.70**±3.40	C
C_7	91.03**±0.64	3.37**±0.63	-1.96±1.18	69.87	97.97**±0.54	3.36**±0.69	31.27**±2.62	31.27**±2.62	19.16**±2.58	18.01**±3.65	C
					Length of inflorescence						
C_1	18.55**±0.64	1.87**±0.63	0.19±1.18	12.10	14.25**±0.17	4.98**±0.47	19.22**±1.22	7.48**±1.17	4.31**±0.51	18.51**±0.21	C
C_2	21.39**±0.64	-3.32**±0.63	-5.98**±1.18	9.26	23.50**±0.26	10.90**±0.79	-11.53**±1.85	-19.13**±1.84	-19.13**±1.80	14.39**±0.74	D
C_3	20.78**±0.64	-1.87**±0.63	1.14±1.18	22.45	17.17**±0.50	6.21**±0.35	13.85**±2.48	15.04**±2.46	4.23**±0.42	-13.70**±2.84	D

C_4	19.85*8±0.64	-3.43**±0.63	-3.01**±1.18	28.64	18.14**±0.50	-7.81**±0.46	9.35*±2.43	10.30**±2.39	-1.48**±0.50	-24.43±30.02	….
C_5	18.18**±0.64	1.58**±0.63	-1.18±1.18	114.99	16.82**±0.19	0.51±0.62	-3.53*±1.48	-1.48±1.43	-4.01**±0.68	14..31**±2.69	D
C_6	23.20**±0.64	-3.05**±0.63	-1.60±1.18	577.90	14.30**±0.14	-2.69**±0.43	7.34**±1.29	6.87**±1.11	-5.58**±0.45	-2.62±2.18	D
C_7	18.67**±0.64	-1.73**±0.63	-1.96±1.18	56.61	21.16**±0.38	-3.40**±0.80	-2.59±2.18	-6.98**±2.18	-2.80**±0.80	-6.50±3.54	D
Days to maturity											
C_1	121.70**±0.64	-2.18**±0.63	-8.47**±1.18	8.48	119.36**±5.23	1.80±0.86	-9.27**±2.78	-4.78±2.71	1.92*±0.89	18.14**±4.22	D
C_2	119.10**±0.64	3.32**±0.63	-5.98**±1.18	28.94	122.22**±0.86	-0.93±1.22	10.50*±4.29	-3.93±4.52	0.86±2.06	11.81±8.36	C
C_3	119.98*8±0.64	-2.66**±0.63	-4.11**±1.18	8.97	112.33**±0.33	2.20±2.05	-3.93**±4.33	5.33±4.52	9.52**±1.26	11.45±6.18	-
C_4	120.52**±0.64	-0.82±0.63	-6.14**±1.18	13.36	115.16**±0.56	-7.18**±2.05	-3.93±4.33	5.33±3.06	-7.07**±1.21	5.22±5.20	--
C_5	118.20**±0.64	0.34±0.63	-5.18**±1.18	14.18	116.37**±0.20	0.66±0.49	5.48±1.76	4.50**±1.33	-5.77±3.25	1.40±1.33	---
C_6	122.20**±0.60	-3.05**±0.63	3.31**±1.18	54.68	116.20**±1.10	2.13**±0.83	12.33**±5.38	11.99*±4.71	1.86*±0.90	-17.79*±7.50	D
C_7	121.20.** ±0.60	3.50**±0.63	3.31**±1.18	53.64	120.83**±0.84	0.12±0.75	-7.15**±3.76	-9.05**±0.37	0.69±0.83	14.74*±4.02	….
Fresh herb yield											
C_1	2269.39**±0.64	68.09**±0.63	286.89**±1.18	38522.79	1580.00**±18.55	21.66±119.28	2435.83**±902.51	2070.00**±901.62	1591.00**±443.94	-2831±1800.00	
C_2	1960.04**±0.64	154.66**±0.63	-398.28**±1.18	54617.95	2603.00**±26.03	127.33**±27.77	-968.33**±118.02	985.33**±118.02	280.00**±32.39	3600.00**±161.30	C
C_3	24.82.06**±0.64	111.00**±0.63	-254.60**±1.18	1648.70	1655.00**±47.69	320.00±658.33	1900.00**±655.54	675.00*±314.06	2650.00*±1269.00	3288.0**±658.33	C
C_4	2373.20**±0.64	-38.93**±0.63	-357.40**±1.18	73666.62	2327.27**±14.05	632.00**±26.55	-1285.00**±79.09	1445.00**±77.35	-976.31**±29.09	1581.10**±124.67	D
C_5	2333.66**±0.64	8.33**±0.63	-83.00**±1.18	20714.86	1816.31**±230.02	934.00**±81.25	545.00**±115.57	857.41**±111.29	1098.00**±32.62	1368.00**±167.30	C
C_6	1140.41**±0.64	296.95**±0.63	705.64**±1.18	554533.80	2308.00**±22.04	247.50**±55.43	36.33±152.40	2583.00**±141.00	444.16**±60.99	593.33*±263.94	
C_7	1833.93**±0.64	179.53**±0.63	160.27*8±1.18	56991.24	2197.00**±53.50	-163.33*±67.46	259.00±257.01	-880.00**±53.50	-577.00**±71.86	-394.00**±356.41	….
Dry herb yield											
C_1	1158.73**±0.64	-84.50**±0.63	-100.43**±1.18	26556.91	790.00**±5.77	277.00**±28.14	1531.45**±66.60	1059.33**±62.00	-265.71**±31.40	1062.90**±127.06	C
C_2	744.03**±0.64	27.66**±0.63	52.03**±1.18	4994.75	1066.66**±44.09	40.00±26.14	1361.00**±351.73	1046.00**±183.96	271.66±296.27	1243.33*±633.66	C
C_3	1156.60**±0.64	46.73**±0.63	4.07**±1.18	9733.26	802.00**±27.15	-63.33±76.73	1896.50**±189.10	1412.20**±188.02	13.16±77.71	2532.34**±328.23	D
C_4	997.24**±0.64	144.40**±0.63	220.24**±1.18	24476.6	1052.89**±37.78	418.80**±32.77	-197.12±183.36	-309.00±164.00	-472.64**±44.01	-37.30±25.60	….
C_5	1004.53**±0.64	113.33**±0.63	-19.09**±1.18	61350.9	860.88**±12.07	196.00**±11.16	-217.10**±60.30	-109.54*±53.19	248.64**±27.29	471.40±60.90	D
C_6	665.03**±0.64	121.66**±0.63	231.03**±1.18	10189.15	900.00**±28.86	45.33±69.19	1118.00**±186.68	1117.33**±180.24	-60.66±75.63	-1596**±315.00	D
C_7	815.57**±0.64	93.00**±0.63	159.23**±1.18	6964.56	1050.00**±28.86	180.99**±48.69	75.83±156.02	268.33±151.06	-1433.00**±52.53	-338.33**±239.53	….
Oil content											
C_1	3.45**±0.64	0.10±0.63	0.07±1.18	1.20	3.45**±0.64	0.10±0.63	0.07±1.18	----------	---------	--------	
C_2	2.72**±0.64	0.66±0.63	1.64±1.18	8.22	1.69**±0.33	-3.60**±01	14.05**±0.02	-3.50**±0.01	1.37**±0.10	0.44±0.46	….
C_3	2.75**±0.64	0.43±0.63	1.64±1.18	8.23	4.59**±0.33	-1.02**±0.34	6.07**±1.33	7.12**±1.33	-0.52±0.35	9.31**±1.38	C
C_4	3.48**±0.64	-0.23±0.63	0.51±1.18	1.33	3.48**±0.64	-0.23±0.63	0.51±1.18	-------	--------	--------	
C_5	4.90**±0.64	-1.39±0.63	-1.73±1.18	9.66	3.27**±0.13	0.48*±0.20	-1.07**±0.10	-5.80**±0.07	-0.20±0.75	3.50**±0.17	D
C_6	3.56**±0.64	0.55±0.63	0.12±1.18	0.49	4.90**±0.64	-1.39±0.63	-1.73±1.18	---------	--------	----------	
C_7	3.86**±0.64	-0.44±0.93	-0.75±1.18	0.26	3.56**±0.64	0.55±0.63	0.12±1.18	----------	---------	----------	

Where, *, ** Significant at 5% and 1% level of significant, respectively. C_1= EC- 388788 x IC- 333322, C_2 = EC- 387896 x IC- 326711, C_3= EC- 388896 x IC- 369247, C_4= EC- 388887 x IC- 386833, C_5 = EC- 387837 x EC- 338785, C_6 = IC -369247 x IC- 370846, and C_7= IC- 344681 x IC- 326735.