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Influence of inorganic fertilizer and spacing on yield and quality of sacred basil (*Ocimum sanctum* Linn.)

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Abstract
Research on sacred basil to increase its productivity was studied in a field experiment during the year 2015-16 at the Kittur Rani Channamma College of Horticulture, Arabhavi. Result revealed that among the inorganic fertilizers application of 175:95:80 kg NPK per ha recorded significantly maximum plant height (85.33 cm). Whereas maximum plant spread East-West (68.74 cm), North-South (70.14 cm), fresh yield per ha (15.18 t/ha), oil content (0.40 %) and eugenol content (60.69 %) was recorded in fertilizer level of 150:85:70 kg per ha. At harvest plant spaced at 45×30 cm recorded significantly maximum plant height (81.12 cm) and fresh yield per ha (15.72 t). Whereas, plants planted at wider spacing of 45×60 cm recorded significantly maximum plant spread East-West (68.74 cm), North-South (70.14 cm), oil content (0.30 %) and eugenol content (54.75 %).

Keywords: Growth, Yield, Quality, Days after planting, NPK, Eugenol

Introduction
Sacred basil or Holy basil (*Ocimum sanctum* L.) an aromatic herb belongs to the family Lamiaceae, commonly cultivated in gardens and it is frequently found as an escape. The species is worshipped by the Hindus of India and traditionally grown in courtyard and temples. Tulsi, the Queen of herbs, the legendary 'Incomparable one' of India, is one of the holiest and most cherished of the many healing and healthy giving herbs of the orient. The sacred basil, Tulsi, is renowned for its religious and spiritual sanctity, as well as for its important role in the traditional Ayurvedic and Unani system of holistic health and herbal medicine of the East. It is mentioned by Charaka in the Charaka Samhita; an Ayurvedic text.
The aromatic leaves are used as fresh or dried; seeds are economically important and represent an important source of essential oils. The volatile oil contains eugenol (about 71%). Eugenol methyl ether (20%) other compounds include nerol, caryophyllene, selinene, camphor, cineole, linalool and carvacrol (3%). There are great variations in concentration of these components in the volatile oil from different sources. The leaves contain ascorbic acid (83mg/100 g) and carotene (2.5 mg/100 g).
Spacing plays an important role in determining the yield per unit area. Improper spacing strongly affects the quantity and quality of basil. It is important to facilitate aeration and light penetration into plant canopy for optimizing the rate of photosynthesis. Hence, due attention is to be paid to determine optimum spacing for higher yield in *Ocimum sanctum* L. Improper nutrition leads to nutrient imbalance in plant which is one of the major factors contributing to lower yields in many crops. Under normal agro climatic conditions, the deficiencies of major nutrients namely nitrogen, phosphorus and potassium are more common and pose serious problem in crop production

Material and methods
The experiment was carried out in the experimental field of the Department of Plantation, Spices, Medicinal and Aromatic Plants, Kittur Rani Channamma College of Horticulture, Arabhavi, Belgaum district, Karnataka. The experiment was laid out with factorial concept in a randomized block design with two replications. The gross plot size was 3.6 m x 3.0 m ($10.8m^2$).

Treatment Details

The details of the factors under study in the experiment are given below.

Factor 1: Fertilizer levels (NPK kg/ha)

F_0 : Control (0:0:0)
F_1 : 100:65:50 (RDF)
F_2 : 125:75:60
F_3 : 150:85:70
F_4 : 175:95:80

Factor 2: Plant spacing (cm)

S_1 : 45 × 30
S_2 : 45 × 45
S_3 : 45 × 60

The seeds were broadcasted uniformly on raised beds and covered with powdered sheep manure and beds were watered immediately with the help of rose headed can. Thirty days old healthy, uniform sized seedlings were selected and transplanted in the experimental plots as per the treatments. The nutrients NPK were applied in the form of urea, ssp and mop fertilizers and recommended dose of FYM 15 t per ha was added to all the plots. The experimental plots were applied with the calculated quantity of fertilizers as per the treatments. Out of total quantity, 50 per cent of nitrogen and full dose of phosphorous and potash were supplied as basal dose a day before transplanting. The remaining 50 per cent of nitrogen was given as top dressing at 30 days after transplanting. The crop was harvested 3 months after planting at full bloom stage, when the lower leaves started to yellowing and the whole plants were cut at 15 cm above the ground level.

The height of five labeled plant was measured in centimeter from ground level to the growing tip of the plant and the average was worked out. The East-West and North-South spread of the plant was recorded at 30, 60 and 90days after planting and the average was worked out and expressed in centimeters.

The fresh yield per hectare was recorded at the time of harvest. The fresh yield per hectare was calculated on the basis of fresh yield per plot. The fresh yield per hectare was expressed in terms of ton. Eugenol content in sacred basil was estimated by using Gas chromatography and expressed in percentage (%)

Table 1: Effect of inorganic fertilizers and spacing on plant height at different stages of growth in sacred basil (*Ocimum sanctum* L.)

Treatment	Plant height(cm)		
	30 DAP	**60DAP**	**90 DAP**
Fertilizer Level(F)			
F_0:0:0:0 kg NPK/ha	31.17	60.17	66.56
F_1: 100:65:50 kg NPK /ha	33.17	62.00	73.98
F_2: 125:75:60 kg NPK /ha	34.42	63.17	77.37
F_3: 150:85: 70 kg NPK/ha	35.41	65.33	80.59
F_4 : 175:95:80 kg NPK/ha	37.55	68.17	85.33
S.Em ±	**1.58**	**1.95**	**1.43**
CD @ 5%	**NS**	**NS**	**4.34**
Spacing level(S)			
S_1: 45 cm× 30 cm	37.82	66.50	81.12
S_2: 45 cm × 45 cm	34.97	64.20	75.57
S_3 : 45 cm × 60 cm	30.23	60.60	73.61
S.Em±	**1.22**	**1.51**	**1.11**
CD @ 5%	**3.70**	**4.57**	**3.36**
Interaction effects (S x F)			
F_0S_1	36.00	62.50	64.23
F_0S_2	34.00	60.66	70.23
F_0S_3	23.50	57.50	65.22
F_1S_1	36.50	64.50	78.78
F_1S_2	33.50	62.50	73.56
F_1S_3	29.50	59.00	69.61
F_2S_1	38.00	66.00	80.72
F_2S_2	34.50	64.00	77.85
F_2S_3	30.75	59.50	73.55
F_3S_1	38.50	68.00	88.22
F_3S_2	35.23	66.00	77.06
F_3S_3	32.50	62.00	76.50
F_4S_1	40.12	71.50	93.66
F_4S_2	37.63	68.00	79.16
F_4S_3	34.89	65.00	83.19
S.Em±	**2.73**	**3.37**	**2.48**
CD @ 5%	**NS**	**NS**	**7.52**

DAP- Days after planting NS – Non significant

Table 2: East-West and North-South plant spread in sacred basil (*Ocimum sanctum* L.) at different stages of growth as influenced by inorganic fertilizer and spacing

Treatment	E-W (cm)			N-S (cm)		
	30 DAP	60DAP	90 DAP	30 DAP	60DAP	90 DAP
Fertilizer level(F)						
F_0:0:0:0 kg NPK/ha	15.75	33.26	50.08	23.43	29.50	49.58
F_1: 100:65:50 kg NPK /ha	20.37	40.03	59.73	32.09	37.88	55.47
F_2: 125:75:60 kg NPK /ha	23.28	44.97	63.46	35.87	41.34	62.98
F_3: 150:85: 70 kg NPK/ha	28.49	50.44	68.74	41.61	49.05	70.14
F_4 : 175:95:80 kg NPK/ha	25.33	47.38	65.78	38.53	46.06	65.26
S.Em ±	**1.27**	**1.05**	**0.97**	**0.87**	**0.76**	**1.30**
CD @ 5%	**3.84**	**3.18**	**2.95**	**2.47**	**2.31**	**3.93**
Spacing level(S)						
S_1: 45 cm× 30 cm	19.52	38.61	58.11	30.06	38.05	55.94
S_2: 45 cm × 45 cm	22.58	43.41	61.31	34.89	41.18	59.90
S_3 : 45 cm × 60 cm	25.83	47.62	65.25	37.97	43.07	66.22
S.Em±	**0.98**	**0.81**	**0.75**	**0.63**	**0.59**	**1.00**
CD @ 5%	**2.98**	**2.47**	**2.29**	**1.92**	**1.79**	**3.05**
Interaction effects (S x F)						
F_0S_1	13.63	25.10	42.56	14.62	26.06	39.51
F_0S_2	14.45	37.18	49.16	25.00	34.79	46.68
F_0S_3	19.18	37.50	58.51	30.67	38.10	62.55
F_1S_1	16.62	31.65	59.07	28.22	35.12	52.73
F_1S_2	21.51	41.00	60.12	32.50	37.40	53.67
F_1S_3	23.00	47.45	60.00	35.55	41.12	60.01
F_2S_1	20.06	41.80	60.55	32.38	39.61	59.12
F_2S_2	23.90	44.62	62.57	36.27	41.24	62.03
F_2S_3	25.89	48.50	67.25	38.96	43.19	67.79
F_3S_1	24.57	47.87	66.20	38.83	45.23	65.78
F_3S_2	27.83	48.27	68.15	41.40	47.55	70.56
F_3S_3	33.06	55.18	71.88	44.62	54.37	74.07
F_4S_1	22.75	46.65	62.18	36.27	44.26	62.56
F_4S_2	25.23	46.00	66.56	39.28	44.91	66.56
F_4S_3	28.00	49.49	68.60	40.05	49.00	66.67
S.Em±	**2.19**	**1.82**	**1.69**	**1.41**	**1.32**	**2.25**
CD @ 5%	**NS**	**5.51**	**5.12**	**4.28**	**3.99**	**6.82**

DAP- Days after planting NS – Non significant

Table 3: Effect of inorganic fertilizers and spacing on fresh and dry herbage yield of Sacred basil (*Ocimum sanctum* L.)

Treatment	Fresh herbage yield (t/ha)	Oil content (%)	Eugenol content (%)
Fertilizer level(F)			
F_0:0:0:0 kg NPK/ha	8.25	0.13	43.10
F_1: 100:65:50 kg NPK /ha	9.89	0.18	50.57
F_2: 125:75:60 kg NPK /ha	11.74	0.24	53.16
F_3: 150:85: 70 kg NPK/ha	15.18	0.40	60.69
F_4 : 175:95:80 kg NPK/ha	13.56	0.30	56.93
S.Em±	**0.45**	**0.01**	**0.63**
CD @ 5%	**1.38**	**0.04**	**1.90**
Spacing level(S)			
S_1: 45 cm× 30 cm	15.72	0.21	51.50
S_2: 45 cm × 45 cm	10.08	0.24	52.42
S_3 : 45 cm × 60 cm	9.37	0.30	54.75
S.Em±	**0.35**	**0.01**	**0.48**
CD @ 5%	**1.07**	**0.03**	**1.47**
Interaction effects (S x F)			
F_0S_1	9.99	0.10	40.52
F_0S_2	8.12	0.14	41.71
F_0S_3	6.65	0.16	47.06
F_1S_1	12.69	0.14	48.75
F_1S_2	8.01	0.16	50.95
F_1S_3	8.98	0.25	52.02
F_2S_1	16.07	0.21	52.74
F_2S_2	10.20	0.24	53.30
F_2S_3	8.96	0.27	53.44
F_3S_1	21.42	0.33	59.12
F_3S_2	12.56	0.40	59.26
F_3S_3	11.55	0.46	63.69
F_4S_1	18.45	0.25	56.39
F_4S_2	11.51	0.28	56.88
F_4S_3	10.71	0.35	57.53
S.Em±	**0.79**	**0.02**	**1.08**
CD @ 5%	**2.39**	**NS**	**NS**

DAP- Days after planting

Result and Discussion

At harvest, the maximum plant height (85.33cm) was recorded with the application of 175:95:80 kg NPK per ha (F_4). The positive influence of the nutrients on plant height may be due to the fact that nitrogen, promoting the vegetative growth by the enhanced cell division, cell elongation and greater synthesis of chlorophyll, protein and amino acids, while phosphorus increases the plant height by increasing the cell multiplication in the plant tissue and potassium is involved in protein and carbohydrates metabolism, which leads to cell enlargement and trigger the growth of meristamatic tissue, while, the plant height was least (66.56 cm) in F_0 (control). The results obtained are in agreement with the findings of Muniramappa *et al.* (1997) [6] in kalmegh, Arularasu *et al.* (2008) [2] in sacred basil and and Singh *et al*. (2004) [9] in French basil.

At harvest, plants planted at closer spacing of 45 x 30 cm (S_1) were found tallest (81.12cm) compared to the plants planted at wider spacing (S_3). The increased plant height in closer spacing might be due to the fact that the plants under closer spacing tend to grow vertically for more light and air and hence plants were taller. This is in close agreement with the findings of Patel and Arora (1983) [7] in carnation, Singh *et al*. (2004) [9], Ajimoddin *et al*. (2005) [1] and Mirjalili (2014) [5] in french basil.

While, at harvest, the plants which were supplied with 150:85:70 kg NPK per ha (F_3) recorded the maximum plant spread (E-W and N-S) of 68.74 and 70.14 cm respectively. The higher plant spread might be due to the robust nature of plant growth at this level as is evident by more number of branches and leaves. These results are in accordance with the findings of Muniramappa *et al.* (1997) [6] in kalmegh, Lokesh and Gangadharappa (2007) [4] in makoi. Plants spaced at 45x 60 cm (S_3) recorded the highest plant spread (N-S) of 66.22 cm and (E-W) of 65.25 cm. The higher plant spread could be attributed to higher surface area, which resulted in plageotrophic growth. Similar results were reported by of Ramesh *et al.* (1996) [8] in kalmegh.

Fresh yield per hectare differed significantly with different levels of inorganic fertilizer. Application of 150:85:70 kg NPK per ha (F_3) recorded the maximum fresh yield per hectare (5.18 t). This may be attributed to fact that under increasing inorganic fertilizer levels, there would be luxuriant growth of the plant, which leads to production of more number of leaves and branches ultimately resulting in higher fresh yield per plot. The results are similar to the findings of Gulati *et al*. (1978) [3] and Muniramappa *et al.* (1997) [6] in kalmegh.

The closer spacing of 45 x 30 cm (S_1) produced significantly higher fresh yield per ha (15.72 t) and the minimum (9.37 t) was observed in 45 x 60 cm (S_3). This might be due to the luxuriant growth of plants during vegetative phase which resulted in fresh herbage yield per plot. Similar results were obtained Arularasu *et al*. (2008) [2] in sacred basil and Lokesh and Gangadharappa (2007) [4] in makoi.

Application of 150:85:70 kg NPK/ha recorded the highest (0.40 and 60.69 %) essential oil and eugenol content and the lowest (0.13 and 43.10 %) was found in control. This was due to the positive role of inorganic fertilizer on plants and presence of higher essential oil content in herb. These results are in line with the findings of Singh and Ramesh (2000) [10] in rosemary. There was significant effect of spacing on essential oil and eugenol content. However, spacing of 45×60 cm (S_3) recorded maximum essential oil and eugenol content (0.30 and 54.75%). This might be due to the fact that in wider rows, better penetration of light created congenial temperature regime favourable for accumulation of essential oil in the leaves.

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