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Research Note

Genetic association for oil yield and its component traits in different *Ocimum* species

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Abstract
The genus *Ocimum* belonging to family Lamiaceae is a medicinal aromatic plant that produces essential oils used for various aromatic and medicinal purposes. The present study on genetic correlation and path-coefficient was carried out in 20 lines belonging to four different *Ocimum* species *i.e. O. basilicum, O. tenuiflorum, O. gratissimum* and *O. kilimandscharicum* to identify component traits facilitating indirect selection. The yield traits (herb yield, oil content and oil yield) revealed strong genetic association among them exhibiting positive direct path of herb yield (0.729) and oil content (0.532) towards oil yield that were having high positive genetic correlation of 0.792 and 0.726 respectively. All the component traits, except plant height, number of branches/ plant, number of seeds/ inflorescence and canopy spread showed positive association with oil yield and can be used for indirect selection for higher oil yield in *Ocimum*.

Keywords
Ocimum, genetic correlation, path coefficient analysis, essential oil yield, indirect selection.

The genus *Ocimum* belonging to family Lamiaceae includes over 60 herbaceous and bush species, which differ widely for morpho – agronomical traits and essential oil composition. Nine species are found in India, of which three are exotic (Anonymous, 1966; Willis, 1966; Balayan and Pushpangadhan, 1988). The genus *Ocimum*, a medicinal aromatic plant is an important source of essential oils, which are widely, used in perfume, pharmaceutical, cosmetic, food and flavor industries (Douglas, 1969; Manniche, 1989). Flower, fruit, leaf, stem, root and almost every part of the plant possess great medicinal value and are used as an expectorant, analgesic, anticancer, anti-asthmatic, anti-emetic, diaphoretic, anti-diabetic, anti-fertility, hepatoprotective, hypotensive, hypolipidemic, etc. (Singh *et al*., 2010). Whole plant or plant parts as raw or as extracts and decoctions have been reported to be useful in ayurvedic as well as traditional (folklore) treatments for large number of diseases such as gastritis, ulcers, dysentery and hepatic disorders; glaucoma, cataract, chronic conjunctivitis and other diseases associated with eyes; cold, cough and flu; prophylactic against malaria and dengue fever; ringworm infection; as nerve tonic and memory enhancement, etc. (Singh *et al*., 2010). Several bioactive properties have also been attributed to the essential oils and solvent extracts of the *Ocimum* species plants (Roy *et al*., 1979; Prasad *et al*., 1986; Ahmed and Bhattacharya, 1991).

Oil yield is a complex trait, quantitative in nature, influenced by several genetic and environmental factors with low genetic advance (Ibrahim *et al*., 2011). So selection for yield *perse* is not reliable, which necessitates indirect selection through component traits. The ideal component traits can be identified based on their genetic relationship with yield that can be assessed by correlation and path-coefficient studies. However, in *Ocimum* reports on trait association are not available much. So the present study was formulated to unravel the genetic relationships underlying the yield and its component traits in four different *Ocimum* species.

The present study was carried out in a Randomized Block Design with three replications during *Kharif*, 2009 in the research farm of CSIR-Central Institute of Medicinal and Aromatic Plants - Research Centre, Hyderabad, India. 20 *Ocimum* germplasm lines/ advanced selection material/ released varieties belonging to 4 different species – *O. basilicum*, *O.*

tenuiflorum, *O. gratissimum* and *O. kilimandscharicum* (Table 1) were sown in nursery at a line spacing of 15 cm. Five weeks old seedlings were transplanted to the main field having individual plot size of 4 x 2 m^2. The row to row and plant to plant spacing was 60 cm each. The experimental crop received 60 kg P_2O_5 and 40 kg K_2O/ha uniformly in the form of basal dose at the time of final land preparation. Nitrogen @ 80 kg/ha was applied in the form of urea in equal split doses at 45 days after transplanting and after each harvest. Crop was given supplemental irrigations at 10-15 days interval (based on rainfall) besides life saving irrigation after transplanting.

Observations on plant height (cm), number of branches/ plant, canopy spread (cm), number of leaves/ plant, inflorescence length (cm), number of whorls/ inflorescence, and number of seeds/ inflorescence were recorded before first harvest (early seed setting stage) on 10 randomly selected plants per replication. The inflorescence traits *i.e.* inflorescence length, number of whorls and number of seeds were observed on 20 inflorescences per plant. Biomass yield (t/ ha) was quantified based on plot yield. Number of harvests varied from 1 to 3 among the different germplasm lines and the pooled harvest data was expressed as tones per hectare (t/ha). Crop was harvested at early seed setting stage and oil was distilled using Clevenger's apparatus. The essential oil content (%) was determined on basis of volume / weight X 100 (Guenther, 1972). The data on oil content and biomass yield were used to quantify oil yield (kg/ha). Oil yield was calculated from multiplication of biomass X oil content (%) calculated.

The analysis of variance was obtained according to Panse and Sukhatme (1967). Correlation and Path coefficient were estimated according to Miller *et al*. (1958) and Dewey and Lu (1959). The analysis was performed by using "Windostat" statistical software.

Results and discussion

Analysis of variance showed significant differences among genotypes for different characters indicating presence of large degree of variability for further genetic studies. Correlation measures the mutual relationship between two or more variables, which provides better understanding of yield components that helps plant breeder during selection. The genotypic (r_g) and phenotypic (r_p) correlations are presented in table 2. The genotypic correlations were higher in magnitude than corresponding phenotypic correlations in most cases indicating strong inherent association between various characters at genic level.

Days to maturity that was positively associated with canopy spread (r_g: 0.488 and r_p: 0.460) and plant height (r_g: 0.407 and r_p: 0.399) showed significant negative association with number of leaves/ plant (r_g: -0.327 and r_p: -0.320) and thus negatively related with herb yield (r_g: 0.050 and r_p: 0.050). Plant height showing significant positive association with canopy spread (r_g: 0.689 and r_p: 0.663) exhibited positive association with herb yield (r_g: 0.073 and r_p: 0.067) but negatively related with oil content (r_g: -0.179 and r_p: -0.177) and oil yield (r_g: -0.080 and r_p: -0.082). Plant height showed significant negative correlation with number of branches/ plant (r_g: -0.453 and r_p: -0.441) indicating that tall plants have relatively less number of branches.

The canopy traits *i.e.* canopy spread and number of leaves/ plant were positively associated with each other (r_g: 0.299 and r_p: 0.279) and showed significant negative association with oil yield, which was due to their negative genetic correlation with oil content indicating that with increase in leaf spread and leaf number, the oil content may get reduced. Inflorescence traits – inflorescence length and number of whorls/inflorescence were positively associated with each other (r_g: 0.218 and r_p: 0.184) and number of seeds/ inflorescence, while their association was negative with canopy traits (canopy spread and number of leaves/ plant). Number of whorls/inflorescence in spite of having significant positive association with oil content (r_g: 0.273 and r_p: 0.213) showed negative association with oil yield (r_g: -0.015 and r_p: -0.007) due to its significant negative association with herb yield (r_g: -0.258 and r_p: -0.192). Number of seeds/ inflorescence showed negative association with all the yield traits – herb yield (r_g: -0.469 and r_p: -0.459), oil content (r_g: -0.190 and r_p: -0.186) and oil yield (r_g: -0.502 and r_p: -0.492) exhibiting seed number to have negative influence on yield. This indicates that *Ocimum* should be harvested before seed formation (at 100 % flowering) since seed setting will affect oil yield.

Knowledge of correlation alone however is often misleading as the correlation observed may not be true. Two characters may show correlation just because they are correlated with a common third one (Jaiswal and Gupta, 1967). In such cases, it becomes necessary to study a method, which takes into account the casual relationship in addition to the degree of relationship. Path coefficient analysis is one such method that takes into account both kind of relationship. The genotypic correlations were partitioned into direct and indirect effects to know the relative importance of component traits towards essential oil yield (Table 3).

Strong association was found among the yield traits in *Ocimum* species evident from highest positive direct path of herb yield (0.729) and oil content (0.532) towards oil yield that were having highest positive genetic correlation of 0.792 and 0.726 respectively. Similar kinds of genetic relationship were reported by Ibrahim *et al* (2011) in *O. basilicum* and other crops by Baslma (2008) and Mijic *et al.* (2009).

Following herb yield and oil content days to maturity having positive genetic correlation with oil yield showed positive direct path (0.131) and indirectly effected via canopy spread (0.064), plant height (0.053) and oil content (0.022). Inflorescence length that gave positive genotypic correlation (0.111) showed negative direct path (-0.110) but was indirectly contributed via number of leaves/plant (0.062), number of branches/plant (0.034) and canopy spread (0.022).

Number of whorls/inflorescence (0.073) and number of leaves/plant (0.046) having negative genetic correlation showed positive direct effect towards oil yield. This may be due to high negative indirect effect via number of leaves/plant (-0.026), herb yield (-0.019) and number of branches/plant (-0.013) with respect to number of whorls/inflorescence and via inflorescence length (-0.027), oil content (-0.021), number of whorls/inflorescence (-0.016), days to maturity (-0.015) and number of seeds/inflorescence (-0.011) for number of leaves/ plant. So selection only on the basis of correlation may not be appropriate indicating that number of whorls/inflorescence and number of leaves/ plant should be given due importance in selection programme.

The correlation and path coefficient analysis revealed that the yield traits *i.e.* herb yield, oil content and oil yield possesed strong genetic association among them. All the component traits in the present study, except plant height, number of branches/ plant, number of seeds/ inflorescence and canopy spread emerged as most important characters for the improvement of oil yield. Hence, due emphasis should be placed on these characters while breeding for high oil yield in *Ocimum*.

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Table: 1. Details of experimental material used under present investigation

S.No.	Experimental Material	Species	Description
1	Mulagu - I	*O. basilicum*	Germplasm collection – Dual composition of methyl chavicol and linalool
2	OB Tall	*O. basilicum*	Germplasm collection – Tall and rich in methyl chavicol
3	MC Original	*O. basilicum*	Germplasm collection – With high methyl chavicol content
4	Linalool Original	*O. basilicum*	Germplasm collection - High linalool content
5	Linalool Variant	*O. basilicum*	Selection - Linalool rich variant identified from the base population of linalool original
6	Exotic	*O. basilicum*	Advanced Selection - Linalool and eugenol rich novel globe shaped selection
7	MC Globe	*O. basilicum*	Germplasm collection - Methyl chavicol rich globe shaped morphotype
8	Broad-Dark Green	*O. basilicum*	Germplasm collection - Morphotype with broad and dark green leaves
9	Broad-Pale Green	*O. basilicum*	Germplasm collection - Morphotype with broad and pale green leaves
10	MC Narrow Leaves	*O. basilicum*	Germplasm collection - Narrow leaves morphotype rich in methyl cinnamate
11	Citral-III	*O. basilicum*	Selection - Identified from linalool rich base population having citral
12	CIM Saumya	*O. basilicum*	Variety - Developed by CSIR-CIMAP rich in methyl chavicol
13	Camphor	*O. kilimandscharicum*	Germplasm collection - Rich in camphor
14	OT Purple Tall	*O. tenuiflorum*	Germplasm collection - Tall morphotype of *O. tenuiflorum*
15	OT Purple Dwarf	*O. tenuiflorum*	Germplasm collection - Dwarf morphotype of *O. tenuiflorum*
16	OT Green	*O. tenuiflorum*	Germplasm collection - Green morphotype of *O. tenuiflorum*
17	CIM Kanchan	*O. tenuiflorum*	Variety - Developed by CSIR-CIMAP rich in methyl eugenol
18	CIM Ayu	*O. tenuiflorum*	Variety - Developed by CSIR-CIMAP rich in eugenol
19	OG Original	*O. gratissimum*	Germplasm collection - Rich in eugenol
20	OG Variant	*O. gratissimum*	Selection - High oil content variant identified from OG original

Table: 2. Correlation coefficient for oil yield and its component traits in *Ocimum* species.

Traits	Correlation	Days to Maturity	Plant Height (cm)	No. of Branches/ Plant	Canopy Spread (cm)	Inflorescence Length (cm)	No. of Whorls/ Inflorescence	No. of Leaves/ Plant	No. of Seeds/ Inflorescence	Herb Yield (t/ ha)	Essential Oil Content (%)	Essential Oil Yield (Kg/ha)
Days to Maturity	rg	1.000	0.407***	0.030	0.488***	0.071	-0.065	-0.327*	-0.043	-0.050	0.168	0.064
	rp	1.000	0.399**	0.026	0.460***	0.071	-0.050	-0.320*	-0.039	-0.050	0.168	0.064
Plant Height (cm)	rg		1.000	-0.453***	0.689***	-0.083	0.142	-0.039	-0.078	0.073	-0.179	-0.080
	rp		1.000	-0.441 ***	0.663***	-0.078	0.111	-0.040	-0.073	0.067	-0.177	-0.082
No. of Branches/Plant	rg			1.000	-0.060	-0.326*	-0.173	0.340**	0.060	0.002	0.076	-0.004
	rp			1.000	-0.045	-0.318 *	-0.131	0.334 **	0.064	0.003	0.073	-0.004
Canopy Spread (cm)	rg				1.000	-0.211	-0.047	0.299*	0.049	0.032	-0.477***	-0.294*
	rp				1.000	-0.190	-0.037	0.279 *	0.046	0.029	-0.451 ***	-0.280*
Inflorescence Length (cm)	rg					1.000	0.218	-0.584***	0.382***	0.086	0.171	0.111
	rp					1.000	0.184	-0.574 ***	0.363**	0.086	0.165	0.109
No. of Whorls/ Inflorescence	rg						1.000	-0.353**	0.370***	-0.258*	0.273*	-0.015
	rp						1.000	-0.256 *	0.264 *	-0.192	0.213	-0.007
No. of Leaves/ Plant	rg							1.000	-0.241	-0.028	-0.462***	-0.292*
	rp							1.000	-0.236	-0.027	-0.459 ***	-0.289*
No. of Seeds/ Inflorescence	rg								1.000	-0.469***	-0.190	-0.502***
	rp								1.000	-0.459 ***	-0.186	-0.492***
Herb Yield (t/ ha)	rg									1.000	0.185	0.792***
	rp									1.000	0.183	0.792***
Essential Oil Content (%)	rg										1.000	0.726***
	rp										1.000	0.725***
Essential Oil Yield (Kg/ha)	rg											1.000
	rp											1.000

Note: * Significant at 5% probability level, ** Significant at 1% probability level, *** Significant at 0.1% probability level, rg – Genotypic Correlation and rp – Phenotypic Correlation.

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Table: 3. Path-coefficient analysis for oil yield and its component traits in *Ocimum* species

Traits	Days to Maturity	Plant Height (cm)	No. of Branches/Plant	Canopy Spread (cm)	Inflorescence Length (cm)	No. of Whorls/ Inflorescence	No. of Leaves/Plant	No. of Seeds/ Inflorescence	Herb Yield (t/ ha)	Essential Oil Content (%)	rg Essential Oil Yield
Days to Maturity	**0.131**	0.053	0.004	0.064	0.009	-0.008	-0.043	-0.006	-0.006	0.022	**0.064**
Plant Height (cm)	-0.047	**-0.115**	0.052	-0.079	0.010	-0.016	0.004	0.009	-0.008	0.021	**-0.080**
No. of Branches/Plant	-0.004	0.065	**-0.143**	0.008	0.047	0.025	-0.049	-0.009	0.003	-0.011	**-0.004**
Canopy Spread (cm)	-0.043	-0.061	0.005	**-0.088**	0.019	0.004	-0.026	-0.004	-0.003	0.042	**-0.294***
Inflorescence Length (cm)	-0.008	0.009	0.034	0.022	**-0.110**	-0.023	0.062	-0.040	-0.009	-0.018	**0.111**
No. of whorls/ Inflorescence	-0.004	0.010	-0.013	-0.003	0.016	**0.073**	-0.026	0.027	-0.019	0.020	**-0.015**
No. of Leaves/ Plant	-0.015	-0.002	0.016	0.014	-0.027	-0.016	**0.046**	-0.011	-0.001	-0.021	**-0.292***
No. of Seeds/ Inflorescence	0.001	0.002	-0.001	-0.001	-0.009	-0.009	0.006	**-0.024**	0.011	0.005	**-0.502*****
Herb Yield (t/ ha)	-0.036	0.053	0.002	0.023	0.063	-0.188	-0.021	-0.342	**0.729**	0.135	**0.792*****
Essential Oil Content (%)	0.089	-0.095	0.040	-0.254	0.091	0.145	-0.246	-0.101	0.099	**0.532**	**0.726*****

Residual Effect = 0.073
Note: * Significant at 5% probability level, *** Significant at 0.1% probability level and rg – Genotypic Correlation