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Research Article

Yield, and Quality Enhancement of Sweet Basil (*Ocimum basilicum* L.) through Integration of Spacing and Fertilizers under Telangana Conditions

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ABSTRACT

To study the integration of spacing and fertilizers on yield and quality enhancement of sweet basil (*Ocimum basilicum* L.) under Telangana conditions, a field experiment was conducted in Factorial RBD with three replications in 2020-2021 at the medicinal and aromatic plants research station, Rajendranagar, Hyderabad, to analyze quantitative and qualitative parameters of sweet basil as influenced by spacing and inorganic fertilizers. There were 15 treatment combinations consisting of two factors, viz., 3 plant spacings (S_1: 40 cm × 20 cm, S_2: 50 cm × 30 cm, and S_3: 60 cm × 40 cm) and 5 fertilizer levels (F_1: 60:30:30 NPK Kg/ha; F_2: 90:45:45 NPK Kg/ha, F_3: 120:60:60 NPK Kg/ha, F_4: 150:75:75 NPK Kg/ha, F_5: Absolute control). Results indicated that maximum fresh herbage yield (296.10 q/ha), seed yield (420.00 Kg), essential oil percentage (0.33%), and oil yield (54.65 kg/ha) were found in the treatment combination of 40 cm × 20 cm spacing and 150:75:75 NPK Kg/ha (S1F4). Treatments did not affect the concentration of limonene, linalool, methyl chavicol, eugenol, methyl eugenol, β-elemene, caryophyllenenor, and antioxidant activity in basil oil.

Keywords: Sweet basil; Spacing; Fertilizers; Yield; Quality

INTRODUCTION

Ocimum basilicum L. (Sweet basil) is a popular food seasoning belonging to the family Lamiaceae which is characterized by a great variability of morphology and chemotypes. Sweet basil, originally native to India and other regions of Asia, is utilized as an ingredient in Western and Mediterranean diets. Its leaves contain essential oils of strong aroma. Basil leaves and shoots are used fresh or dried in culinary applications. Some studies have reported that sweet basil contains high concentrations of phenolic compounds, which are characterized by high antioxidant capacities. Basil extracts are also used in the manufacturing of cosmetic and pharmaceutical products or biopesticides. The high economic value of basil oil is due to the presence of a complex mixture of volatile substances, monoterpenes, sesquiterpenes and their oxygenated analogs present at low concentrations in plants.

These oil compounds determine the specific aroma and flavours for each basil species and variety. Basil essential oil is synthesized and stored in glandular trichomes of leaves. Generally, the main compounds responsible for the typical aroma are 1,8-cineole, methyl cinnamate, methyl chavicol and linalool. In basil, more than 200 compounds from the essential oil were identified and different chemotypes have been classified for *O. basilicum* according to the essential oil chemical composition. Basil oil was reported to have antimicrobial, antioxidant, and insecticidal properties.

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Fresh basil is widely used in Mediterranean cuisine with foods such as tomato products, vegetables, salads, pizza, meat, soups, and seafood. It is commonly known that the presence of essential oils and their composition determine the specific aroma of plants and the flavour of the condiment, while coloured (or purple) basils are used for decorative purposes. As a spice, dried and ground basil leaves are used in bakery products, confectionary, ice creams, vinegars, meat, and flavoring products.

There is a strong interest in growing medicinal and aromatic plants to produce a desired essential oil chemical profile. Active principal constituents from the basil essential oil are affected by diversified factors water stress, salt stress, extraction processes and drying methods as well as, cultivation practices as effect of plant nutrition and plant densities on sweet basil productivity and essential oil composition. The hypothesis of this study was that spacing and conventional fertilizer administered to sweet basil would result in significant differences in growth, essential oil yield or composition. The objective of this study was to evaluate the effects of spacing, and conventional fertilizers applied at five different doses of fertilizer application rates and three different spacing on yield essential oil production as well as chemical profile in sweet basil [1].

MATERIALS AND METHODS

The field experiment was conducted at medicinal and aromatic plants research station, Rajendranagar, Hyderabad during 2020-21. The field was ploughed crosswise, harrowed twice and harrowing. The seeds of sweet basil were sown in nursery beds in the month of July (last week). One month old seedlings were transplanted in plot size 5 M × 4 M factorial randomized block design with fifteen treatments which were replicated three times. The framed out treatments for the experiment were T_1=S_1F_1-40 cm × 20 cm+60:30:30 NPK Kg/ha, T_2=S_1F_2-40 cm × 20 cm +90:45:45 NPK Kg/ha, T_3=S_1F_3-40 cm × 20 cm+120:60:60 NPK Kg/ha, T_4=S_1F_4-40 cm × 20 cm+150:75:75 NPK Kg/ha, T_5=S_1F_5-40 cm × 20 cm+Absolute Control, T_6=S_2F_1-50 cm × 30 cm+60:30:30 NPK Kg/ha, T_7=S_2F_2-50 cm × 30 cm+90:45:45 NPK Kg/ha, T_8=S_2F_3-50 cm × 30 cm+120:60:60 NPK Kg/ha, T_9=S_2F_4-50 cm × 30 cm+150:75:75 NPK Kg/ha, T_{10}=S_2F_5-50 cm × 30 cm+Absolute Control, T_{11}=S_3F_1-60 cm × 40 cm+60:30:30 NPK Kg/ha, T_{12}=S_3F_2-60 cm×40 cm+90:45:45 NPK Kg/ha, T_{13}=S_3F_3-60 cm × 40 cm+120:60:60 NPK Kg/ha, T_{14}=S_3F_4-60 cm × 40 cm+150:75:75 NPK Kg/ha, T_{15}=S_3F_5-60 cm × 40 cm +Absolute Control.

Data collection: The experimental plots were observed frequently to record changes in plant characters at different physiological stages of growth. Five plants were randomly selected from each plot and data was recorded.

Fresh yield per plot (kg): At the time of harvest the whole net plot was harvested and weighed by using the electronic balance and the mean was worked out and expressed in terms of kilograms (kg) per plot.

Dry yield per plot (kg): After taking fresh weight, the plant samples were dried in sun for one week. Till the samples attained a constant weight and then weighed. The dry yield was expressed in terms of kilograms (kg) per plot.

Fresh yield per hectare (q): The fresh yield per hectare was computed based on per plot yields and was expressed in quintals per hectare.

Dry yield per hectare (q): The dry yield per hectare was computed based on dry yields per plot and was expressed in quintals per hectare.

Seed yield per plot (kg): At the time of harvest the whole net plot was harvested and dried to extract the seed and weighed by using the electronic balance and expressed in terms of kilograms (kg) per plot.

Seed yield per hectare (kg): The seed yield per hectare was computed based on seed yield per plot and expressed in kilograms.

Essential oil content: Oil recovery was estimated by hydro distillation method using Clevenger apparatus. To estimate the oil recovery 1000 g of fresh herbage sample, comprising of leaves, inflorescence, and small twigs, was taken. The chopped sample was put in 5000 ml capacity round bottom flask half filled with water. Distillation was done for about 2 to 3 hours. The oil being lighter than water got collected in the burette and reading was recorded which were later transferred into a test tube and was recorded as oil recovery. The essential oil was dried over anhydrous sodium sulphate and stored at 4-6°C, until analysed.

The essential oil content was calculated by using formula:

Essential oil content (% Volume/Weight basis)=Quantity of essential oil (ml) × 100 Weight of herb (g)

Essential oil yield (kg/ha): The values obtained from essential oil content percentage are used for calculating the essential oil yield in kg/ha by using the formula:

Total oil yield kg/ha=Total dry biomass (kg/ha) × Essential oil content

Composition of essential oil: The Varian CP-3800 gas chromatograph was equipped with a 30 m 0.25 mm, 0.25 mm film thickness DB-5 capillary column. The carrier gas (H_2) was used as mobile phase with an average flow of 0.5 ml/min in the split ratio of 1:25, makeup flow (N_2 gas) at 28 ml min^{-1} flow; the temperature of S/SL injector and detector (FID) was 280°C. A 1 ml headspace syringe was utilized to draw the sample from vial. The column oven was programmed from 120°C to 280°C at the rate of 8°C min^{-1} by the final hold time of 2 min. Sample was injected in split mode, injector and detector temperature being at 250°C and 280°C respectively. The peaks generated in the total ion chromatogram are identified standard reference peaks.

Antioxidants: DPPH (2,2-diphenyl-1-picrylhydrazyle) method. The antioxidants present in seed were analysed as suggested by Brand-Williams et al. [2].

The antioxidant activity was determined by the ability of extract to scavenge DPPH (2,2-diphenyl-1-picryl-hydrazyl) radical. This method was described by Brand-Williams et al. DPPH is reduced by antioxidant present in the sample. The optical absorbance of this purple-coloured solution of DPPH in methanol is measured at 517 nm. This change is detected by the UV spectrophotometer. The reduction of the DPPH radical was determined by measuring the absorption of the resulting oxidised solution at 517 nm against methanol blank. To 1 ml of methanol, 3 ml of DPPH was added and used as control. Methanol was used as blank. Total Antioxidant capacity of sample by DPPH assay was expressed as Trolox Equivalents mg/100 g sample [3].

Per cent inhibition=AC–AE/AE × 100

Where,

AC: Absorption of control

AE: Absorption of extract or standard

TAC by DPPH assay TE mg/100 g=std. conc. × sample % inhibition × volume made up × 100./sample % inhibition × aliquot taken sample weight (g) × 1000

The data recorded were subjected to statistical analysis using factorial randomized block design and ANOVA technique suggested by Panse and Sukhatme.

RESULTS AND DISCUSSION

The present study was carried out to investigate the effect of fertilizer and spaceing on yield and quality of sweet basil. The results obtained from the experiments have been cited and discussed in Tables.

Fresh yield per plot and per hectare

There was a significant difference observed among the treatments. The treatment combination of 40 cm × 20 cm spacing and 150:75:75 NPK Kg/ha (S_1F_4) recorded maximum fresh yield per plot (59.22 Kg) and was followed with other treatment S_1F_3 of 40 cm × 20 cm spacing and 120:60:60 NPK Kg/ha (56.28 Kg). The lowest fresh yield per plot (15.02 Kg) was observed at treatment combination of 60 cm × 40 cm and absolute control (S_1F_5) (Table 1).

Table 1: Yield enhancement of sweet basil (*Ocimum basilicum* L.) through integration of spacing and fertilizers under Telangana conditions.

Treatments	Fresh yield/plot (Kg)	Fresh yield/hectare (q)	Dry yield/plot (kg)	Dry yield/hectare (q)
Spacings				
S_1	51.23	256.14	29.39	146.93
S_2	31.4	156.99	17	85
S_3	22.06	110.28	11.63	58.14
S.Em ±	0.25	1.18	0.11	0.7
CD at 5%	0.75	4.11	0.33	2.32
Fertilizer levels				
F_1	33.57	167.83	19.03	95.17
F_2	34.41	172.03	19.38	96.88
F_3	40.03	200.13	21.54	107.72
F_4	42.58	212.9	22.27	111.35
F_5	23.89	119.45	14.47	72.33
S.Em ±	0.33	1.52	0.16	0.91
CD at 5%	1.03	5.31	0.48	2.73
Interactions (Spacing and fertilizer levels)				
S_1F_1	51.43	257.15	29.22	146.1
S_1F_2	52.55	262.75	29.84	149.2
S_1F_3	56.28	281.4	32.1	160.5

S_1F_4	59.22	296.1	33.12	165.6
S_1F_5	36.66	183.3	22.65	113.25
S_2F_1	28.81	144.05	16.3	81.5
S_2F_2	29.39	146.95	16.4	82
S_2F_3	37.52	187.6	19.66	98.3
S_2F_4	41.28	206.4	20.19	100.95
S_2F_5	19.99	99.95	12.45	62.25
S_3F_1	20.46	102.3	11.58	57.9
S_3F_2	21.28	106.4	11.89	59.45
S_3F_3	26.28	131.4	12.87	64.35
S_3F_4	27.24	136.2	13.5	67.5
S_3F_5	15.02	75.1	8.3	41.5
S.Em ±	0.57	2.63	0.25	1.58
CD at 5%	1.71	7.92	0.75	4.74
Spacings			Fertilizer levels	
S_1-40 cm × 20 cm			F_1-60: 30: 30 NPK Kg/ha	
S_2-50 cm × 30 cm			F_2-90: 45: 45 NPK Kg/ha	
S_3-60 cm × 40 cm			F_3-120: 60: 60 NPK Kg/ha	
			F_4-150: 75: 75 NPK Kg/ha	
			F_5-Absolute control	

Significant variation in fresh yield per hectare was observed among the interaction effects. The treatment combination of 40 cm × 20 cm spacing and 150: 75: 75 NPK Kg/ha (S_1F_4) recorded maximum fresh yield per hectare (296.10 q) and was followed with other treatment S_1F_3 40 cm × 20 cm spacing and 120:60:60 NPK Kg/ha (281.40 q). The lowest fresh yield per hectare (75.10 q) was observed at treatment combination of 60 cm × 40 cm and absolute control (S_1F_5).

The maximum fresh yield per plot and hectare was noticed with closer spacing of 40 cm × 20 cm (S_1), higher plant population per unit area is noticed under closer spacing when compared to wider spacing which ultimately resulted in higher fresh yield per plot and per hectare. This may be attributed to the increase in number of plants per unit area and optimum utilization of above and below ground resources at closer spacing. The above results agree with the findings of Martin and Christian, Bekhradi et al., Abbas, in *Ocimum basilicum*, Pooja et al., Mounika et al., in *Ocimum santum* [4-8].

From the data it is revealed that, maximum fresh yield per plot and per hectare was recorded in F_4 (150:75:75 NPK Kg/ha) in both the seasons, the increase in yield may be attributed to the fact that under increasing nitrogen levels, there would be luxuriant vegetative growth of the plant, which leads to production of fresher yield per plot and per hectare. Further it might be due to better vegetative growth in terms of plant height, number of branches through different sources per plant and widen plant spread over other treatments. Moreover, it was due to the application of optimum and balanced nutrients through inorganic sources, promoted better photosynthetic activity that resulted in increased carbohydrate synthesis. The above results agree with the findings of Hassan et al., Baraa Al-Mansour, Ipsilandis et al., in *Ocimum basilicum* [9-11].

Interaction between spacing and nutrients had a significant effect on fresh yield per plot and per hectare in both Kharif and Rabi seasons. The treatment combination of 40 cm × 20 cm spacing and 150:75:75 NPK Kg/ha (S_1F_4) recorded maximum fresh yield per plot and per hectare. This may be due to the positive effect of closer spacing and nutrients individually on higher vegetative growth and reflection of the same beneficial effect in combination. Similar findings were observed by Amir and Bilal, in Sweet basil, Pooja et al., in Sacred basil [12].

Dry yield per plot and per hectare

Dry yield per plot varied significantly due to spacing at all the stages of plant growth. At closer spacing of S_1-40 cm × 20 cm recorded the highest dry yield per plot (29.39 Kg). The minimum dry yield per plot (11.63 Kg) was noticed in wider spacing of S_3-60 cm × 40 cm. Fertilizer application had a significant effect on dry yield per plot. The maximum dry yield per plot (22.27 Kg) was recorded in F_4 (150:75:75 NPK Kg/ha) followed by F_3 (120:60:60 NPK Kg/ha) (21.54 Kg) and minimum dry yield per plot (14.47 Kg) was noticed in absolute control (F_5).

Significant variation in dry yield per plot was observed among the interaction effects. The treatment combination of 40 cm × 20 cm spacing and 150:75:75 NPK Kg/ha (S_1F_4) recorded maximum dry yield per plot (33.12 Kg) and was followed with other treatment S_1F_3 40 cm × 20 cm spacing and 120:60:60 NPK Kg/ha (32.10 Kg). The lowest dry yield per plot (8.30 Kg) was observed at treatment combination of 60 cm × 40 cm and absolute control (S_1F_5).

All spacings differed significantly with respect to dry yield per hectare. Among the spacings, S_1-closer spacing of 40 cm × 20 cm recorded the highest dry yield per hectare (146.93 q). The minimum dry yield per hectare (58.14 q) was noticed in wider spacing of 60 cm × 40 cm.

The maximum dry yield per hectare was recorded in F_4 (150:75:75 NPK Kg/ha) (111. 35 q) followed by F_3 (120:60:60 NPK Kg/ha) (107.72 q) and minimum dry yield per hectare (72.33 q) was noticed in absolute control (F_5).

The maximum dry yield per hectare was recorded in treatment combination of 40 cm × 20 cm spacing and 150:75:75 NPK Kg/ha (S_1F_4) (165.60 q) and was followed with other treatment S_1F_3 40 cm × 20 cm spacing and 120:60:60 NPK Kg/ha (160.50 q). The lowest dry yield per plant (41.50 q) was observed at treatment combination of 60 cm × 40 cm and absolute control (S_3F_5).

The maximum dry yield per plot and per hectare was noticed with closer spacing of 40 cm × 20 cm (S_1); this was due to the fact that the more number of plants per unit area at this spacing helped to accumulate higher dry matter. The above results are in agreement with the findings of Martin and Christian, Bekhradi et al., in *Ocimum basilicum*, Kumar et al., [13], Pooja et al., Mounika et al., in *Ocimum santum*.

From the data it is revealed that, maximum dry yield per plot and per hectare was recorded in F_4 (150:75:75 NPK Kg/ha) in both the seasons, this was due to positive role played by inorganic fertilizer on growth and metabolism of plants, which increased the accumulation of dry matter in the plant. The above results are in agreement with the findings of Baraa Al-Mansour and M. Vasundhara, Ipsilandis et al., in *Ocimum basilicum*, Cheena et al., [14], in Clove basil, and Mahantesh et al., in Japanese mint [15].

Interaction between spacing and nutrients had significant effect on dry yield per plot and per hectare the treatment combination of 40 cm × 20 cm spacing and 150:75:75 NPK Kg/ha (S_1F_4) recorded maximum dry yield per plot and per hectare. This may be due to positive effect of closer spacing and nutrients individually on higher vegetative growth and the same beneficial effect has been reflected in the combination also. Similar findings were observed by Olcay and Emine [16], Amir and Bilal in Sweet basil.

Seed yield per plot and per hectare

A significant difference observed among the spacings with respect to seed yield per plot. Significantly higher value was recorded in S_1-closer spacing of 40 cm × 20 cm recorded the highest seed yield per plot (0.63 Kg). While it was minimum seed yield per plot (0.41 Kg) noticed in wider spacing of 60 cm × 40 cm. Fertilizer application had significant effect on seed yield per plot. The maximum seed yield per plot was recorded in F_4 (150:75:75 NPK Kg/ha) (0.72 Kg) followed by F_3 (120:60:60 NPK Kg/ha) (0.63 Kg) while it was minimum (0.33 Kg) noticed in absolute control (F_5) (Table 2).

Table 2: Quality enhancement of sweet basil (*Ocimum basilicum* L.) through integration of spacing and fertilizers under Telangana conditions.

Treatments	Seed yield/plot (Kg)	Seed yield/hectare (kg)	Essential oil ratio (%)	Essential yield per hectare (kg)
Spacings				
S_1	0.63	315	0.31	46.08
S_2	0.53	263	0.32	27.1
S_3	0.41	207	0.31	19.06
S.Em ±	0.003	2.15	0.002	0.21
CD at 5%	0.009	6.42	NS	0.71

Fertilizer levels				
F_1	0.44	218.33	0.33	29.5
F_2	0.5	251.67	0.33	30.23
F_3	0.63	313.33	0.34	35.36
F_4	0.72	361.67	0.35	37.53
F_5	0.33	163.33	0.34	21.11
S.Em ±	0.004	2.33	0.003	0.27
CD at 5%	0.012	6.74	NS	0.88
Interactions (Spacing and fertilizer levels)				
S_1F_1	0.52	260	0.31	45.29
S_1F_2	0.61	305	0.33	46.25
S_1F_3	0.78	390	0.35	51.36
S_1F_4	0.84	420	0.33	54.65
S_1F_5	0.4	200	0.34	32.84
S_2F_1	0.43	215	0.31	25.26
S_2F_2	0.51	255	0.35	25.42
S_2F_3	0.64	320	0.33	32.44
S_2F_4	0.75	375	0.34	34.32
S_2F_5	0.3	150	0.32	18.05
S_3F_1	0.36	180	0.31	17.95
S_3F_2	0.39	195	0.32	19.02
S_3F_3	0.46	230	0.33	22.27
S_3F_4	0.58	290	0.35	23.62
S_3F_5	0.28	140	0.34	12.45
S.Em ±	0.007	4.8	0.005	0.47
CD at 5%	0.021	14.91	NS	1.46
Spacings			Fertilizer levels	
S_1-40 cm×20 cm			F_1-60: 30: 30 NPK Kg/ha	
S_2-50 cm×30 cm			F_2-90: 45: 45 NPK Kg/ha	
S_3-60 cm × 40 cm			F_3-120: 60: 60 NPK Kg/ha	
			F_4-150: 75: 75 NPK Kg/ha	

F_5-Absolute control

Significant variation in seed yield per plot was observed among the interaction effects. The treatment combination of 40 cm × 20 cm spacing and 150:75:75 NPK Kg/ha (S_1F_4) recorded maximum seed yield per plot (0.84 Kg) and was followed by S_1F_3 40 cm × 20 cm spacing and 120:60:60 NPK Kg/ha (0.78 Kg). The lowest seed yield per plot (0.28 Kg) was observed at treatment combination of 60 cm × 40 cm and absolute control (S_1F_5).

Seed yield per hectare varied significantly due to spacing at all the stages of plant growth. At closer spacing of 40 cm × 20 cm recorded the highest seed yield per hectare (315.00 Kg). The minimum seed yield per hectare (207.00 Kg) was noticed in wider spacing of 60 cm × 40 cm. The maximum seed yield per hectare (361.67 Kg) was recorded in F_4 (150:75:75 NPK Kg/ha) followed by F_3 (120:60:60 NPK Kg/ha) (313.33 Kg) and minimum seed yield per hectare (163.33 Kg) was noticed in absolute control (F_5).

The treatment combination of 40 cm × 20 cm spacing and 150:75:75 NPK Kg/ha (S_1F_4) recorded maximum seed yield per hectare (420.00 Kg) and was followed with other treatment S_1F_3 40 cm × 20 cm spacing and 120: 60: 60 NPK Kg/ha (390.00 Kg). The lowest seed yield per plant (140.00 Kg) was observed at treatment combination of 60 cm × 40 cm and absolute control (S_3F_5).

In both the seasons the maximum seed yield per hectare was noticed with closer spacing of 40 cm × 20 cm (S_1), with fertilizer application of 150:75:75 NPK Kg/ha (F_4) and treatment combination of 40 cm × 20 cm spacing and 150:75:75 NPK Kg/ha (S_1F_4). This may be due to positive effect of closer spacing and nutrients individually on higher vegetative growth and the same beneficial effect has been reflected in the combination also. Similar findings were observed by Olcay and Emine, Amir and Bilal in Sweet basil, and Pooja et al., in Sacred basil.

Essential oil content (%): The essential oil content (%) at full bloom stage showing non-significant differences with the spacings, fertilizer applications and their interaction. Essential oil content was found to be unaffected in response to plant spacing and fertilization. Negligible difference in oil content signifies that the character may be genetically controlled (Figures 1 and 2).

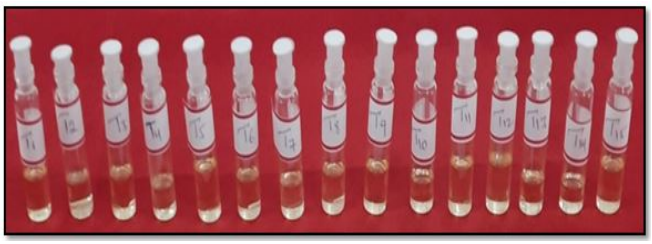

Figure 1: Integrated effect of spaceing and fertilizers on essential oil content.

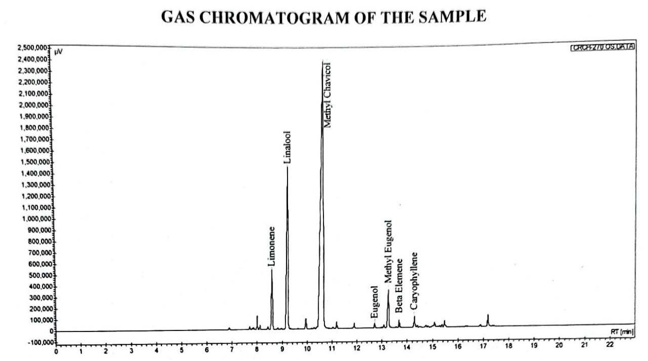

Figure 2: Integrated effect of spacing and fertilizers on composition of essential oil.

Essential oil yield (Kg/ha): At closer spacing of 40 cm × 20 cm recorded the highest essential oil yield (46.08 Kg/ha). The minimum essential oil yield (19.06 Kg/ha) was noticed in wider spacing of 60 cm × 40 cm. Fertilizer application had significant effect on essential oil yield the maximum essential oil yield (37.53 Kg/ha) was recorded in F_4 (150:75:75 NPK Kg/ha) followed by F_3 (120:60:60 NPK Kg/ha) (35.36 Kg/ha) and minimum essential oil yield (21.11 Kg/ha) was noticed in absolute control (F_5) (Table 2).

Among the interaction effects, the treatment combination of 40 cm × 20 cm spacing and 150:75:75 NPK Kg/ha (S_1F_4) recorded maximum essential oil yield (54.65 Kg/ha) and was followed with other treatment S_1F_3-40 cm × 20 cm spacing and 120: 60: 60 NPK Kg/ha (51.36 Kg/ha). The lowest essential oil yield (12.45 Kg/ha) was observed at treatment combination of 60 cm × 40 cm and absolute control (S_3F_5).

The maximum essential oil yield was noticed with closer spacing of 40 cm × 20 cm (S_1), this may be attributed to increase in number of plants per unit area. Moreover, the increase in essential oil yield at higher plant density was also due to higher leaf yield per hectare at high density. The above results are in agreement with the findings of Abhraham et al., Majeed et al., in *Ocimum basilicum*, Kumar et al., Pooja et al., Mounika et al., in *Ocimum santum*, and Nithin et al., in Mentha arvensis [17,18].

From the data it is revealed that, maximum essential oil yield was recorded in F_4 (150:75:75 NPK Kg/ha) in both the seasons, essential oil is synthesized from products of photosynthesis through enzymatic actions. Inorganic fertilizers enhance the content of macro and micro elements in the soil, play an essential role in the plant growth and development and amount of the essential oil. Further the increase in essential oil due to application of nitrogen chemical fertilizer could increase in agriculture yield. Anita and Anna documented that highest yield of sweet basil's aerial organs was obtained by applying 150 kg/ha. Added nitrogen supply increases photosynthesis rate and enables the plant to grow rapidly and produced considerable biomass and basic metabolism, which may increase production and accumulation of essential oil. Moreover, it may be due to increase in the number of oil glands or the enlargement in oil gland. The above results are in agreement with the findings of Ipsilandis et al., Faraj Moayedi et al., in *Ocimum basilicum*, Cheena et al., in Clove basil and Hamed Keshavarz et al., in Mint [19,20].

Interaction between spacing and nutrients had significant effect on essential oil yield. The treatment combination of 40 cm × 20 cm spacing and 150:75:75 NPK Kg/ha (S_1F_4) recorded maximum essential oil yield. This may be due to positive effect of high number of plants per unit area and the enhanced accumulation of essential oil under the conditions when plants are well supplied with nitrogen results from the increased production of biomass as well as from the direct impact on the biosynthesis of this substance. Similar findings were observed by Pooja et al., in sacred basil.

Composition of essential oil (%)

Non-significant differences were observed among the treatments on this parameter. The major constituent present is Methyl Chavicol with a range of 60.02% among spacings, 60.01% to 60.02% among fertilizer applications and 60.01% to 60.03% among interactions. Next compound observed in this majorly was linalool, followed by limonene, methyl eugenol, caryophyllene, β elemene and eugenol (Table 3).

Table 3: Influence of spacing and fertilizers on composition of sweet basil (*Ocimum basilicum* L.) essential oil under Telangana conditions.

Treatments	Limonene	Linalool	Methyl chavicol	Eugenol	Methyl eugenol	β Elemene	Caryophyllene
Spacings							
S_1	5.67	19.18	60.02	0.35	4.02	0.64	0.94
S_2	5.68	19.16	60.02	0.35	4.02	0.63	0.94
S_3	5.67	19.18	60.02	0.35	4.01	0.62	0.95
S.Em ±	0.03	0.14	0.38	0.001	0.02	0.004	0.006
CD at 5%	NS	NS	NS	NS	NS	NS	NS
Fertilizer levels							
F_1	5.67	19.18	60.02	0.35	4.02	0.64	0.94
F_2	5.67	19.17	60.02	0.35	4.02	0.63	0.95
F_3	5.67	19.17	60.02	0.34	4.01	0.64	0.95
F_4	5.67	19.18	60.02	0.35	4.02	0.62	0.95
F_5	5.68	19.16	60.01	0.34	4.01	0.63	0.94
S.Em ±	0.04	0.18	0.5	0.002	0.03	0.005	0.007
CD at 5%	NS	NS	NS	NS	NS	NS	NS
Interactions (Spacing and fertilizer levels)							
S_1F_1	5.68	19.17	60.02	0.35	4.03	0.64	0.94
S_1F_2	5.67	19.18	60.02	0.34	4.02	0.63	0.93
S_1F_3	5.66	19.19	60.01	0.33	4.01	0.65	0.95
S_1F_4	5.65	19.18	60.02	0.35	4.03	0.64	0.95
S_1F_5	5.67	19.17	60.01	0.35	4.03	0.63	0.94
S_2F_1	5.67	19.18	60.02	0.34	4.02	0.63	0.93
S_2F_2	5.68	19.16	60.02	0.35	4.01	0.63	0.96

S_2F_3	5.68	19.15	60.03	0.35	4.02	0.63	0.94
S_2F_4	5.67	19.16	60.01	0.35	4.01	0.64	0.93
S_2F_5	5.69	19.15	60.02	0.34	4.03	0.64	0.94
S_3F_1	5.66	19.19	60.01	0.35	4.02	0.65	0.95
S_3F_2	5.65	19.18	60.01	0.35	4.02	0.64	0.96
S_3F_3	5.68	19.18	60.03	0.34	4.02	0.63	0.95
S_3F_4	5.69	19.19	60.02	0.35	4.03	0.65	0.96
S_3F_5	5.66	19.16	60.01	0.33	4.01	0.64	0.94
S.Em ±	0.07	0.31	0.86	0.004	0.06	0.01	0.01
CD at 5%	NS	NS	NS	NS	NS	NS	NS
Spacings				Fertilizer levels			
S_1-40 cm × 20 cm				F_1-60: 30: 30 NPK Kg/ha			
S_2-50 cm × 30 cm				F_2-90: 45: 45 NPK Kg/ha			
S_3-60 cm × 40 cm				F_3-120: 60: 60 NPK Kg/ha			
				F_4-150: 75: 75 NPK Kg/ha			
NS–Non Significant				F_5-Absolute control			

Antioxidants (%)

Non-significant differences were observed with the application of spacing, fertilization effect and their interaction on this parameter [21-23]. The antioxidants within a range of 54.83 to 55.12, among spacings, 53.97 to 55.68 among fertilizer application and 53.30 to 56.80 among interaction effects (Table 4).

Table 4: Influence of spacing and fertilizers on antioxidant activity of sweet basil (*Ocimum basilicum* L.) under Telangana conditions.

Treatments	**Antioxidants**
Rabi	
Spacings	
S_1	54.99
S_2	54.83
S_3	55.12
S.Em ±	0.46
CD at 5%	NS
Fertilizer levels	
F_1	55.68

F_2	55.52
F_3	53.97
F_4	54.81
F_5	54.93
S. Em ±	0.6
CD at 5%	NS
Interactions (Spacing and fertilizer levels)	
S_1F_1	55.71
S_1F_2	54.31
S_1F_3	54.92
S_1F_4	55.54
S_1F_5	54.49
S_2F_1	56.1
S_2F_2	55.45
S_2F_3	53.3
S_2F_4	54.57
S_2F_5	54.73
S_3F_1	55.23
S_3F_2	56.8
S_3F_3	53.7
S_3F_4	54.31
S_3F_5	55.57
S.Em ±	0.77
CD at 5%	NS
Spacings	Fertilizer levels
S_1-40 cm × 20 cm	F_1-60: 30: 30 NPK Kg/ha
S_2-50 cm × 30 cm	F_2-90: 45: 45 NPK Kg/ha
S_3-60 cm × 40 cm	F_3-120: 60: 60 NPK Kg/ha
	F_4-150: 75: 75 NPK Kg/ha
NS-Non-Significant	F_5-Absolute control

CONCLUSION

In conclusion fresh herb yield, dry herb, seed yield and essential oil yield in sweet basil (*Ocimum basilicum* L.) was significantly affected by 40 cm × 20 cm plant density and 150:75:75 NPK Kg/ha fertilizer condition. As a conclusion basil can be grown with 40 cm × 20 cm plant density under maximum fertilizer doses for high herb and essential oil yield. In addition, plants do not have any harvesting, any disease and pest problem during growing period. However, the plant density and fertilizer doses does not show any affect on the composition of essential oil and antioxidant percentage of sweet basil. It can be said that basil could be grown easily, and yield of this plant could be increased by using appropriate agronomical methods.

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