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Response of turmeric (*Curcuma longa* L.) cv. Salem planted by pro tray seedling method to spacing and nutrients

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Abstract
The present investigation entitled "Response of turmeric (*Curcuma longa* L.) cv. Salem planted by pro tray seedling method to spacing and nutrients" was carried out during the year 2020-2021 at AICRP on spices, Asond Block, Central Experiment Station, Wakavali.

At various periods of growth, the spacing (S_4) substantially recorded the maximum growth and developmental characteristics; nevertheless, the spacing (S_1) significantly recorded the highest plant height. The highest characteristics of mother rhizome, primary rhizome, secondary rhizome and highest yield per plant were observed in spacing (S_4). Although the spacing (S_1) recorded the best yield per plot and yield per hectare. In the case of different spacing quality character i.e. curcumin was non-significant. However, the characteristic of growth and developmental, mother rhizome, primary rhizome, secondary rhizome, yield per plant, yield per plot and yield per hector were recorded highest in F_2 fertilizer level and lowest in F_3 fertilizer level. Quality character i.e. curcumin was non-significant in the case of fertilizer levels.

During the course of an investigation, the interaction effect between spacings and fertilizer levels revealed that the treatment combination of S_4F_2 recorded significantly maximum growth and developmental characteristics which was superior over the rest of treatment combinations except for plant height which was maximum in S_1F_2 interaction. The characteristics of mother rhizome, primary finger, secondary finger and yield per plant were also recorded the maximum with the same treatment combination S_4F_2. However, significantly the highest yield per hector and yield per plot was recorded with a treatment combination of S_1F_2. Curcumin content was not significantly influenced by the interaction effect of spacings and fertilizer levels.

From the above investigation it is concluded that for securing higher yield per hectare under the Konkan region, it is advisable to grow the turmeric with S_1 spacing (30 × 15 cm) with F_2 (220:50:150 NPK kg/ha) fertilizer level.

Keywords: Turmeric, curcumin, spacing, fertilizer

Introduction

Turmeric is used in traditional medicine as a household remedy for various diseases including biliary disorders, anorexia, cough, diabetic wounds, hepatic disorders, rheumatism and sinusitis hence turmeric is affectionately called "Kitchen Queen". Turmeric is used to treat animal wounds and ulcers in veterinary medicine. Turmeric powder is used to protect containers from insects and ants by sprinkling it around them. Fresh turmeric pickle, which has huge pieces of soft turmeric, is one of its many applications in Far Eastern dishes.

Generally turmeric is planted during the period of 15th April to 15th May that is before onset of monsoon. However, at that time the acute shortage of water supply in Konkan region during above said period, it is difficult to achieve accurate planting time of turmeric during this period. Further, planting of turmeric after onset monsoon adversely affects the sprouting percentage and leads to decline in productivity. This is the main hurdle in commercial cultivation of turmeric in the Konkan region. To have a breakthrough, the possibility of cultivation of turmeric by preparing pro tray seedling from single node finger rhizome in pro trays can be exploited. Turmeric is a nutrient loving plant and removes large amount of nutrients from soil, so enough nutrients must be applied in order to meet its nutritional requirements and to obtain higher yields.

As regards the cost of planting material if the farmers go by traditional method of planting with mother rhizome the cost on seed become high which is not affordable by low-income group farmers.

However, raising of seedlings in pro tray has been proved as chief technology which reduces the cost on seed by 90% Spacing is also one of the important factors that greatly influence the yield contributing character and eventually affects the yield of turmeric to great extent. Therefore, this research is initiated to determine the optimum dose and right spacing that allow maximum yield of turmeric both in quantity and quantity by pro tray seedling method to meet the good yield with following

2. Materials and Methods

The field trial was conducted at All India Co-ordinated Research Project on Spices, Asond Block, Central Experiment Station, Wakawali, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during May, 2021 to February, 2022.

The experiment was laid out in Split Plot Design (RBD) with twenty eight treatments replicated twice. The treatments detalis are as given in table 1. The recommended dose of fertilizers (100: 50: 50 kg N, P_2O_5 and K_2O kg ha^{-1}) and other package of practices for rice were imposed uniformly for all the treatments including control treatments except weed management treatments.

Table 1: Treatment details for the field experiment

Main plot: Spacing

Sr. No.	Spacing Code		Spacing details
1)	S_1	:	30 X 15 cm
2)	S_2	:	30 X 20 cm
3)	S_3	:	30 X 30 cm
4)	S_4	:	40 X 30 cm

Subplot: Fertilizer level

Sr. No.	Fertilizer Code		Fertilizer details
1)	F_1	:	200:50:150 NPK kg/ha
2)	F_2	:	220:50:150 NPK kg/ha
3)	F_3	:	180:50:150 NPK kg/ha
4)	F_4	:	200:70:150 NPK kg/ha
5)	F_5	:	200:30:150 NPK kg/ha
6)	F_6	:	200:50:170 NPK kg/ha
7)	F_7	:	200:50:130 NPK kg/ha

Results and Discussion

In turmeric (*Curcuma longa* L.) cv Salem, the plant yield attributes were influenced by application of different fertilizer levels and spacings.

Table 1: Effect of spacing, fertilizer levels and their interaction on yield and quality of turmeric (cv. Salem) planted by pro tray method

Yield and Quality																				
	Yield per plant (g)					Yield per plot (kg)					Yield per hector (t)					Curcumin %				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean
F_1	147.20	168.70	184.40	213.75	178.51	9.80	8.43	6.14	5.34	7.43	32.66	28.1	20.46	17.8	24.76	3.80	3.80	3.81	3.31	3.68
F_2	165.91	204.67	250.75	283.71	226.26	11.05	10.23	8.35	7.09	9.18	36.83	34.1	27.83	23.63	30.60	3.85	3.85	3.85	3.86	3.85
F_3	103.57	112.15	165.15	184.05	141.23	6.90	5.61	5.50	4.60	5.65	23	18.7	18.33	15.33	21.20	3.76	3.76	3.77	3.77	3.76
F_4	141.20	163.38	228.45	258.42	197.86	9.41	8.17	7.61	6.46	7.91	31.36	27.23	25.36	21.53	26.37	3.85	3.83	3.84	3.84	3.84
F_5	124.25	143.90	178.45	242.14	172.19	8.28	7.20	6.05	5.94	6.87	27.6	24	20.16	19.8	22.89	3.785	3.79	3.79	3.79	3.79
F_6	147.15	181.10	199.60	236.25	191.03	9.8	9.06	6.65	5.91	7.86	32.66	30.2	22.16	19.7	26.18	3.845	3.85	3.85	3.85	3.85
F_7	134.25	145.07	167.90	193.10	160.08	8.9	7.25	5.59	4.83	6.64	29.66	24.16	18.63	16.1	22.14	3.775	3.78	3.67	3.67	3.72
Mean	137.65	159.85	196.39	230.20		9.16	7.99	6.54	5.75		30.54	27.94	21.90	19.13		3.81	3.81	3.80	3.73	
	S.Em±		CD @ 5%			S.Em±		CD @ 5%			S.Em±		CD @5%			S.Em±		CD @ 5%		
S	0.07		0.32		SIG	0.23		1.02		SIG	0.06		0.29		SIG	0.05		-		NS
F	0.09		0.28		SIG	0.18		0.52		SIG	0.09		0.25		SIG	0.05		-		NS
S X F	0.19		0.55		SIG	0.35		1.03		SIG	0.17		0.50		SIG	0.10		-		NS

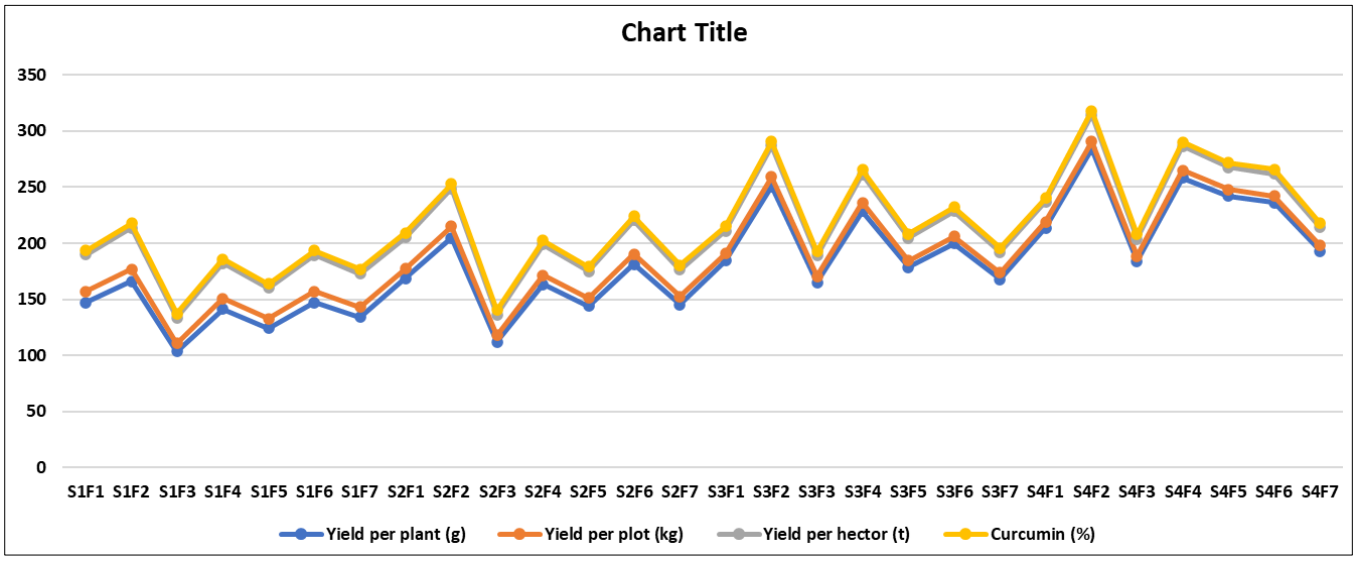

Fig 1: Effect of spacing, fertilizer levels and their interaction on yield and quality of turmeric (cv. Salem) planted by pro tray method

Crop yield is the conversion of solar energy into useful form of chemical energy which is mainly governed by its genetic makeup. However, efficiency for utilization of solar energy in terms of yield can be enhanced either by the alteration in genetic makeup of crop plants or by agronomic manipulation. Plant spacing is one of the ways of agronomic manipulations, which maintain the optimum plant population.

Yield per plant (g)

Effect of spacing

An examination of the data in **Table 1** and **Fig. 1** indicated that much wider spacing S_4 (40 x 30 cm) produced the maximum yield per plant (230.20 g), which was significantly higher than S_3 i.e. 30 x 30 cm (196.39 g) and S_2 i.e. 30 x 20 cm (159.85 g). The closer spacing S_1 (30 x 15 cm) recorded the lowest yield per plant (137.65 g). The average yield per plant was shown to improve as spacing was increased. Wider spacing produced the best yield per plant, which was much better than closer spacing. Among the various plant spacings, wider spacing provided the proportionally largest weight of rhizome, resulting in maximum yield per plant. Bahadur *et al*. (2000) [3] reported a similar finding, stating that wider spacing (50 X 40 cm) generated the maximum yield per plant (189.35 g).

Effect of fertilizer levels

The F_2 i.e. 220:50:150 NPK kg/ha fertilizer level produced the highest yield per plant (226.26 g), outperforming all others. F_3 i.e. 180:50:150 NPK kg/ha fertilizer level has recorded the lowest yield per plant (141.23 g). Majeed *et al*. (2020) [8] found that the treatment with the highest nitrogen dosage (182 kg/ha) had the best yield per plant (257.7 g). According to Arrarde *et al*. (2003), the amount of nitrogen fertiliser used grew along with the yield per plant. According to Sing *et al*. (2017) [18], a greater dose of nitrogen level combined with bio fertiliser resulted in the maximum yield per plant (208.2 g).

Effect of interaction

Significantly the highest yield per plant (283.71 g) was observed in the S_4F_2 i.e. S_4 - 40 x 30 cm; F_2 - 220:50:150 NPK kg/ha interaction, which was significantly superior to the rest of the interactions as well as S_1F_3 i.e. S_1 - 30 x 15 cm; F_3 - 180:50:150 NPK kg/ha interaction resulted in low yield per plant (103.57 g). The combined effect of spacing and nitrogen levels elucidated that the increase may be because of more availability of space, nutrients, moisture and better interception of sunlight for better development of rhizomes in wider spacing. Further, the higher yields at the higher nitrogen level may be due to better stem size and higher number of rhizomes per plant which may result from increase in number of leaves per plant with increase in nitrogen level. This may result in thgher photosynthesis.

Yield per plot

Effect of spacing

The largest yield per plot (9.16 kg) was reported at S_1 (30 x 15 cm) tighter spacing, which was considerably superior to S_2 (30 x 20 cm), which yielded 7.99 kg, and S_3 (30 x 30 cm), which yielded 6.54 kg and the lowest yield per plot (5.75 kg) was obtained with wider spacing S_4 (40 x 30 cm). The highest yield per plot was obtained with closer plant spacing, whereas the lowest yield per plot was obtained with broader spacing. This might be attributable to the increased plant population or the fact that more plants were accommodated per unit area with closer plant spacing than with medium and broader spacing, resulting in the highest yield per plot. Similar results were obtained by Wakhare (2001) [20], who reported that the highest yield per plot (7.76 kg) was recorded at a spacing of 45 x 15 cm. These results are consistent with those from Shashidhar (1995) [15], who reported that the highest yield per plot (7.73 kg) was recorded at a spacing of 45 x 22.5 cm.

Effect of fertilizer levels

The data indicated that the F_2 (220:50:150 NPK kg/ha) fertilizer level produced the highest yield per plot (9.18 kg), while the F_3 (180:50:150 NPK kg/ha) fertilizer level produced the lowest yield per plot (5.65 kg). According to Medda and Hore (2003) [10], the greatest nitrogen content (200 kg/ha) produced the highest yield per plot.

Effect of interaction

The S_1F_2 i.e. S_1 - 30 x 15 cm; F_2 - 220:50:150 NPK kg/ha interaction, had the greatest yield per plot (11.05 kg), which was at par with S_2F_2 i.e. S_2 - 30 x 20 cm; F_2 - 220:50:150 NPK kg/ha (10.23 kg). Low yield per plot was caused by the S_4F_3 i.e. S_4 - 40 x 30 cm; F_3 - 180:50:150 NPK kg/ha interaction (4.60 kg). Here, it may be elucidated that yield attributing characters like mother rhizome, primary finger, secondary finger and yield per plant were also maximum per unit area of wider plant spacing as compared to the rest of other spacings.

Yield per hectare

Effect of spacing

The statistics on yield per hectare showed that S_1 (30 x 15 cm), which was more closely spaced than S_2 (30 x 20 cm), S_3 (30 x 30 cm) and S_4 (40 x 30 cm) recorded the highest yield per hectare (30.54 t). The increased yield per hectare was obtained by the tighter spacing because there are more plants per unit space, which is thought to be natural. These findings closely match those of Ramchandra and Muthuswami (1984) [14], who found that the spacing of 30 x 15 cm showed its superiority over others by yielding the greatest rhizome yield of (47.43 t/ha) in turmeric. According to Rajput *et al*. (1980) [13] a closer spacing of 30 X 45 cm led to a much better yield in turmeric than other spacings, followed by 45 x 45 cm and 45 x 60 cm. Chattopadhyay *et al*. (1993) [5] reported that the turmeric yield decreases with an increase in spacing and the spacing 20 x 30 cm was found to be optimum which recorded a significantly higher yield (25.72 t/ha). Medhi and Bora (1993) [11] studied the effect of different spacings on turmeric and reported that closer spacing of 45 x 20 cm produced a higher yield (23.40 t/ha) over wider spacings (45 X 30 and 45 x 40 cm).

Effect of fertilizer levels

The F_2 i.e. 220:50:150 NPK kg/ha fertilizer level produced the highest yield per hector (30.60 t), outperforming all others. F_3 i.e. 180:50:150 NPK kg/ha fertilizer level has recorded the lowest yield per hector (21.20 t). The increase in yield per hectare with the application of higher dose of nitrogen over its lower dose may be due to increased production of metabolites due to higher levels of fertilizers thereby enhancing the nutrient uptake by the plants.

Attared *et al*. (2003) [2] concluded that yield per hectare of turmeric increased with increased in nitrogen fertilizer.

Medda and Hore (2003) [10] reported that maximum yield per hectare obtained at the highest level of nitrogen. Sing *et al*. (2017) [18] concluded that a higher dose of nitrogen level with biofertilizer produced the highest yield per hectare (204.4 q). Meerabai *et al*. (2000) [12] stated that application of highest dose of nitrogen among treatments (120 kg/ha) results in the highest average rhizome yield of 19.8 t/ha. This further also indicates that uptake of all major nutrients and micro-nutrients besides nitrogen had a significant influence on rhizome yield.

Effect of interaction

Interactions between spacing and fertilizer level had a significant impact on the data regarding yield per hectare. The information in Table 1 and Fig. 1 showed that treatment combination S_1F_2 i.e. S_1 - 30 x 15 cm; F_2 - 220:50:150 NPK kg/ha had a considerably higher maximum yield per hectare (36.83 t), which was significantly superior to all other combinations. S_4F_7 S_4 - 40 x 30 cm; F_7 - 200:50:130 NPK kg/ha reported the lowest production per hectare (16.1 t).

An increase in rhizome yield can also be attributed to better growth of plants in terms of plant height, number of leaves and leaf area in these treatments which had positive and significant correlations with yield. The best performance of turmeric in respect of growth parameters under wider spacing over the closer spacings could be explained in terms of sufficient food reserves, which probably encouraged vigorous plant growth and eventually translate into yield.

Curcumin content (%)

Effect of spacing

The results on the curcumin content showed that there was no detectable change in the curcumin content of turmeric between the varied spacings.

The same outcomes were reported by Shashidhar and Sulikeri (1996) [16] who studied the effect of plant densities on the curcumin content of turmeric rhizome and reported that plant spacing had a non-significant effect on curcumin content. Valsala *et al*. (1998) [19] reported that curcumin and curing percentage were not significantly affected by different spacing. Kaur (2001) [6] also concluded that no significant effect of different spacings on the curcumin content of turmeric rhizomes. Manjunathgoud *et al*. (2002) [9] found a non-significant effect on the curcumin content of turmeric with different plant populations.

Effect of fertilizer levels

The findings on curcumin content revealed that there was no noticeable difference in turmeric's curcumin content between the various fertiliser levels. The same results were reported by Kulpapangkorna and Mai-leang (2012) [7] found that the curcuminoids and volatile oil contained in turmeric were more than 5% curcuminoids and 6% volatile oil, which met standard levels and no significantly different in amounts of active constituents by any treatment. Shinde *et al*. (2016) [17] studied the reaction of fertilizer to turmeric cv. Salem in Konkan conditions and discovered that increasing fertilizer N levels did not increase the curcumin content. Additionally, according to Akamine *et al*. (2007) [1] the application of NPK produced the best yield but did not improve the concentration of curcumin.

Effect of interaction

Any of the interaction did not show the significant difference in content of curcumin it may be because curcumin is inherent property of turmeric. The same conclusion was supported by Bilekudari *et al*. (2005) [4] conducted an experiment to assess the effect of spacing and fertilizer levels on radish growth output and quality and observed that the interaction between spacing and fertilizer levels was non-significant.

Economics

The data on economics of turmeric fertilizer level at different spacing are presented in Table 2

The treatment combination S_1F_2 (30 cm X 15 cm with 220:50:150 NPK kg/ha fertilizer level) had the highest B:C ratio (2.65) which was significantly superior over other treatment combinations whereas, the lowest B:C ratio (1.54) was observed in treatment combination S_4F_1 (40 cm X 30 cm with 200:50:150 NPK kg/ha fertilizer level).

Table 2: Economic production of turmeric fertilizer levels at different spacing.

Sr. No.	Treatment	Yield t/ha	Cost of production t/ha	Gross value received Rs/ha	Net profit Rs/ha	B:C ratio
1	S_1F_1	32.66	816148	1923600	1107452	2.36
2	S_2F_1	28.1	800743	1680600	879856	2.10
3	S_3F_1	20.46	592189	1202760	610571	2.03
4	S_4F_1	17.8	441176	682000	242023	1.54
5	S_1F_2	36.83	816287	2164800	1348512	2.65
6	S_2F_2	34.1	860882	2040600	1179717	2.37
7	S_3F_2	27.83	662668	1624800	962131	2.45
8	S_4F_2	23.63	558048	1383600	825551	2.48
9	S_1F_3	23	816008	1380000	563991	1.69
10	S_2F_3	18.7	701204	1084200	382995	1.55
11	S_3F_3	18.33	571889	1081800	509910	1.89
12	S_4F_3	15.33	477470	901800	424329	1.89
13	S_1F_4	31.36	816380	1861800	1045420	2.28
14	S_2F_4	27.23	791075	1621200	830124	2.05
15	S_3F_4	25.36	642261	1501800	859539	2.34
16	S_4F_4	21.53	538041	1263000	724958	2.35
17	S_1F_5	27.6	815916	1623600	807684	1.99
18	S_2F_5	24	760411	1440000	679588	1.89
19	S_3F_5	20.16	591597	1200600	609003	2.03
20	S_4F_5	19.8	525077	1188000	662922	2.26
21	S_1F_6	32.66	816565	1923600	1107034	2.36

22	S_2F_6	30.2	821260	1801200	979939	2.19
23	S_3F_6	22.16	612246	1320600	708353	2.16
24	S_4F_6	19.7	518427	1144200	625772	2.21
25	S_1F_7	29.66	815730	1743600	927869	2.14
26	S_2F_7	24.16	760325	1440600	680274	1.89
27	S_3F_7	18.63	571911	1083600	511688	1.89
28	S_4F_7	16.1	486991	960600	473608	1.97

Conclusion

The treatment combination S_1F_2 (S_1 - 30 x 15 cm; F_2 - 220:50:150 NPK kg/ha) may be recommended to achieve the maximum fresh turmeric output per hectare under the agro-climatic conditions of the Konkan area. However, the experiment was carried out for the first time in this location, and it will be useful to investigate these possibilities again over the next 2-3 years in order to provide precise recommendations.

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