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Growth of menthol mint (*Mentha arvensis* L.) and sugarcane (*Saccharum officinarum* L.) as influenced by intercropping system

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Abstract
The present study was carried out during *Kharif*, 2019 to study the growth of menthol mint and sugarcane as influenced by intercropping system. Results revealed that, growth of menthol mint was not significantly influenced at initial stage (45 DAP). But, in later stages significant variation in menthol mint growth because of sugarcane was observed. At 90 DAP, maximum plant height, spread, number of branches leaf area and total dry matter production (59.29 cm, 52.07 cm, 43.81, 1277.72 cm^2 plant^{-1}, 44.77 g plant^{-1} respectively) were observed in sole menthol mint (T_1). Among the intercropping system with different row proportions studied, maximum plant height (50.37cm) observed in menthol mint (1 row) in sugarcane (120 cm) (T_2). While, plant spread, number of branches, leaf area and dry matter production (45.97cm, 38.53, 1095.37 cm^2 plant^{-1}, 40.95 g plant^{-1} respectively) were observed in menthol mint (2 rows) in sugarcane (180 cm) (T_4). In case of sugarcane, height was not significantly affected by the intercropping system. While, maximum number of tillers per plant, leaf area, dry matter production (6.58, 14069.82 cm^2 plant^{-1}, 993.47 g plant^{-1} respectively) were observed maximum in sole sugarcane (T_8) at 120 DAP. Among the intercropping system with different row proportions studied, maximum number of tillers per plant, leaf area and dry matter production (6.27, 13372.69 cm^2 plant^{-1}, 973.93 g plant^{-1} respectively) at 120 DAP were observed in menthol mint (1 row) in sugarcane (120 cm) (T_2).

Keywords: Menthol mint, sugarcane, intercropping

1. Introduction

Intercropping is growing of two or more crops simultaneously on the same land by utilizing resources such as soil, water, nutrients and solar radiation more efficiently (Rana *et al.*, 2013) [11]. The main purpose of intercropping is to produce higher yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop efficiently (Evans *et al.*, 2001) [2].

Mints belong to the genus *Mentha* (family: Lamiaceae). Although many species of mints are being cultivated world over for their essential oil, four species are predominantly cultivated in India. These include menthol mint, pepper mint, bergamot mint and spear mint (Sharma *et al.*, 2019) [7]. India is the leading producer of menthol mint in the world having 0.3 million hectare area with annual production of 38,000 metric tonne of essential oil. Uttar Pradesh is major menthol mint cultivating state in our country with 80% of total production, other states like Haryana, Punjab, Bihar are other states cultivating menthol mint. In the world China, Brazil, Japan and United States are other countries producing menthol oil (Kumar *et al.*, 2019) [7].

Menthol mint is valuable commercially for its high oil yield and the menthol content. This essential oil is commonly used in medicines for cold remedies, cosmetics, mouth washes and also used as flavouring agent in various types of confectionaries and dental cream (Kumar *et al.*, 2019) [7]. In the recent past, there is greater demand for aromatic crops as they are the raw material for pharmaceutical, perfumery, cosmetics and confectionery industries (Lulie *et al.*, 2014). Mint is supposed to make good companion plant because of short duration, high value and easy cultivation practices.

Sugarcane is an important commercial crop occupies prime position in Indian agriculture. It is the second largest organized agro industry next to textile and plays a crucial role in national economy (Khippal *et al.*, 2016) [4]. Brazil is the largest producer of sugarcane in the world followed by India, Thailand and China. In India, Uttar Pradesh stands first in sugarcane production, followed by Karnataka and Maharashtra (www.knoema.com)

The growth of sugarcane is slow during initial stages, with plenty of uncovered area due to less leaf canopy coverage. In the wide interspaces of sugarcane weeds exploit the growth resources enormously and affect the tillering and growth of sugarcane. During this period one can productively utilize the growth resources by intercropping with different crops which do not compete with sugarcane (Kumari, 2006) [8]. Thus intercropping makes better utilization of soil moisture, nutrients, light and space than monocropping (Khippal *et al.*, 2016) [4]. Hence, growing of compatible intercrops makes effective utilization of resources and improves productivity of the system (Zarekar, 2016 and Kumar *et al.*, 2018) [17 5]. This field experiment was, conducted to investigate the influence of intercropping on growth of menthol mint and sugarcane.

2. Material and Methods
2.1 Details of the experimental site
The field experiment was conducted during *kharif*, 2019 at the K.R.C. college of Horticulture, Arabhavi, of the University of Horticultural sciences, Bagalkot, in Karnataka, India. Arabhavi is situated in Northern dry Zone of Karnataka state (Zone NO.3, Region-2) at 16°15' N latitude and 74°45' E longitude, 612 m above mean sea level. The experimental sites receive, on an average, about 362.9 mm rain annually. The soil at the experimental site was sandy clay loam with pH 7.42.

2.2 Experimental details
The experiment was laid out in randomized block design with three replications. Menthol mint cv. Kosi and sugarcane cv. Co VSI 8005 were chosen for the experiment. Both sugarcane and menthol mint were planted according to their row spacing. Plots of 10.8 m x 6 m size were made. Menthol mint received 150: 60: 60 kg ha^{-1} and sugarcane received 250: 60: 190 kg ha^{-1} N:P:K in the form of Urea, DAP and MOP, gypsum (500 kg ha^{-1}) and micronutrient mixture (50 kg ha^{-1}) were also applied.

Observations of growth parameters like plant height, plant spread, number of branches were recorded at 45, 60 and 90 DAP in menthol mint on randomly selected plants in each replication of different treatments. The leaf area was assessed by using Biovis instrument. For estimation of total dry matter production the selected plants were uprooted from soil and the different plant parts like leaves, stem and roots were separated and dried in oven for 15 hrs at 60°C. While, in sugarcane, plant height, number of tillers, leaf area and total dry matter production were recorded on randomly selected plants in each replication of different treatments at 60,120 DAP.

Treatment details
- T_1 : Menthol mint (45 X 30 cm) sole crop
- T_2 : Sugarcane 120 cm + menthol mint (1 row)
- T_3 : Sugarcane 150 cm + menthol mint (2 rows)
- T_4 : Sugarcane 180 cm + menthol mint (2 rows)
- T_5 : Sugarcane 180 cm paired row (60 cm between rows) + menthol mint (2 rows)
- T_6 : Sugarcane 210 cm paired row (60 cm between rows) + menthol mint (2 rows)
- T_7 : Sugarcane 240 cm paired row (60 cm between rows) + menthol mint (3 rows)
- T_8 : Sugarcane (120 cm X 60 cm) sole crop

3. Result and Discussion
3.1 Menthol mint
Data on growth characters of menthol mint as influenced by intercropping system showed that (Table 1) plant height, spread and number of branches of menthol mint were not significantly differed at initial stage (45 DAP) due to lower competition between component crops as both the plant canopies were small. However, in later stages, significant variation in menthol mint growth because of sugarcane was observed. Sole menthol mint (T_1) recorded maximum plant height (44.69, 59.29 cm), plant spread (36.57, 52.07 cm) and number of branches (17.73, 43.81) at 60 and 90 DAP respectively, this was possibly due to, sole crop had lesser competition as compared to intercropped menthol mint. Among the intercropping system with different row proportions studied, maximum plant height (37.81, 50.37 cm) recorded in menthol mint (1 row) in sugarcane (120 cm) (T_2), as a result of shade caused by sugarcane. The plant spread (25.40, 40.24 cm) and number of branches (11.23, 31.80) at 60 and 90 DAP respectively, were lower, due to lower light penetration. Maximum plant spread (32.15, 45.97 cm) and number of branches (14.57, 38.53 at 60 and 90 DAP respectively), were recorded in menthol mint (2 rows) in sugarcane (180 cm) (T_4). Increase in growth attributes might be due to better light penetration which is required for better plant spread and branching. Similar results were reported in other aromatic crops: Patchouli intercropped with okra, French bean and black gram and different *Mentha* species intercropped in poplar (Singh, 2008; Joshi *et al*., 2018) [3].

Intercropping significantly influenced physiological parameters (Table 2) at all the growth stages except 45 DAP, due to lack of significant competition. Maximum leaf area (663.23, 1277.72 cm^2 $plant^{-1}$) and dry matter production (17.57, 44.77 g $plant^{-1}$) at 60 and 90 DAP respectively, were observed in sole menthol mint (T_1). It was due to increased plant growth and lack of competition posed by component crop. With respect to leaf to stem ratio, no significant variation noticed in menthol mint. Among the intercropping system, menthol mint (2 rows) in sugarcane (180 cm) (T_4) recorded maximum leaf area (548.54, 1095.37 cm^2 $plant^{-1}$) and dry matter production (15.96, 40.95 g $plant^{-1}$ at 60 and 90 DAP respectively) this is attributed to, better light penetration led to wider plant spread, more number of branches and leaf area which resulted in higher dry matter production per plant.

Minimum values (leaf area: 458.34, 948.78 cm^2 $plant^{-1}$ and dry matter production: 13.13, 33.44 g $plant^{-1}$ at 60 and 90 DAP respectively) were observed in menthol mint (1row) in sugarcane (120 cm) (T_2). This was possibly due to shade effect of sugarcane, light penetration to menthol mint was low which limited photosynthetic activity, as a result plant spread, number of branches and leaf area were decreased. Consequently, dry matter production per plant declined. These results are in line with findings of Chandranath (2006) [1] and Rathod (2009) [12].

3.2 Sugarcane
The perusal of data (Table 3) revealed that, the sugarcane height was not significantly affected by the intercropping system. Significant variation noticed in number of tillers at 120 DAP. Maximum number of tillers (6.58 $plant^{-1}$) recorded in sole sugarcane (T_8) at 120 DAP. Due to absence of intercrop there was no competition for growth supporting factors *viz.*, moisture, nutrients and space which resulted in better growth of sugarcane plants.

Among the intercropping system with different row proportions studied, sugarcane (120 cm) with menthol mint (1 row) (T_2) recorded maximum number of tillers (6.27 $plant^{-1}$)

at 120 DAP, which was *on par* with sole sugarcane (T_8). The obvious reason could be that, accommodation of one row of menthol mint posed less competition for space, moisture and nutrients for sugarcane which led to better growth. Minimum number of tillers (4.93 plant^{-1}) at 120 DAP, observed in sugarcane (180 cm paired row) with menthol mint (2 rows) (T_5). This is attributed to tillering in sugarcane starts from 40 days after planting, early formed tillers produce thicker and heavier stems, while later formed tillers die or remain short or immature. Tillering in sugarcane is influenced by various factors such as variety, spacing, light, temperature, soil moisture and nutrients availability. Due to lower inter row space between component crops in sugarcane (180 cm paired row) with menthol mint (2 rows) (T_5), competition for space, nutrients and moisture was high, which affected on growth of sugarcane tiller production. Decline in number of sugarcane tillers per plant in intercropping system were recorded previously (Saini *et al.*, 2003; Kumar *et al.*, 2015) [14, 6].

Data on Physiological attributes (Table 4) indicated that, sole sugarcane (120 x 60 cm) (T_8) recorded maximum leaf area (14069.82 cm^2 plant^{-1} and dry matter production 993.47 g plant^{-1}) at 120 DAP. Among the intercropping system, sugarcane (120 cm) with menthol mint (1 row) (T_2) recorded maximum leaf area and dry matter production (13372.69 cm^2 plant^{-1} and 973.93 g plant^{-1}) at 120 DAP respectively, which was *on par* with sole sugarcane, this was due to, less competition posed by menthol mint as only one row of menthol mint was accommodated in between sugarcane, which resulted in more plant height and tillers and leaf area which in turn increased dry matter production per plant. Minimum (Leaf area: 9442.91 cm^2 plant^{-1}, dry matter production: 779.29 g plant^{-1}) observed in sugarcane (180 cm paired row) with menthol mint (2 rows) (T_5). This might be due to inter row spacing between sugarcane and menthol mint was low, which led to more competition between component crops for nutrients, space and moisture. This impacted on growth of sugarcane plant height, number of tillers and leaf area. Therefore, resulted in lower dry matter production. These results are in conformity with findings of Roodagi (1998) [13] and Prabhakar (1999) [10].

Table 1: Growth of menthol mint as influenced by intercropping system at different stages

Treatments	Plant height			Plant spread			Number of branches		
	45 DAP	60 DAP	90DAP	45 DAP	60 DAP	90DAP	45 DAP	60 DAP	90DAP
T_1	34.65	44.69	59.29	28.57	36.57	52.07	3.40	17.73	43.81
T_2	31.81	37.81	50.37	21.12	25.40	40.24	2.60	11.23	31.80
T_3	30.42	35.29	46.11	26.90	32.08	45.51	3.27	13.93	37.50
T_4	32.25	36.19	48.75	27.12	32.15	45.97	3.33	14.57	38.53
T_5	27.22	33.35	42.80	23.21	27.62	41.82	2.80	12.00	33.97
T_6	29.92	35.26	45.49	26.43	31.87	45.21	3.20	13.50	37.00
T_7	27.40	33.89	43.52	24.36	28.41	42.06	2.93	12.33	34.53
S.Em+	2.25	2.16	2.87	1.72	1.37	1.64	0.20	1.00	1.65
C.D. at 5%	NS	6.64	8.85	NS	4.23	5.05	NS	3.09	5.08

Note: DAP- Days after Planting, NS – Non Significant

Table 2: Physiological attributes of menthol mint as influenced by intercropping system at different stages

Treatments	Leaf area (cm^2)			Leaf to stem ratio			Total dry matter production (g plant^{-1})		
	45 DAP	60 DAP	90DAP	45 DAP	60 DAP	90DAP	45 DAP	60 DAP	90DAP
T_1	147.76	663.23	1277.72	1.72	1.28	1.06	3.78	17.57	44.77
T_2	123.25	458.34	948.78	1.59	1.06	0.96	3.15	13.13	33.44
T_3	137.63	528.84	1029.12	1.56	1.10	1.03	3.57	15.01	37.94
T_4	141.98	548.54	1095.37	1.62	1.14	0.97	3.64	15.96	40.95
T_5	123.87	468.63	955.98	1.61	1.04	0.99	3.19	13.80	35.32
T_6	136.52	522.68	1023.22	1.56	1.11	1.02	3.48	14.89	37.31
T_7	127.29	483.07	968.08	1.57	1.07	0.99	3.30	14.38	37.03
S.Em+	5.57	32.20	53.72	0.11	0.06	0.05	0.14	0.44	1.13
C.D. at 5%	NS	99.22	165.52	NS	NS	NS	NS	1.37	3.48

Note: DAP- Days after Planting, NS – Non Significant

Table 3: Growth of sugarcane as influenced by intercropping system at different stages

Treatments	Plant height (cm)		Number of tillers (plant^{-1})	
	60 DAP	120 DAP	60 DAP	120 DAP
T_2	116.73	184.85	3.40	6.27
T_3	114.60	182.89	3.00	5.86
T_4	115.13	183.05	3.18	6.00
T_5	112.27	181.45	2.47	4.93
T_6	114.13	182.28	2.93	5.47
T_7	113.33	181.67	2.79	5.09
T_8	119.60	186.97	3.48	6.58
S.Em+	5.34	6.73	0.22	0.17
C.D. at 5%	NS	NS	NS	0.53

Note: DAP- Days After Planting, NS – Non Significant

Table 4: Physiological attributes of sugarcane as influenced by intercropping system at different stages

Treatments	Leaf area (cm^2)		Total dry matter production (g $plant^{-1}$)	
	60 DAP	120 DAP	60 DAP	120 DAP
T_2	1907.50	13372.69	88.46	973.93
T_3	1738.34	11947.77	83.28	867.48
T_4	1815.91	12825.65	84.23	892.92
T_5	1511.33	9442.91	77.84	779.29
T_6	1647.73	10715.90	80.44	862.68
T_7	1549.79	9824.46	78.97	789.31
T_8	1926.67	14069.82	89.58	993.47
S.Em+	95.72	343.12	4.62	26.89
C.D. at 5%	NS	1057.24	NS	82.86

Note: DAP- Days after Planting, NS – Non Significant

4. Conclusion

The results of the present study revealed that, intercropping affected growth of menthol mint and sugarcane significantly. Due to absence of intercrop there was no competition for growth supporting factors *viz.*, moisture, nutrients and space which resulted in better growth of both sole menthol mint and sole sugarcane plants. While, in intercropping system, competition between component crops for light and space and nutrients affected the growth of both menthol mint and sugarcane.

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