Original research article

Effect of mulching and nutrition on essential oil yield, quality and nutrient uptake in sweet basil (*Ocimumbasilicum* L.)

ABSTRACT

A field experiment was conducted at College of Horticulture, Bengaluru to investigate the influence of different mulches and nutrition on essential oil yield, quality and nutrient uptake in sweet basil. The treatment combinations consisted of four different mulches *viz*., no mulch, black plastic, silver plastic and organic mulch (spent lemon grass) each with four different nutrient levels *viz*., 100 percentRecommended dose of fertilizers (RDF), combination of 75 percent RDF with humic acid, 75 percent RDF with microbial consortia and 75 percent RDF, humic acid and microbial consortia. Use of black mulch recorded maximum essential oil content (1.13 %), yield (97.21 kg/ha), N (54.56 kg/ha), P (37.71 kg/ha) and K (57.85 kg/ha) uptake. Application of 75 percent RDF with humic acid resulted in maximum essential oil content (1.21 %) whereas, 75 percent RDF with humic acid and microbial consortia recorded maximum essential oil yield (79.03 kg/ha), P (24.82 kg/ha) and K (48.88 kg/ha) uptake. Maximum nitrogen uptake was found in application of 100 percent RDF. Among interaction, maximum essential oil content (1.44 %) and yield (109.92 kg/ha) was noticed in combination of black mulch with 75 percent RDF and humic acid. The highest methyl chavicol content (73.85%) was observed in plants grown with black mulch along with application of 75 pe cent RDF and microbial consortia.

Keywords: Humic acid, Methyl chavicol, Microbial consortia,Mulch, Sweet basil

1. INTRODUCTION

Sweet basil (*Ocimumbasilicum* L.) is a significant annual herb in the lamiaceae family, which is grown for its leaves and inflorescence. The genus Ocimum consists of numerous species and varieties, ranging from 50 to 150 (Runyoro et al., 2010) [15]. It is commonly used as a culinary herb and spice, and its essential oil finds usage in flavouring food, perfumery, and the pharmaceutical industry. The composition of the essential oil varies depending on the chemotype, with high levels of linalool (up to 55%), methyl chavicol (up to 70%), methyl cinnamate, or eugenol (Grayer et al., 1996[9]; Vieira and

Simon, 2006[20]). The unchecked use of weedicides and chemical fertilizers in agriculture is causing severe harm to soil health and reducing the quality of herbs produced. Therefore, it is crucial to cultivate basil that is free from weed infestation and chemical residues, while also ensuring sustainable soil health by enhancing the physical, chemical, and biological properties of the soil (Sarrou et al., 2016) [16]. Regions that prioritize heavy chemical use in farming have caused negative consequences for the environment, agriculture, and health. A potential remedy to decrease dependence on herbicides involves adopting mulch as an alternative approach. (Thakur et al., 2019) [18]. Intensive farming practices, aimed at achieving higher yields, often involve the extensive use of agrochemicals that are both expensive and detrimental to the environment. However, the application of humic acid to soil can improve its physical and chemical properties, increase the availability of nutrients, promote chlorophyll synthesis, and enhance the permeability of plant membranes (Fortun, 1990)[6]. Additionally, the use of biofertilizers can help to fix, solubilize, and mobilize major nutrients in the soil, making them readily available to plants (Gaur and Gaind, 1990) [7]. These biofertilizers can also synthesize various phytohormones, such as auxins, gibberellins, and cytokinins, which can positively influence plant growth and development (Befrozfar et al., 2013)[3].With this background, present study was conducted to investigate the effect of various mulches and nutritional combinations on essential oil yield, quality and nutrient uptake in sweet basil.

2. MATERIAL AND METHODS

2.1 Site characterization

A field experiment was conducted during Rabi, 2018-2019 at the Department of Plantation, Spices, Medicinal and Aromatic crops, College of Horticulture, UHS Campus, GKVK, Bengaluru (Geographical coordinates 12º58[1] N, 77º35[1] E and 930 m MSL). The experimental site was a fairly levelled land with red sandy clay loam soil of fairly uniform fertility status and belonged to the order of alfisols.

2.2 Experimental design

The experiment was conducted in a factorial randomized complete block design (FRCBD) with sixteen treatment combinations replicated thrice as follows.

T1– control - No mulch with 100% RDF (160:80:80 kg/ha)
T2 – No mulch with 75% RDF + Humic acid at 10 kg/ha
T3 – No mulch with 75% RDF + Microbial Consortia at 5 kg/ha
T4 – No mulch with 75% RDF + Humic acid at10 kg/ha + Microbial Consortiaat5 kg/ha
T5 – Plastic mulch Black with 100% RDF
T6 – Plastic mulch Black with 75% RDF + Humic acid at10 kg/ha
T7 – Plastic mulch Black with 75% RDF + Microbial Consortia at 5 kg/ha
T8 – Plastic mulch Black with 75% RDF + Humic acid at 10 kg/ha+ Microbial Consortiaat5 kg/ha
T9 – Plastic mulch Silver with 100% RDF
T10 –Plastic mulch Silver with 75% RDF + Humic acid at 10 kg/ha
T11– Plastic mulch Silver with 75% RDF + Microbial Consortia at 5 kg/ha
T12– Plastic mulch Silver with 75% RDF + Humic acid at 10 kg/ha+ Microbial Consortiaat 5 kg/ha
T13– Organic mulch with 100% RDF
T14– Organic mulch with 75% RDF + Humic acid at 10 kg/ha
T15– Organic mulch with 75% RDF + Microbial Consortia at 5 kg/ha
T16– Organic mulch with 75% RDF + Humic acid at 10 kg/ha + Microbial Consortiaat5 kg/ha

2.3 Experimental details

Healthy seeds of sweet basil variety CIM-Saumya were procured from IIHR, Bengaluru and were mixed with sand in a 1:5 ratio before being sown in well-prepared raised beds. The beds were 4m long, 1m wide and 10 cm high, with seeds sown in rows spaced 5 cm apart. Germination of the seeds was observed in just 2 days, with 90 percent of the seeds sprouting within eight days. To ensure optimal growth, organic manure (FYM) was applied 15 days prior to transplanting the seedlings in the main field. The recommended dose of fertilizers (RDF) at 160:80:80 kg/ha were applied in the form of straight fertilizers such as urea, single super phosphate and muriate of potash. The basal application involved applying 50 percent N along with the full dose of P_2O5 and K_2O, while the remaining 50 percent nitrogen was top-dressed thirty days after transplanting.

The experimental plots were mulched using black and silver plastic of 50µ thickness, as well as organic mulch made from 5spent lemon grass at a rate of 3t/ha. Seedlings of forty days old were transplanted to the plots with a spacing of 60 cm between rows and 40 cm within rows. After transplanting, the plots were immediately irrigated, and regular irrigation was given daily for an hour through drip irrigation. Humic acid and microbial consortia were applied 15 days after transplanting at a rate of 10 kg/ha and 5kg/ha, respectively. Plots without mulch were kept free from weeds throughout the growing period by weeding at regular intervals. The crop was harvested after 60 days of transplanting when it reached the 50 percent flowering stage, as this stage contains the maximum percentage of essential oil.

2.4 Record of observations

Observations were recorded 30 days and 60 days after transplanting (harvest). Fresh and dry herbage yields were recorded for a plot size of 4.8 × 4.0 m, and an estimated yield per hectare was calculated. The herbage was dried in the shade house. Essential oil was estimated using Clevenger's apparatus. Four hundred grams of the fresh herb consisting of leaves and inflorescence was taken to estimate the essential oil content according to different treatments and expressed in percentage (%) on a dry weight basis. The distillation time was standardized to one and a half hours(Chenni et al., 2016)[4].The methyl chavicol and linalool content in essential oil was analyzed by using GC model Varian 3800.

The nitrogen, phosphorous and potassium uptake was computed using following formula

$$\text{Nutrient uptake} = \frac{\text{Dry matter yield (kg)} \times \text{Nutrient content (\%)}}{100}$$

2.5 Statistical analysis

The experimental data recorded on various biometric parameters collected during the study were subjected to statistical analysis by Fisher's method of analysis of variance (ANOVA). Wherever the "F" test was significant for comparison of treatment means, CD values were worked out at 0.05 probability level.

3. RESULTS AND DISCUSSION

3.1 Oil yield

Plants grown on black mulch exhibited the highest essential oil content (1.13%) and yield (97.21 kg/ha) on a dry weight basis, which was significantly different from other treatments. The combination of 75% recommended dose of fertilizers (RDF) with humic acid resulted in the maximum essential oil content (1.21%), and the combination of 75% RDF with humic acid and microbial consortia resulted in the maximum yield (79.03 kg/ha). The interaction between mulch and nutrition also had a significant effect, with the highest oil content (1.44%) observed in plants grown on black mulch with 75% RDF and humic acid (Table1). Plants grown with black mulch may have had increased oil content due to enhanced essential oil biosynthetic pathways activated by photosynthetic light. Humic acid, which can improve enzymatic activity, membrane permeability, cell division and metabolism, may have also contributed to maximizing herbage yield. Studies by Abaas (2014) [1] in Calendula, Giri et al. (2016) [8] in sweet basil, Mendonca et al. (2013) [14] in *Melissa offinalalis*, and Sarrou et al. (2016) [16] in sweet basil have reported similar findings. Humic acid can also improve nutrient uptake, soil physical properties, and synthesize semi-hormonal substances (Turkmen et al., 2005) [19]. The highest essential oil yield observed may be attributed to both the maximum essential content and dry herbage yield. Humic acid application can increase yield and quality by providing nutrients to the plant, while simultaneously increasing the rate of photosynthesis and other plant physiological activities (Khoshghalba et al., 2017) [13]. These results are consistent with the findings of Hendawy et al. (2015) [11] in *Mentha piperita* and El-Ziat et al. (2017) [5] in sweet basil.

3.2 Oil quality

Plants grown with black mulch and application of 75 percent RDF and microbial consortia showed the highest content of methyl chavicol (73.85%) (Fig 1) while, the lowest was recorded in plants grown with silver mulch and 75 percent RDF, humic acid and microbial consortia (29.67%). The highest content of linalool (56.90%) was observed in silver mulch with the application of 75percent RDF, humic acid, and microbial consortia, and the lowest was found in black mulch with the application of 75 percent RDF and microbial consortia (13.73%).The observed high levels of methyl chavicol and linalool in plants could be explained by the activation of secondary metabolism, potentially due to the increased activity of enzymes involved in the biosynthesis of essential oils and improved metabolism. This variation in content among the treatments suggests that different combinations of mulch and nutrition may have differential effects on enzyme activity and metabolism. Similar findings have been reported by Sarrou et al. (2016) [16] in sweet basil and Thakur et al. (2019) [18] in *Rosa damascena.*

3.3 Nutrient uptake

Influence of different mulch, nutrition and their combination had a substantial impact on uptake of nitrogen, phosphorous and potassium as depicted in Table 2.

3.3.1 Nitrogen uptake

Plants grown with black mulch had significantly higher nitrogen uptake (54.56 kg/ha) compared to all other mulches, with the lowest being in organic mulch (19.68 kg/ha). Plants treated with 100 percent RDF had the highest nitrogen uptake (43.37 kg/ha), whereas the lowest was recorded in plants treated with a combination of 75 percent RDF and humic acid (30.85 kg/ha). Among the interaction of factors, plants grown with black mulch and treated with 100 percent RDF recorded the highest nitrogen uptake (70.18 kg/ha), which was significantly different from all other treatment combinations. The use of black mulch has resulted in higher nitrogen uptake by the plants, which could be due to factors such as increased mineralization under mulched conditions, reduced leaching, and optimal moisture levels that improve nutrient availability in the soil solution, ultimately leading to increased nutrient uptake by the plants. This finding is supported by previous studies conducted on sweet basil (Heidari et al., 2012) [10], lettuce (Khazaie et al., 2013) [12], thyme (Solberg and Dragland, 2014) [17], and ashwagandha (Anuroopa et al., 2017) [2], which have reported similar results.

3.3.2 Phosphorous uptake

In terms of phosphorus uptake, plants grown with black mulch recorded the highest uptake (37.71 kg/ha), which was significantly different from all other mulches, while the least was recorded in plants with organic mulch (8.39 kg/ha). Among nutrition, the combination of 75 percent RDF, humic acid, and microbial consortia resulted in the highest phosphorous uptake (24.82 kg/ha), which was similar to plants treated with 75 percent RDF and microbial consortia (24.71 kg/ha). The least phosphorous uptake was found in plants treated with 75 percent RDF and humic acid (15.89 kg/ha). Among the interaction of factors, black mulch with the application of 75 percent RDF and microbial consortia resulted in the highest phosphorous uptake in soil (39.03 kg/ha). The use of mulch helps retain moisture in the soil and prevent nutrient loss, while applying humic acid improves the soil's nutrient-holding capacity. Additionally, microbial consortia, containing phosphorous solubilizing bacteria, aids in the solubilization of inorganic phosphorus and mineralization of organic phosphorus. This is due to the action of low molecular weight organic acids secreted by bacteria and the synthesis of various phosphatases, resulting in increased phosphorous content in the soil. These findings are consistent with those of other studies, such as Heidari et al. (2012) [10] in sweet basil, Khazaie et al. (2013) [12] in lettuce, Solberg and Dragland (2014) [17] in thyme, and Anuroopa et al. (2017) [2] in ashwagandha.

3.3.3 Potassium uptake

Plants grown with black mulch also recorded the highest potassium uptake (57.85 kg/ha), while the least was recorded in plants with organic mulch (30.64 kg/ha). The combination of 75 percent RDF, humic acid, and microbial consortia resulted in the highest potassium uptake (48.88 kg/ha). In contrast, the least was found in plants treated with 75 percent RDF and humic acid (39.23 kg/ha). The interaction between mulch and nutrition did not vary significantly for potassium uptake.The increased potassium uptake in the plants might be attributed to the secretion of organic acids by potassium mobilizing bacteria, such as *Frateuria aurantia*, which enhances the mobilization of potassium in the soil. These beneficial soil microorganisms are rhizosphere-competent and can colonize various ecological niches in the rhizosphere, thereby facilitating the mobilization of a wider range of nutrients. This finding is consistent with the studies of Heidari et al. (2012) [10] in sweet basil, Khazaie et al. (2013) [12] in lettuce, Solberg and Dragland (2014) [17] in thyme, and Anuroopa et al. (2017) [2] in ashwagandha.

Table 1. Influence of mulching and nutrition on essential oil content and yield

Treatment	Essential oil content (%)	Essential oil yield (kg/ha)
M_0	1.13	67.21
M_1	1.13	97.21
M_2	1.10	78.34
M_3	0.94	45.24
±S.E.M	0.03	3.34
CD at 5%	0.009	9.65
N_0	1.00	64.83
N_1	1.21	73.29
N_2	0.99	70.86
N_3	1.10	79.03
±S.E.M	0.03	3.34
CD at 5%	0.009	9.65
M_0N_0	1.17	66.97
M_0N_1	1.30	73.50
M_0N_2	1.05	58.54
M_0N_3	0.98	69.81
M_1N_0	0.98	81.36
M_1N_1	1.44	109.92
M_1N_2	0.91	93.02
M_1N_3	1.20	104.56
M_2N_0	1.04	70.00
M_2N_1	1.09	71.65
M_2N_2	1.00	74.60
M_2N_3	1.27	97.13
M_3N_0	0.82	41.01
M_3N_1	0.99	38.08
M_3N_2	0.98	57.28
M_3N_3	0.96	44.60
±S.E.M	0.006	6.68
CD at 5%	0.017	NS

M_0- No mulch, M_1- Black plastic mulch M_2-Silver plastic mulch, M_3-Orhanic mulch, N_0- 100 % RDF, N_1-75% RDF combined with humic acid, N_2-75% RDF combined with microbial consortia, N_3-75% RDF combined with humic acid and microbial consortia, S.E.M- Standard Error or means and CD- Critical difference

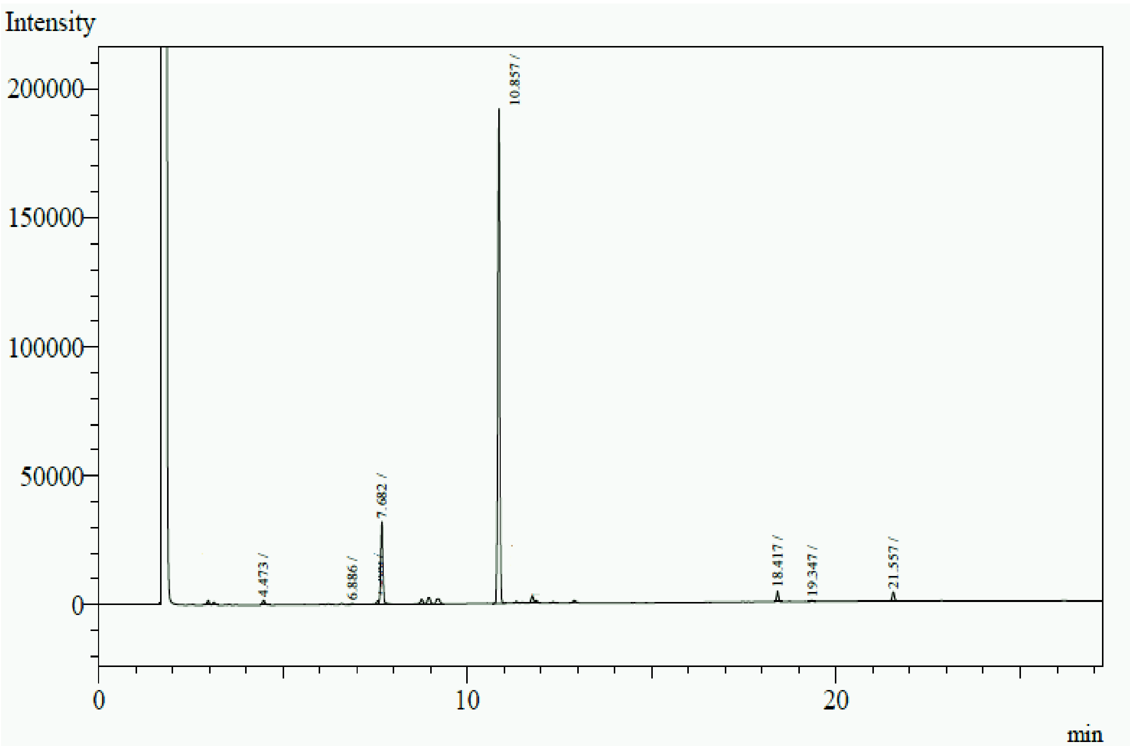

Fig 1.Graph obtained from GC-MS showing the influence of black mulch along with 75 percent RDF and humic acid on methyl chavicol and linalool content inessential oil ofbasil

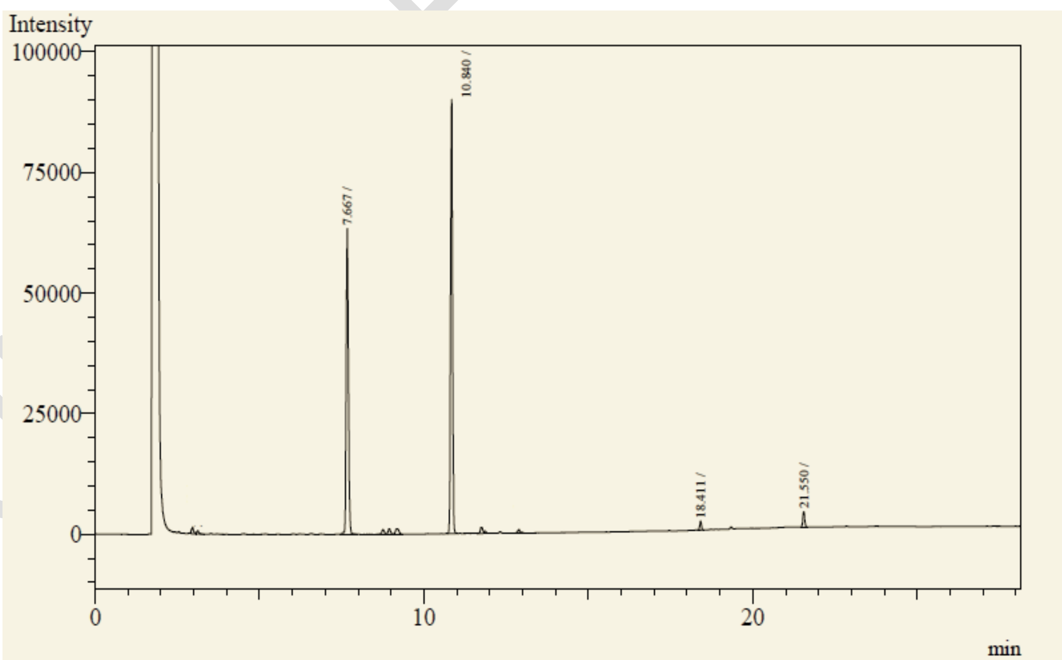

Fig 2.Graph obtained from GC-MS showing the influence of black mulch along with of 75percent RDF

and humic acid on methyl chavicol and linalool content in essential oil of basil

Table 2. Influence of mulching and nutrition on plant nutrient uptake

Treatments	N (kg/ha)	P (kg/ha)	K (kg/ha)
M_0	37.34	12.79	38.17
M_1	54.56	37.71	57.85
M_2	40.14	27.73	47.66
M_3	19.68	8.39	30.64
S.Em. ±	2.15	1.38	2.44
CD at 5%	6.23	4.00	7.04
N_0	43.37	21.19	39.28
N_1	30.85	15.89	39.23
N_2	39.27	24.71	46.93
N_3	38.24	24.82	48.88
S.Em. ±	2.16	1.39	2.44
CD at 5%	6.23	4.00	7.04
M_0N_0	47.64	12.09	32.41
M_0N_1	30.96	7.49	38.41
M_0N_2	31.68	16.52	35.90
M_0N_3	39.09	15.05	45.97
M_1N_0	70.18	36.96	51.14
M_1N_1	37.17	36.44	50.31
M_1N_2	58.37	39.03	66.77
M_1N_3	52.54	38.42	63.18
M_2N_0	41.19	28.71	43.72
M_2N_1	32.04	10.63	46.13
M_2N_2	44.09	34.66	46.59
M_2N_3	43.26	36.93	54.20
M_3N_0	14.48	7.02	29.84
M_3N_1	23.23	9.02	22.05
M_3N_2	22.93	8.64	38.48
M_3N_3	18.08	8.88	32.18
S.Em. ±	4.31	2.77	4.88
CD at 5%	12.45	8.00	NS

M_0- No mulch, M_1- Black plastic mulch M_2-Silver plastic mulch, M_3-Orhanic mulch, N_0- 100 % RDF, N_1-75% RDF combined with humic acid, N_2-75% RDF combined with microbial consortia, N_3-75% RDF combined with humic acid and microbial consortia, S.E.M- Standard Error or means and CD- Critical difference

4. CONCLUSION

To summarize the findings, the use of black mulch has been shown to enhance essential oil content, essential oil yield, and nutrient uptake in plants. Meanwhile, supplementing with 75% RDF and humic acid led to the highest essential oil content, while adding microbial consortia resulted in the highest essential oil yield, phosphorous uptake, and potassium uptake. The application of 100 percent RDFresulted in the highest nitrogen uptake. When combined with black mulch, 75% RDF and humic acid yielded the highest essential oil content and essential oil yield. On the other hand, black mulch combined with 75% RDF and microbial consortia resulted in the highest methyl chavicol content, while silver mulch with 75% RDF, humic acid, and microbial consortia yielded the highest linalool content. Overall, the combination of black mulch, 75% RDF, and humic acid was the most effective in achieving maximum essential oil yield.

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