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Optimization of harvesting stages for higher yield of *Ocimum spp*. in North Indian Plains

Gupta M. ✉

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Abstract

Sweet basil (*Ocimum basilicum* L.) is a popular culinary herb belongs to the family *Lamiaceae.* Basil also named as great basil or saint-joseph-wart. Leaf of basil has a pungent & strong taste some Asian basils have a clove like flavour. Basil used as a culinary herbs have been reported to posses antioxidant activities. A field experiment was conducted at the research farm of CSIR-Central Institute of Medicinal and Aromatic Plant,Research Centre, Pantnagar (U.S.Nagar) Uttarakhand.India during kharif season 2018. The highest oil yield observed in T_2 Cim-Snigdha (126.99 kg/ha) as compared to T_3 Cim-Soumya (108.64 kg/ha), T_5 Cim-Surabhi (86.22 kg/ha) as compared to others. The lowest oil yield (37.90 kg/ha) recorded in T_4 Cim-Jyoti. Oil yield also differ at different harvest stages of different *Ocimum sp*. The highest oil yield 142.69 kg/ha observed at 100% flowering stage (S_4) as compared to 138.56 kg/h at seed setting stage (S_5), 63.60 kg/ha at 50% flowering stage (S_3), and 56.63 kg/ha at bud initiation stage (S_2). The lowest oil yield 25.54 kg/ha recorded at pre budding stage (S_1). The highest oil yield 267.00 kg/ha was recorded in T_3S_4 interaction of variety and harvest stages (*Cim-Soumya* at 100% flowering) as compared to other treatments. Therefore recommended the Ocimum should be harvest at 100% flowering stage to get maximum oil yield and return to the farmers as compared to other.

Key words: ***Ocimum basilicum L., bud initiation stage, perennial, mediterranian basils***

Introduction

Sweet basil (*Ocimum basilicum* L.) is a popular culinary herb belongs to the family *Lamiaceae.* Basil also named as great basil or saint-joseph-wart. The original place of basil is central Africa to Southeast Asia. It is a tender plant & used in cuisines worldwide. Traditionally basil is a green plant, some varieties, such as leaves purple in color. Basil grows between 30-130cm (12-51in) is tall, with opposite, light green, silky leaves 3-11cm (1.2-4.3in) long and 1-6cm (1.2-4.3in) long and 1-6cm (0.39-2.36in) in broad. The flowers are small, white in color and arranged in a terminal spike. Basil leaves have wilted from lack of water. Yellow leaf of bottom indicated plant stressed. Basil can also be propagated reliably from cuttings with the stem short cutting soak in water until roots develop. It can be cultivated as annual/ seasonal to perennial depends on climatic conditions as in frost prone area as seasonal and in hot area as perennial. Basil has shown antioxidant and antimicrobial activities due to its phenolic and aromatic compounds (Gutierrez *et al.,* 2008; Hussain *et al.,* 2008; Suppakul *et al.,* 2003). Leaf of basil has a pungent and strong taste some Asian basils have a clove like flavor. Its stronger then the mediterranian basils. Basil is commonly used in fresh because cooking quickly destroy the flavor.it is a main ingredients in pesto dish. Basil used as a Culinary herbs have been reported to posses antioxidant activities (Yanishlieva *et al.,* 2006) suggesting that they might have potential human health benefits. The aromatic and curative properties of basil are connected with the presence of essential oil, mainly in the leaves and flowers. Basil essential oil is used to flavours foods, dental and oral products in fragrances and in medicines. *Basilicum* sp. Contains high concentration of Linalool & Methyl chevicol 3:1 ratio aroma basil have 1,8-cineale & methyl eugenol. *Basilicum sp. Cim-Soumya, Cim-Sharda, Cim-Surabhi and Cim-Jyoti* released by *CSIR-CIMAP*. *Cim-Soumya* have a two strong component i.e. methyl chevicol (62.5-77.6 %) and linalool (14.4-34.1 %). Chemical component of *Cim-sharda* in methyl chevicol, 1,8-cineole,linalool, l-campher, limonene, campene

Author's Address
117/622, Q Block, Sharda Nagar, Kanpur 208025 (U.P.)
E-mail.: *gupta_monika2005@yahoo.com*

germacrene D. Methyl eugenol major compound of *Cim-Sharda. Cim-Surabhi* survive better in winter season comparison to other basilicum sp. *Cim-Surabhi* have higher linalool content (70-75%) with low amount of linalool acetate (8.50%). Cim-Surabhi also suitable for rainfed cultivation (March-December). *Cim-Jyoti* of *Ocimum africanum* essential oil compound is citrol, 1,8-cineole, linalool, L-camphor ,limonene, eugenol, comphene germacrene-D. is the major compound. Major compound of *Cim-Snigdha* is methyl cinnamate is widely used in aroma, pharmaceutical & cosmetic industries. The new strains of *Ocimum basillicum* (OBH-3 now christened as *Cim-Snigdha). Cim-Snigdha* is an improved herb oil yield variety content (78.7%) methyl cinnamate (CSIR-CIMAP, 2015). This variety regularly recorded a higher biomass & oil yield. At present the demand of Ocimum oil is done on the basis of oil type and its increasing in day by day on national and international market at the same time gap between demand and supply also increased. Demand is very high comparison to production rate. At present market price of Ocimum oil is 1000-1200 per kg oil.

Materials and Methods

Experimental site: A field experiment was conducted at the research farm of CSIR-Central Institute of Medicinal and Aromatic Plant, Research Centre, Pantnagar (U.S.Nagar) Uttarakhand India during kharif season 2018. The experimental site is located between 29^0N latitude and 70.38 E longitudes and at an altitude of 243m above mean sea level. The maximum temperature ranges between 35 to 45^0C, and minimum between 2^0C to 5^0C. the experimental soil was sandy-loam in texture, neutral in reaction (7.2 ph), medium in organic carbon (0.52%), low in available nitrogen (135 kg ha^{-1}), and medium in available phosphorus (13 kg ha^{-1}) as well as in potassium (140 kg ha^- The experimental design is randomized block design five treatment and five harvesting stages.

Transplanting material: The crop is propagated by seed. 500gm seed required in one hectare field for raising nursery.

Raising of nursery: The raised nursery of basil sp. (Cim-Surabhi, Cim-Jyoti, Cim-Soumya, Cim-Snigdha and Cim-Sharda) by seed. The seeds of *Ocimum* were shown on 21/05/2018 in well pulverized field at 1-2 cm depth in row. The sizes of each bed with inter row spacing of 15cm and intra row spacing is continuous. Seeds were covered by fine soil of the field and provided light irrigation just after covering. Nursery beds were irrigated as per the need of crop.

Field preparation: Recommended dose of fertilizers were applied @ 80:60:40 NPK/ha. The full dose of P & K and $1/3^{rd}$ of N applied as basal and remaining $2/3^{rd}$ dose of N applied in two equal splits at 25 & 40 days after transplanting. Irrigate the crop as and when desired. The appropriate plant protection measures were followed. The crop was kept free from weeds by hand weeding.

Experimental design and details of treatments

The field experiment was laid out in a Factorial Randomized Block Design with five *Ocimum* spp. (Cim-Sharda, Cim-Snigdha, Cim-Somya, Cim-Surabhi) and *Ocimum africanum* (Cim-Jyoti) and five harvest stages i.e. S_1-pre budding stage, S_2-bud initiation stage, S_3-50% flowering, S_4-100% flowering (full blooming), S_5-seed setting stage in three replications. The numerical data of all the components were subjected to analysis of variance (ANOVA) using randomized block design. Statistical analysis of data was done following standard procedures (Snedecor and Cochran, 1967).

Transplantation of crop: Transplanting of seedling is done in 15/06/2018 with treatment spacing row to row 40cm and plant to plant 30cm. Transplanted to the respected field at 3-4 leaf stage (25 days old seedlings).

Growth and yield analysis: The effect of sweet basil *Ocimum basilicum* L. (Cim-Sharda, Cim-Snigdha, Cim-Somya, Cim-Surabhi) and *Ocimum africanum* (Cim-Jyoti) as T_1 Cim-Sharda, T_2 Cim-Snigdha, T_3 Cim-Soumya, T_4 Cim-Jyoti and T_5 Cim-Surabhi and harvest stages like i.e. S_1-pre budding stage, S_2- bud initiation stage, S_3-50% flowering, S_4-100% flowering (full blooming), S_5-seed setting stages on plant height, number of branches, fresh herb yield, and oil yield.

Results and Discussion

The field experiment was conducted at the research farm of CSIR-CIMAP Research Center Pantnagar during kharif season 2018 to evaluate the effect of *Ocimum spp.* and harvest stages on plant height,

number of branches, fresh herb yield, and oil yield of sweet basil *Ocimum basilicum* L. (Cim-Sharda, Cim-Snigdha, Cim-Somya, Cim-Surabhi) and *Ocimum africanum* (Cim-Jyoti) at different harvest stages like i.e. S_1-pre budding stage, S_2- bud initiation stage, S_3-50% flowering, S_4-100% flowering (full blooming), S_5-seed setting stage. Spacing *Ocimum spp.* transplanted at 40 and 30 cm as inter row and intra row spacing respectively. Fetilizers were applied @ 80:60:40 NPK/ha. The full dose of P and K and 1/3rd of N applied as basal and remaining 2/3rd dose of N applied in two equal splits at 25 and 40 days after transplanting. Irrigate the crop as and when desired. The appropriate plant protection measures were followed.

Plant height: The detailed scrutiny of table-1 revealed that the maximum plant height (101.5 cm) was recorded in T_5 Cim-Surabhi followed by (94.3 cm) T_3 Cim-Soumya, (93.9 cm) T_2 Cim-Snigdha, (92.6cm) T_1 Cim-Sharda, and the lowest plant height (85.3cm) were recorded in T_4 Cim-Jyoti.

The plant height at different growth stages of ocimum species also differ significantly the highest plant height (134.3cm) recorded in S_5 (seed setting stage) as compared to (107.5cm) at S_4 (100% flowering), (88.7cm) at S_3 (50% flowering), (69.3cm) at S_2 (bud initiation stage) the lowest plant height (67.7cm) at S_1 (pre budding stage).

The interaction effect of *Ocimum sp*. and growth stage on plant height shows a highest plant height (144.7cm) at T_4S_5 Cim-Jyoti (seed setting stage) as followed by (124.7cm) at T_5S_4 Cim-Surabhi (100% flowering), (99.0cm) at T_1S_3 Cim-Sharda (50% flowering), (86.0cm) at T_5S_1 Cim-Surabhi (pre budding stage) the lowest interaction (83.0cm) recorded in Cim-Surabhi (bud initiation stage). The results obtained are in agreement with results obtained by (Ersahin, 2006)

Numbers of branches / plant: Table-2 shows a detailed study of no. of branches of *Ocimum sp*. The maximum no. of branches (25) per plant was recorded in T_1 Cim-Sharda and T_5 Cim-Surabhi as compared to (23) per plant at T_3 Cim-Soumya and T_4 Cim-Jyoti. While lowest no. of branches (21) per plant was observed in T_2 Cim-Snigdha. The no. of branches differs at different growth stages of the experiment. The maximum no. of branches (29) per plant found in S_3 (50% flowering), as compared to (27) per plant at S_2 (bud initiation stage), (26) per plant at S_5 (seed setting stage) and (20) per plant at S_4 (100% flowering stage). The lowest (15) per plant no of branches were recorded in S_1 (pre budding stage). The interaction b/w harvest stage and different sp. The heighest (36) per plant no. of branches observed at T_5S_5 Cim-Surabhi (seed setting stage) as followed (35) per plant T_1S_3 Cim-Sharda (50% flowering stage), (28) per plant Cim-Soumya (bud initation stage), (22) per plant Cim-Snigdha (100% flowering stage). The lowest (20) interaction of no.of branches were recorded in T_1S_1 Cim-Sharda (pre budding stage). The similar trends of results were reported by Ekren *et al.,* 2009.

Fresh herb yield: The detailed fresh herb yield of *Ocimum sp* experiment describe in table-3.the highest fresh herb yield (144.67 q/ha) observed at T_1 Cim-Sharda as compared to (139.57 q/ha) T_2 Cim-Snigdha, (126.2 q/ha) T_5 at Cim-Surabhi, (107.19 q/ha) T_3 at Cim-Soumya. The lowest fresh herb yield (93.95q/ha) found in T4 Cim-Jyoti. Fresh herb yield of *Ocimum spp*. also differ significantly at different harvest stages. The highest fresh herb yield (217.104 q/ha) S_5 seed setting stage as compared to (145.68 q/ha) at S_4 100% flowering, (118.61q/ha) at S_3 50% flowering, (67.55q/ha) at S_1 pre budding stage. The lowest fresh herb yield (62.70q/ha) observed in S_2 bud initiation stage. Fresh herb yield of *Ocimum spp*. interaction between varieties and harvest stage. The highest fresh herb yield (330.96 q/ha) were recorded in T_1S_5 Cim-Sharda at seed setting stage as comparesd to (196.44 q/ha) T_5S_4 Cim-Surabhi at 100% flowering, (178.32 q/ha) Cim-Sharda at 50% flowering, (108.80 q/ha) Cim-Surabhi at bud initiation stage. Lowest fresh herb yield recorded in (51.20 q/ha) Cim-Jyoti at pre budding stage. The similar observations were reported by Ekren *et al.,* 2009; Ersahin, 2006; Nurzynska-Wierdak, 2007.

Oil yield: Table-4 shows an effect of oil yield of *Ocimum spp.* in different varieties & harvest stages. The highest oil yield observed in (126.99 kg/ha) at T_2 Cim-Snigdha as compared to (108.64 kg/ha) at T_3 Cim-Soumya, (86.22 kg/ha) at T_5 Cim-Surabhi and (67.26 kg/ha) at T_1 Cim-Sharda. The lowest oil yield (37.90 kg/ha) recorded in T_4 Cim-Jyoti. Oil yield also differ at different harvest stages of different *Ocimum spp*. The highest oil yield (142.69 kg/ha) at S_4 100% flowering stage as compared to (138.56kg/ha) at S_5 seed setting stage, (63.60kg/ha) at S_3 50% flowering stage, (56.63kg/ha) at S_2 bud initiation stage. The lowest oil yield (25.54 kg/ha)

Table 1. Effect of different varieties and harvest stages on plant height of *Ocimum spp.*

Treatment	S_1	S_2	S_3	S_4	S_5	Mean
T_1	63.0	67.3	99.0	92.0	141.7	92.6
T_2	70.0	74.3	94.7	110	120.3	93.9
T_3	71.3	67.3	86.3	104.7	141.7	94.3
T_4	48.3	54.3	73.0	106.3	144.7	85.3
T_5	86.0	83.0	90.7	124.7	123.3	101.5
Mean	67.7	69.3	88.7	107.5	134.3	
SoV	S		T		S*T	
$SEm_{\pm}$	0.58		0.58		2.90	
LSD $_{(P=0.05)}$	1.64		1.64		8.24	

Table 2. Effect of different varieties and harvest stages on number of branches of *Ocimum spp*.

Treatment	S_1	S_2	S_3	S_4	S_5	Mean
T_1	20	26	35	19	24	25
T_2	12	27	29	22	15	21
T_3	14	28	24	21	28	23
T_4	12	27	30	18	29	23
T_5	17	28	27	19	36	25
Mean	15.0	27	29	20	26	
SoV	S		T		S*T	
$SEm_{\pm}$	0.60		0.60		3.04	
LSD $_{(P=0.05)}$	1.73		1.73		8.65	

Table 3. Effect of different varieties and harvest stages on fresh weight q/ha of *Ocimum spp.*

Treatment	S_1	S_2	S_3	S_4	S_5	Mean
T_1	75.60	38.88	178.32	99.60	330.96	144.67
T_2	74.64	62.31	139.47	172.08	249.36	139.57
T_3	65.64	55.24	59.15	183.84	172.08	107.19
T_4	51.20	48.29	130.76	76.44	163.08	93.95
T_5	70.68	108.80	85.35	196.44	170.04	126.26
Mean	67.55	62.70	118.61	145.68	217.104	
SoV	S		T		S*T	
$SEm_{\pm}$	1.93		1.93		9.66	
LSD $_{(P=0.05)}$	5.49		5.49		27.46	

Table 4. Effect of different varieties and harvest stages on oil yield L/ha of *Ocimum spp.*

Treatment	S_1	S_2	S_3	S_4	S_5	Mean
T_1	14.73	41.75	101.00	50.00	128.84	67.26
T_2	43.62	86.00	88.12	167.19	250.00	126.99
T_3	23.00	68.17	34.51	267.00	150.54	108.64
T_4	22.32	23.68	51.32	44.62	47.58	37.90
T_5	24.03	63.55	43.05	184.65	115.82	86.22
Mean	25.54	56.63	63.60	142.69	138.56	
SoV	S		T		S*T	
$SEm_{\pm}$	1.18		1.18		5.88	
LSD $_{(P=0.05)}$	3.34		3.34		16.72	

T_1 Cim-Sharda, T_2 Cim-Snigdha, T_3 Cim-Soumya, T_4 Cim-Jyoti and T_5 Cim-Surabhi, S_1-pre budding stage, S_2- bud initiation stage, S_3-50% flowering, S_4-100% flowering (full blooming), S_5-seed setting stage

recorded in S_1 pre budding stage. The interaction effect of Ocimum species and different harvest stages were also differ. The highest (267.00 kg/ha) oil yield interaction shows in T_3S_4 *Cim-Soumya* at 100% flowering as compared to (250.00 kg /ha) T_2S_5 at *Cim-Snigdha* seed setting stage, (101.00 kg/ha) T_1S_3 *Cim-Sharda* 50% flowering, (86.00 kg/ha) T_2S_2 *Cim-Snigdha* bud initiation stage. The lowest interaction of oil yield recorded in (43.62 kg/ha) T_2S_1 *Cim-Snigdha* at pre budding stage.

Conclusion

The observation recorded revealed that among Ocimum spp. Variety T_2 *Cim-Snigdha* provided highest oil yield (126.99 q/ha). While harvesting of *Ocimum spp.* at S_4 (100 % flowering stage) provided highest oil yield as compared to other stages. The interaction effect of variety & harvest stages are also differ significantly maximum oil yield of Ocimum spp. T_3 *Cim-Soumya* at 100% flowering stage provided highest oil yield (267.00 q/ha). Therefore recommended the Ocimum should be harvest at 100% flowering stage to get maximum oil yield and return to the farmers as compared to other.

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