Received: 22 Apr 2022 | Revised: 22 Jun 2023 | Accepted: 24 Jun 2023

Electronic Journal of Plant Breeding

Research Note

Assessment of genetic variability and association among yield traits in M_2 population of menthol mint *cv*. Kosi

R. Chandrakala[1]*, T. N. Pushpa[1], D. Srikantaprasad[1], T. N. Lakshmidevamma[2], J. S. Hiremath[1] and Mukund Shiragur[3]

[1]Department of PMA, KRC College of Horticulture, Arabhavi, Karnataka, India
[2]Department of BCI, College of Horticulture, Bengaluru, Karnataka, India
[3]Department of FLA, KRC College of Horticulture, Arabhavi, Karnataka, India
***E-Mail:** chandrakalaraj897@gmail.com

Abstract

Menthol mint, is a perennial herbaceous aromatic plant cultivated as an annual for its commercially valued essential oil. The plant is highly heterozygous in its genetic constitution and vegetatively propagated by stolons, making it a promising material for inducing mutation to create variability. Stolons of mint cultivar Kosi was subjected to gamma irradiation (20 Gy and 40 Gy) and 42 promising putative mutants selected from both 20 Gy and 40 Gy of M_1V_1 generation based on growth and yield parameters were forwarded to M_1V_2, laid out in RCBD with two replications. The study revealed that essential oil yield exhibited significant positive association with leaf area, fresh herb yield, and shade dried herb yield. Hence, selection for these traits can improve yield. Path coefficient analysis revealed that shade dried herb yield per plant, leaf area, and plant spread exhibited positive direct effect on yield. Among these characters shade dried herb yield per plant and leaf area possessed both positive association and high direct effects. Hence, selection for this character could bring improvement in yield and yield components in menthol mint.

Keywords: Correlation; *Mentha arvensis* L.; Heritability; Path analysis

Japanese mint or menthol mint (*Mentha arvensis* L.) belongs to the family Lamiaceae, which comprises of a vast group of herbs with notable economic value. This plant is not only considered as aromatic but also medicinal due to its analgesic, anaesthetic, antiseptic, astringent, carminative, expectorant, nervine, stimulant, and stomachic properties which is used to treat inflammatory diseases, ulcer and stomach problems. The Japanese mint essential oil is the primary source of natural menthol, which is used in personal care products like moisturizers, lip balms, hair oil, talcum powder, and bathing products (Kumar *et al.,* 2015).

Various mint species are commercially cultivated in India, among which menthol mint holds a prime position with India being the global leader with 75 per cent of total menthol production followed by China, Brazil, Thailand, and Vietnam. The country accounts for an annual production of 38,000 metric tonnes of essential oil from a 3.3 lakh hectare area with an average productivity of around 120 kilograms per hectare (Kumar *et al.,* 2019). The state of Uttar Pradesh accounts for around 90 per cent of Indian production whereas, the remaining 10 per cent is from Punjab, Rajasthan and other states. Menthol mint has emerged as a competent cash crop in different cropping systems in North Indian plains and it is commercially grown under tropical and subtropical conditions.

All the mint species available in India are introductions and varieties are developed through selection and hybridization based breeding programmes. Being a highly heterozygous vegetatively propagated plant, mint offers good scope for mutation breeding (Naveena *et al*., 2020; Ghosh, 2018). However, research in India has been focussed on North Indian conditions and the developed varieties perform better there. So, there is a need to create and develop varieties for South Indian conditions (Venkatesha *et al*., 2020). In this direction, the creation of variability through induced mutations in this vegetatively propagated crop can contribute immensely through genetic manipulation (Gustafsson, 1947) in terms of both quantitative and qualitative traits within a shorter period of time. With this background *cv*. Kosi, the ruling variety of North India due to its desirable traits like high herbage yield, oil yield, and short duration (90 days) was used for inducing mutation.

The experimental site is located in the northern dry zone (Zone-III-Belagavi District) of Karnataka at a latitude of 16°15' N, longitude 74°45' E and at an altitude of 612 meters above mean sea level. During the experimental period, the maximum and minimum temperatures were 38.00º C and 18.05º C, respectively. Based on the growth and yield parameters compared with check cultivar Kosi, 42 putative single mutant plants were selected and advanced to M_1V_2 generation during *Kharif* 2019-2020. These lines were evaluated following randomized complete block design (RCBD) along with check cultivar *cv*. Kosi with two replications. Each of these lines received twelve plants propagated using stolons of a single mother plant and spaced at 90 cm X 90 cm. Growth parameters *viz.,* plant height (PH), plant spread (PS), number of branches (NB), leaf area (LA), number of days taken for flowering (NDF) and leaf to stem ratio (LS); and yield parameters like fresh and shade dried herb yield (FHY & SDHY) were recorded in in five randomly selected plants and compared with check cultivar at the time of harvest in M_1V_2. Essential oil content was estimated by taking known weight of three hour shade withered herbage from each plot, in M_1V_2 using essential oil extraction unit of CSIR – Institute of Himalayan Bio – resource Technology patented Technology and expressed in percentage. Genetic variability parameters *viz*., genotypic variability (Vg), phenotypic variability (Vp) (Mahmud and Kramer, 1951), genotypic co-efficient of variability (GCV), phenotypic co-efficient of variability (PCV) (Burton and Devane, 1953), broad sense heritability (H_{BS}) (Comstock and Robinson, 1952), genetic advance as percent of mean (Johnson *et al.,* 1955) in M_1V_2 generations. The analysis of variance was also carried out for growth and yield characters in M_1V_2 generation using Windostat version 9.2 from Indostat services. Phenotypic and genotypic correlation co-efficient were worked out (Panse and Sukhatme, 1967) and they were partitioned into direct and indirect effect of the yield-related traits on fresh herbage yield and essential oil yield in M_1V_2, using the path coefficient analysis (Dewey and Lu, 1959).

Variability parameters, character association and path analysis of putative mutants of cv. Kosi in M_1V_2 generation: The estimates of genotypic variance (GV), phenotypic variance (PV), genotypic co-efficient of variation (GCV), phenotypic co-efficient of variation (PCV), broad sense heritability (h^2b), and genetic advance in percent of mean (GAM) for different characters is presented in **table 1**. Higher estimates of PCV & GCV were observed for fresh herbage yield per plant (35.68% & 32.06%), fresh herbage yield per plot (36.87% & 30.38%), shade dried herb yield per plant (37.02% & 33.98%), shade dried herb yield per plot (37.52% & 31.04%), essential oil yield per plant (37.98% & 25.49%) and essential oil yield per plot (36.40% 31.04%). The heritability estimates alone will not provide an indication of genetic improvement that could be possible from selection of superior genotypes. Hence, genetic advance over mean (GAM) was calculated. Estimates of heritability and genetic advance over per

Table 1. Estimates of mean, range, parameter of variability, heritability (h^2%) and genetic advance over mean (GAM) for putative mutants of *cv*. Kosi in M_1V_2 generation

Traits	PCV (%)	GCV (%)	h^2 (%)	GAM (%)
Plant height (cm)	11.47	6.32	30.4	7.18
Plant spread (cm)	12.17	8.28	46.2	11.60
Number of branches	34.29	17.89	27.2	19.22
Leaf to stem ratio	23.08	11.74	25.9	12.30
Leaf area (cm^2)	15.80	8.01	25.7	8.37
Number of days taken for flowering	3.18	1.75	30.3	1.989
Fresh herbage yield per plant (g)	35.68	32.06	80.8	59.37
Fresh herbage yield per plot(kg)	36.87	30.38	67.9	51.58
Shade dried herb yield per plant (g)	37.02	33.98	84.3	64.26
Shade dried herb yield per plot(kg)	37.52	31.04	68.4	52.89
Essential oil content (%)	7.99	7.99	32.8	9.42
Essential oil yield per plant (g)	37.98	25.49	45.0	35.24
Essential oil yield per plot(g)	36.40	36.40	81.4	67.66

https://doi.org/10.37992/2023.1402.086

cent mean were expressed high for fresh herbage yield per plant (80.08% & 59.37%), fresh herbage yield per plot (67.90% & 51.58%), shade dried herbage yield per plant (84.30% & 64.26%), shade dried herb yield per plot (68.40% & 52.89%) and essential oil yield per plot (81.40% & 67.66%) respectively. The high estimates of heritability and GAM specified that additive genes direct these characters and there is ample scope for their enhancement through selection. Similar heritability pattern was also reported by Nair and Shiva (2003) and Venkatesha *et al.* (2020). Yield of mint is a result of interactions of a number of interrelated characters. For rational approach towards the improvement of yield, selection will be more rewarding when it is based on the components of yield. The efficiency of selection for yield mainly depends on the direction and magnitude of association between yield and its components and among themselves. In the present study, for all the characters, genotypic correlation coefficient was higher than respective phenotypic correlation coefficient (**Table 2**), which may be ascribed to the low effect of environment on the character expression. At genotypic level, positively and highly significant correlation of leaf area (0.549), shade dried herb yield per plant (0.483) and fresh herbage yield per plant (0.444) with essential oil yield per plant was observed in the study. At phenotypic level essential oil yield per plant had shown highly positive significant relationship with shade dried herb yield per plant (0.309) and fresh herb yield per plant (0.291). This is in agreement with the findings of Venkatesha *et al.* (2020). Correlation studies give an idea about the positive and negative associations of different characters with yield and also among themselves. However, the nature and extent of contribution of these characters towards yield is not obtained.

The path coefficient analysis between the components of EOY was worked out at genotypic and phenotypic levels (**Table 3 and 4**, respectively). At genotypic level the highest direct positive effect on essential oil yield per plant was recorded by shade dried herb yield per plant (1.326) followed by leaf area (0.859), number of days taken for flowering (0.509) and plant spread (0.411). Whereas, fresh herbage yield per plant (-1.115), plant height (-0.492), number of branches (-0.262) and leaf to stem ratio (-0.116) showed direct negative effect on essential oil yield per plant. At phenotypic level highest direct positive effect on essential oil yield per plant by the shade dried herb yield per plant (0.479), leaf to stem ratio (0.175), plant spread (0.117) and leaf area (0.104). Whereas, plant height (-0.254), number of branches (-0.132), days taken for flowering (-0.122) and fresh herbage yield per plant (-0.011) showed direct negative effect on essential oil yield per plant. Genotypically plant height exhibited maximum indirect negative effect through fresh herbage yield. The genotypic indirect effect of plant height, plant spread and shade dried herbage yield was negative and maximum through fresh herbage yield (-0.592, -0.448 and

Table 2. Estimates of genotypic and phenotypic correlation coefficients in putative mutants of *cv.* Kosi in M_1V_2 generation

		PH	PS	NB	LS	LA	NDF	FHY	SDHY	EOY
PH	G	1	0.735**	0.126	0.071	0.356**	-0.673**	0.530**	0.512**	-0.180
	P		0.589**	0.095	-0.297**	0.301**	-0.167	0.304**	0.346**	-0.076
PS	G		1	0.588**	-0.138	0.293**	-0.388**	0.401**	0.467**	0.136
	P			0.389**	-0.430**	0.300**	-0.160	0.401**	0.367**	0.023
NB	G			1	0.049	0.402**	-0.656**	0.412**	0.499**	0.126
	P				-0.350**	0.413**	-0.176	0.393**	0.367**	0.020
LS	G				1	0.185	0.503**	-0.718**	-0.711**	0.052
	P					-0.348**	0.130	-0.500**	-0.467**	0.008
LA	G					1	-0.805**	0.686**	0.791**	0.549
	P						-0.326**	0.509**	0.515**	0.147
NDF	G						1	-0.534**	-0.523**	0.004
	P							-0.279**	-0.299**	0.018
FHY	G							1	0.985**	0.444**
	P								0.948**	0.291**
SDHY	G								1	0.483**
	P									0.309**

PH : Plant height NDF : Number of days taken for flowering NB : Number of branches
PS : Plant spread FHY : Fresh herbage yield per plant SDHY : Shade dried herb yield per plant
LS : Leaf to stem ratio EOY : Essential oil yield per plant LA : Leaf area
*Significant at P=0.05 **Significant at P=0.01 r value at 5%= 0.212 and 1%= 0.276

Table 3. Estimates of genotypic path coefficient analysis in mutants of in *cv*. Kosi in M_1V_2 generation

	PH	PS	NB	LS	LA	NDF	FHY	SDHY	EOY
PH	**-0.492**	0.302	-0.033	-0.008	0.306	-0.343	-0.592	0.68	-0.180
PS	-0.361	**0.411**	-0.154	0.016	0.251	-0.198	-0.448	0.62	0.136
NB	-0.062	0.241	**-0.262**	-0.005	0.346	-0.334	-0.459	0.662	0.126
LS	-0.035	-0.057	-0.012	**-0.116**	0.159	0.256	0.802	-0.944	0.052
LA	-0.175	0.12	-0.105	-0.021	**0.859**	-0.41	-0.766	1.049	0.549
NDF	0.331	-0.159	0.172	-0.058	-0.692	**0.509**	0.596	-0.694	0.004
FHY	-0.261	0.165	-0.108	0.083	0.59	-0.272	**-1.115**	1.363	0.444
SDHY	-0.252	0.192	-0.13	0.082	0.679	-0.266	-1.146	**1.326**	0.483

*Significant at P=0.05, **Significant at P=0.01, r value at 5%= 0.212 and 1%= 0.27
Residual effect= 0.5243
Bold: Direct effect Above and below diagonal effect: indirect effect

Table 4. Estimates of phenotypic path coefficient analysis in mutants of *cv*. Kosi in M_1V_2 generation

	PH	PS	NB	LS	LA	NDF	FHY	SDHY	EOY
PH	**-0.254**	0.069	-0.012	-0.052	0.031	-0.020	-0.004	0.166	-0.076
PS	-0.150	**0.117**	-0.052	-0.075	0.031	-0.019	-0.004	0.176	0.023
NB	-0.024	0.045	**-0.132**	-0.061	0.043	-0.021	-0.004	0.176	0.020
LS	0.075	-0.050	0.046	**0.175**	-0.036	0.016	0.005	-0.224	0.008
LA	-0.076	0.035	-0.054	-0.061	**0.104**	-0.040	-0.006	0.247	0.147
NDF	0.042	-0.018	0.023	0.022	-0.034	**0.123**	0.003	-0.143	0.018
FHY	-0.077	0.047	-0.052	-0.087	0.053	-0.034	**-0.011**	0.455	0.291
SDHY	-0.088	0.043	-0.048	-0.081	0.053	-0.036	-0.011	**0.479**	0.309

PH : Plant height
FHY : Fresh herbage yield per plant
LS : Leaf to stem ratio
NDF : Number of days taken for flowering
NB : Number of branches
EOY : Essential oil yield per plant
PS : Plant spread
SDHY : Shade dried herb yield per plant
LA : Leaf area

Residual effect= 0.9034
Bold: Direct effect Above and below diagonal effect: indirect effect

-1.146, respectively), while it was negative for leaf to stem ratio through shade dried herbage yield (-0.944), positive for leaf area and fresh herbage yield through shade dried herbage yield (1.049 and 1.363, respectively) and negative for number of days taken for flowering through shade dried herbage yield (-0.694) and shade dried herbage yield through fresh herbage yield (-1.146).

Phenotypically the major indirect effect of plant height, plant spread, number of branches, leaf to stem ratio, leaf area, number of days taken for flowering and fresh herbage yield were through shade dried herbage yield (0.076, 0.176, 0.176, -0.224, 0.247, -0.144 and 0.455 respectively), while that of shade dried herbage yield was through plant height (-0.088).

The highest direct effect in positive direction on essential oil yield per plant was observed by leaf to stem ratio, leaf area, fresh herbage yield per plant, days taken for flowering and number of branches. Parallel findings are also reported by Singh *et al.* (2000). Hence, direct selection of these traits would be helpful for improvement of essential oil yield.

Essential oil yield per plant was found to have a positive and highly significant correlation with leaf area, shade dried herb and fresh herbage yield per plant. Hence, selection for these traits would also help in improving essential oil yield per plant in this crop. Selected 20 putative mutant lines are forwarded for further evaluation, selection and need to be stabilized in future generations.

REFERENCES

Burton, G.V. and Devane, E. M. 1953. Estimating heritability from replicated clonal material. *Agronomy Journal*, **45** (10): 478-481. [Cross Ref]

Comstock, R.R. and Robinson, H.F. 1952. Genetic parameters, their estimation and significance. In: Proceedings of 6th International Grassland Congress. State College, PA, USA: Pennsylvania State College, 1952, pp. 248–291.

Dewey, D.R. and Lu, K.H. 1959. A correlation and path co-efficient analysis of components of crested wheat grass seed production. *Agronomy Journal*, **51** (9): 515-518. [Cross Ref]

Ghosh, S.L. 2018. Determination of radio sensitivity of jasmine (Jasminum spp.) to gamma rays. *Electronic Journal of Plant Breeding*, **9**(3): 956-965. [Cross Ref]

Gustafsson, A. 1947. Practical utility of artificially induced mutation. *Hereditas*, **33**: 1-100.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soyabean. *Agronomy Journal*, **47**: 314-318. [Cross Ref]

Kumar, B., Kumar, U. and Kumar Yadav, H. 2015. Identification of EST-SSRs and molecular diversity analysis in *Mentha piperita*. *Crop Journal*, **3**: 335-342. [Cross Ref]

Kumar, R., Upadhyay, R.K., Venkatesha, K.T., Padalia, R.C. and Tiwari, A.K. 2019. Performance of different parts of planting materials and plant geometry on oil yield and suckers production of menthol mint (*Mentha arvensis* L.) during winter season. *International Journal of Current Microbiology and Applied Sciences*, **8** (1): 1261-1266. [Cross Ref]

Mahmud, I. and Kramer, H.H. 1951. Segregation for yield, height and maturity following a soyabean cross. *Agronomy Journal*, **43** (12): 605-609. [Cross Ref]

Naveena, N., Subramanian, S., Jawaharlal, M., Iyanar, K. and Chandrasekhar, C.N. 2020. Mutagenic effectiveness and efficiency of gamma rays and ethyl methane sulphonate on Hibiscus rosa-Sinensis L. Cultivar Red Single. *Electronic Journal of Plant Breeding*, **11**(04): 1187-1193. [Cross Ref]

Nair, A.S. and Shiva, K.N. 2003. Genetic variability, correlation and path coefficient analysis in gerbera. *Journal of Ornamental Horticulture*, **6** (3): 180-187.

Panse and Sukhatme, P.V. 1967. Statistical methods of agricultural workers. Indian Council of Agriculture Research, New Delhi.

Singh, S.P., Tiwari, R.K. and Dubey, T. 2000. Studies on selection parameters in *Mentha arvensis*. *Journal of Medicinal and Aromatic Plant Sciences*, **22** (1): 443-446.

Venkatesha, K.T., Singh, V.R., Padalia, R.C., Upadyay, R.K. and Divya. 2020. Correlation and path-analysis for morpho-economic traits and chemical constituents of essential oil in Corn mint (*Mentha arvensis* L.) accessions. *Arabian Journal of Medicinal and Aromatic Plants*, **6**(2): 1-16.