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Influence of growing environment on growth and yield of fenugreek leaves under shade net and open condition

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Abstract
A field experiment was conducted at Horticultural College and Research Institute, Coimbatore, during 2018-19 to study the performance of fenugreek variety CO 2 sown in shade net house (50% shade) and open field condition in different months. Among the growing conditions, fenugreek grown for leaf purpose under shade net house exhibited better performance in terms of growth, yield and quality than open condition. The Observations on morphological and quality traits were recorded in every month after sowing so as to study the environmental influence on growth and yield of fenugreek foliage. The days taken for germination were earlier (5.09 days) when the seeds were sown during November under shade net condition compared to open field condition. The vegetative and yield attributes *viz.*, plant height (26.77 cm), number of leaves (33.20) and leaf yield (3.11 kg/plot) were found to be the highest during the month of November sown crop followed by October sown crop in shade net house condition. While, in open condition, fenugreek seeds sown during the months of August and March failed to germinate causing crop failure. In this study, the yield was almost doubled under shade net house condition, when compared to open field condition. It is also inferred that the crop can be grown for leaf purpose under shadenet during summer.

Keywords: Fenugreek, months, shade net, open field, growth parameters

Introduction
Fenugreek (*Trigonella foenum-graecum* L.) belonging to the family Fabaceae, is an important seed spice as well as an important leafy vegetable. Because of its multivarious uses, fenugreek ranks as the third most important seed spice of India after coriander and cumin. It is a self-pollinated dicotyledonous plant with branched stems, trifoliate leaves, which bears white to yellow flowers and produces golden yellow to brown seeds. Fenugreek is a multipurpose crop being used as a spice, leafy vegetable, fodder and medicinal plant. The fresh tender leaves and shoots are much used as a vegetable for human consumption since ancient times and as forage for cattle and also in medicine. Fenugreek contains a number of chemical constituents including steroidal sapogenins, 6–7% fat, 23-26% protein and 58% carbohydrates of which about 25% is dietary fiber. Diosgenin component has been found in the oily embryo of fenugreek. Fenugreek is also a rich source of iron, containing 33 mg/100 g dry weight. Leaves contain seven saponins, graecunins compounds of diosgenin, 86.1% moisture, 4.4% protein, 0.9% fat, 1.5% minerals, 1.1% fiber, 6% carbohydrates, ascorbic acid (220.97 mg per 100 g of leaves), β-carotene (19 mg per 100 g of leaves), vitamin C (52 mg), thiamine (40 µg), riboflavin (310 µg) and nicotinic acid (800 µg).

Generally, sowing was done in the kharif season. It is mainly grown during the month of October for leafy purpose and the performance is poor during summer months. The year round production of leafy fenugreek can be done by adopting protected cultivation. Growing under protected condition increases the possibility of making the leaf available in the market when it is in great demand. fenugreek can tolerant frost and freezing weather condition. It can't be grown during hot summer month. Growers can cultivate a crop in any season under shade net/polyhouse by adjusting the microclimate required by this plant species. The prevalence of varied climatic conditions i.e., in South India, the summer starts from April to June and south west monsoon season starts from June to September and north east monsoon starts during October. While, in North India, the summer season starts from March and ends in May and rainy season starts from June to October, besides severe winter from November to February.

Differences in changes in microclimate at different stages of crop growth can be offered by varying dates of sowing in fenugreek. Hence, a research work was under taken to study the performance of leafy fenugreek during different months of sowing under open field and shade net house conditions.

Material and Methods

The experiment was laid out in Randomized Block Design (RBD) with three replications. In the present experiment CO 2 variety of fenugreek seeds collected from the Department of Spices and Plantation crops, HC&RI, Coimbatore were evaluated under two environments *viz.*, open field condition (G1) and shade net condition (G2) and different months of sowing for treatments *viz.*, from August (S1),September (S2), October (S3), November (S4), December (S5), January (S6), February (S7), March (S8) thus, making total sixteen treatment combinations. The seeds were sown every months in raised beds (1m×2m size) with the spacing of 25cm × 30cm. The plots were applied with FYM @ 10 t per ha. Fertilizers were applied at the rate of 25: 25: 50 kg of NPK per hectare. Before sowing, the seeds were soaked in water for 12 hours to hasten the germination and line sowing was done. The green leaves were harvested in early morning when they attained a marketable stage.

Observations

Observations on growth parameters *viz.*, Days taken for germination, Plant height, Number of leaves, Number of primary branches at 35 DAS and at the time of harvesting yield were recorded. Five plants from each plot were tagged to record the observations.

Statistical analysis

The recorded data were analysed statistically using SPSS (Statistical packages for social sciences) *version*. 16 and mean comparison was carried out by Duncan's multiple range test (DMRT) and critical difference were worked out at five percent probability level.

Result and Discussion

Days taken for germination

Early germination was observed in the month of November under both open condition (7.54 days) and shade net (5.09 days) followed by October month under open condition (7.91days) and shade net condition (5.32 days). Days taken for germination was significantly affected by time of sowing and different growing condition (Table 1). Among the growing condition, seeds sown under shade net found to record minimum number of days to germinate with an average of 7.11 days, whereas average number of days taken for seeds germination under open field condition was 9.63 days. During the summer month March there was no germination in open field condition. Under shade net condition, late germination was recorded during March (9.49 days). Generally, Fenugreek seeds can germinate and establish well in the temperature range of 22-27 ºC. The optimum temperature range of 21-32 ºC prevailed during October and November month under shade net and also in open condition which may be the reason for the early germination in that particular month. In open condition, the crop did not germinate during summer month (March) but under the shade net conditions, the germination was not affected and the crop establishment was observed even during summer. In summer season, research was conducted in different leafy vegetable fenugreek showing the early germination (4.01 days) under shade net condition. (Solanki *et al*., 2018) [11] The temperature was observed to have a significant effect on the maximum germination percentage, germination uniformity, germination rate and time to 5, 10, 50, 90 and 95% germination in fennel (Heidari *et al*., 2014) [7].

High temperature was found to be the main limiting factor for the germination and growth of coriander (Sarada *et al*, 2011) [12]. Since temperature has considerable effect on germination characters *viz.*, germination rate and days taken to germination, it is therefore the most critical factor in the determination of success or failure of crop establishment. This reduction or inhibition in germination rate at undesirable temperatures can be attributed to the reduction or inhibition of enzymatic activity which is responsible for seed germination process.

November was the optimum sowing time for production of fenugreek leaf in open field without any reduction in rate of seed germination. Similar results were also reported by several researchers in coriander Kamaha and Maguire (1992), Guha *et al.*, (2014) [5]. Moreover, another mechanism for this reduction is reduced metabolic efficiency at temperatures higher than optimum (Hansen *et al.*, 2002) [6]. This results indicated that summer month was not ideal for the germination of fenugreek.

Plant height

The highest plant height of 26.77 cm was observed in November month under shade net condition. Significant differences in plant height was recorded under different growing condition and time of sowing (Table 1). While comparing the growing conditions maximum mean plant height of 23.78 cm and 21.37 cm were recorded in shade net and open field condition respectively. During March and August months there were no growth in open condition. Even under shade net condition, minimum plant height was observed in March (18.54cm). In fenugreek, growth parameters were significantly influenced by sowing dates, e.g. plant height, number of primary branches and leaves (Bhattacharaya *et al*., 2006) [3]. It appears that the decreased light penetration into middle and lower layers of canopy which decreases the auxin decompositions there by enhances the plant height. According toimam and Ranjbar, (2000) [8], plant height increased due to shading as supported by Singh *et al.*, (1994) [13] and Tehlan and Malik, (2010) [15].

Number of leaves per plant

The results showed that, the crop raised under November had more number of leaves per plant (26.80) in open field as well as shade net conditions (33.20). Number of leaves per plant was varying significantly with time of sowing and growing condition. During March month, number of leaves recorded under shade net conditions were 20.20 whereas, under open condition, there was a crop failure (Table 1). Whereas, the crop grown under shade net condition recorded the highest mean value of 23.47 leaves when compared to open condition (19.96). In fenugreek effect of temperature under three different sowing dates Oct.1st, Oct 20th, and Nov. 10th growth to be observed in the two winter seasons indicated the significant differences between the three sowing dates on plant height, number of leaves and number of branches, in both seasons. First winter season showed that the early sowing date (oct.1st) was recorded the high value for all parameters, and the 2nd winter season has the same trend, and

there is no significance difference between the two seasons. (Abou shleel, 2014) [2]

Vegetative growth parameters were found to be better in shade net condition which might be due to favorable growing condition. Plants under shade produced more number of leaves which had increased photosynthetic area through the action of cell division and cell enlargement. These results were in similar with the findings of previous researchers Sinha *et al.,* (2005) [14].

Number of primary branches per plant

More number of primary branches were produced during November (5.12) under open field condition followed by the seeds sown during October (4.04).The number of primary branches was significantly influenced by the time of sowing and growing conditions under open field condition (Table 2).In shade net condition, more number of primary branches were recorded in the plants (seed sown during November months (4.61)) followed by December, the treatment of sowing. Among the different growing conditions, the mean number of primary branches (4.17) was the highest in open field condition and it was the lowest in shade net condition (4.02). The growing condition influences the number of primary branches per plant. The maximum number of primary branches per plant was recorded in the crops which were grown in open field condition than that of plants grown under shade net condition. This may be due to the fact that plants grown under shade net conditions, intercept less light intensity and thus, photo-assimilates were deficient for the growth of auxiliary branches Moosavi *et al.*, (2014) [9]. Among the different shade intensities, 50 per cent shade recorded the highest number of leaves, plant height, number of branches and internodal length (21.92, 19.17cm, 6.17 and 6.08 cm, respectively) as compared with remaining shade intensity (0%, 35% and 75%) in coriander (Mahajan *et al*., 2017).

Leaf yield

The leaf yield showed a significant variation during different months of sowing under open field and shade net condition (Table 2). The leaf yield was the highest in the crop raised during November (3.11 kg/plot) followed by October (2.97 kg/plot) under shade net condition and the same trend was observed in open field condition with leaf yield of 1.01 kg/plot in the November raised crop. The mean leaf yield/plot was higher under shade net condition (2.51 kg/plot) and it was lower in the open field condition (0.78 kg/plot). The greater leaf number on November sown crop might have helped in the production of more metabolites and consequent growth accumulation of total solids which ultimately resulted in the production of larger amount of green leaf yield. November month showing the favourable environmental condition to grow the crop in earlier better leaf yield can be obtained.

Cost economics (Benefit cost ratio (BCR))

In fenugreek, cost economics were worked out under shade net and open field condition during different months of sowing (Table 3). Among the growing condition yield was the highest in November sown crop under shade net condition (15.55 t/ha).Whereas the lowest yield was recorded in (2.3t/ha) February under open field condition. There was a crop failure during the month of August and March under open field condition, hence there was no yield and the income was nil. Whereas under shade net condition, there was year round crop production, even during the off-season there by generating considerable income.

In Fenugreek B:C ratio was calculated, among different months, November month has the highest (5.47) B:C ratio under shade net condition. The mean leaf yield/plot and leaf yield (t) per hectare were higher under shade net condition and it was lower in the open field condition. The B:C ratio was also high under shade net condition indicating the profitability of the crop. This might be also due to more plant height, number of leaves and leaf area in shade net which developed carbohydrates through photosynthesis and ultimately increased yield. Cultivation under protected environment is the technique of providing favorable environmental or growth condition to the plants. It is rather used to protect plants from the adverse climatic conditions by providing optimum conditions of light, temperature, humidity, CO_2 and air circulation for the best growth of plants to achieve maximum yield (Dixit, 2007) [4].

Table 1: Effect of different months of sowing on days taken for germination, plant height, No. of leaves per plant

Time of sowing (S)	Days taken for germination		Plant height (cm)		No. of leaves per plant	
	Open (G1)	Shade (G2)	Open (G1)	Shade (G2)	Open (G1)	Shade (G2)
August	NA	8.70	NA	25.40	NA	21.80
September	10.66	7.51	20.99	26.29	18.40	24.40
October	7.91	5.32	22.10	25.83	23.93	27.80
November	7.54	5.09	23.68	26.77	26.80	33.20
December	9.22	6.25	21.82	23.29	17.60	22.93
January	10.95	6.89	22.54	23.58	14.60	18.60
February	11.51	7.60	17.11	20.51	18.40	18.80
March	NA	9.49	NA	18.54	NA	20.20
Mean	9.63	7.11	21.37	23.78	19.96	23.47
SE(d)	0.46	0.42	1.00	1.02	1.92	2.09
CD (P=0.05)	0.99**	0.91**	2.15**	2.20*	4.11**	4.49*
** - Highly significant, * - Significant and NS – Non-Significant						

Table 2: Effect of different months of sowing on No. of primary branches and yield (kg/plot)

Time of sowing (S)	No. of primary branches		Yield (kg/plot)	
	Open (G1)	Shade (G2)	Open (G1)	Shade (G2)
August	NA	3.77	NA	2.1
September	3.96	3.51	0.86	2.61
October	4.04	3.96	0.7	2.97
November	5.12	4.61	1.01	3.11
December	4.03	4.48	0.93	2.87
January	3.89	4.40	0.72	2.45
February	3.96	3.46	0.46	2.04
March	NA	3.99	NA	1.98
Mean	4.17	4.02	0.78	2.51
SE(d)	0.27	0.23	0.06	0.05
CD (P=0.05)	0.59**	0.48 NS	0.14**	0.10**
** - Highly significant, * - Significant and NS – Non-Significant				

Table 3: B: C ratio of different treatments

Time of sowing (S)	Cost economics							
	Open condition (G1)				Shade net condition (G2)			
	Yield (t/ha)	Gross income (Rs./ha)	Net Income (Rs./ha)	B:C ratio	Yield (t/ha)	Gross income (Rs./ha)	Net Income (Rs./ha)	B:C ratio
August	NA	0	NA	0.00	10.5	262500	205600	4.61
September	4.3	86000	59100	3.20	13.05	261000	204100	4.59
October	3.5	70000	43100	2.60	14.85	297000	240100	5.22
November	5.05	101000	74100	3.75	15.55	311000	254100	5.47
December	4.65	93000	66100	3.46	14.35	287000	230100	5.04
January	3.6	72000	45100	2.68	12.25	245000	188100	4.31
February	2.3	57500	30600	2.14	10.2	255000	198100	4.48
March	NA	NA	NA	NA	9.9	247500	190600	4.35

Conclusion

The present study revealed that sowing during November month under open field and shade net house condition is found to be useful to improve the yield as well the income. Also, it is proved that, cultivation under shade net house condition can improve the production of leafy fenugreek which is beneficial for farmers.

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