EFFECT OF PLANT SPACING ON PROFITABLE YIELD OF TURMERIC (*CURCUMA LONGA* L.)

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ABSTRACT: A research trail was carried out to elucidate the effect of plant spacing on the profitable yield of turmeric (*Curcuma longa* L.) at the Horticultural Research Area of Faculty of Agriculture, Gomal University, Dera Ismail Khan during 2009. The experiment was laid out in RCBD with five treatments/plant spacing (30x10, 30x20, 30x30, 30x40 and 30x50cm^2) and each treatment was replicated thrice. Plant spacing 30x50cm^2 have evidenced significant findings for almost all the parameters, as it took significantly least days taken to sprouting (82.00), maximum plant height (67.73 cm), number of leaves per plant (8.0), leaf length (35.22 cm), leaf diameter (9.917 cm), stem per plant (5.66), number of finger per plant (15.67), finger length (5.367 cm), finger weight (76.10 gm), diameter of finger (4.220 mm) and turmeric yield (2184 kg ha^{-1}).Thus it is concluded that a wider plant spacing of 30x50cm^2 would be more beneficial for the commercial production of turmeric (*Curcuma longa* L), especially under the agro-climatic condition of Dera Ismail Khan.

Key words: Plant spacing, sprouting, turmeric yield, commercial.

INTRODUCTION

Turmeric (*Curcuma longa* L.) like ginger belongs to the family Zingiberaceae. This plant is native to tropical South Asian region e.g. India, Pakistan, Bangladesh, Sri Lanka etc. Turmeric plants are gathered annually for their rhizomes and re-seeded from some of those rhizomes in the following season (Anonymous, 2010). Turmeric can be grown under diverse tropical conditions with altitudes ranging from sea level to 1500m above sea level (Rema and Madan, 2001). It requires well drained sandy or clay loam soil and temperature ranging between 20-30^{0}C with annual rainfall of 1500 mm or more (Olojede *et al*., 2005). It requires 2 years, minimum tillage, beds of 15cm height with 50 cm spacing between bed (Gill *et al*., 2004) and requires 2500 Kg rhizomes per acre (Chan *et al*., 2009). Planting is done either on raised beds or on ridges during March-April, under organic conditions as it requires 5-6 tons/hectare FYM. Its varieties are matures at different times ranging from 7-9 months. Its average yield is 20-25 tons of green turmeric (Filho *et al*., 2004). It produces tall, very beautiful, white flower spikes, if clumps are left undisturbed for a year. The flower is so attractive that it is worth growing for this alone. It requires a well-drained soil, frost-free climate. Heavy shade will reduce the yield but light shade is beneficial (Shashidhar and Sulikeri, 1996).

It has diversified uses. People of South Asia including India, Pakistan and Bangladesh usually use turmeric in curry preparation because of its typical color and flavor (Islam *et al*., 2002). Dry turmeric contents consist of about 69.43 % carbohydrates, 6.30 proteins, 5.10 oil and 3.5 % mineral and other important elements (Islam *et al*., 2002; Hossain *et al*., 2005).

In Pakistan, it was first grown on the trail basis at Kasoor District in the mid fifties, which flourished well. At present it is grown in abundance in Kasoor, Okara, Lahore and Sialkot districts in Punjab, Bannu and Haripur districts in the KPK and Mirpurkhas and Sanghar districts in Sindh. As compared to the other provinces KPK ranks second in turmeric production after Punjab with an area of 400 hectares with a total production of 3400 tons with an average of 8.5 ton ha^{-1} (Anonymous, 2008). Latest Data is not available.

Demand for turmeric is increasing year by year in Pakistan, while its production technology has not been fully developed. The economical yield of turmeric in Pakistan is very low (8.5 ton ha^{-1}) as compared to that of other major turmeric growing countries like India where its range from 25 to 30 ton ha^{-1} (Kandiannan and Chandaragir, 2006). The lower yield in Pakistan is mainly due to lack of high yielding varieties and sub-optimal management practices like fertilizer, inadequate plant population etc. Farmers in our country face many difficulties in weed management, fertilizer application and irrigation in turmeric fields, because of insufficient information about the emergence, growth patterns and yield of turmeric plants, and weed growth in relation to the planting date. Turmeric production per unit land area is very low because of poor knowledge on proper cultivation technology of the farmers (Ishimine *et al*.,

2003). Improvement of crop cultivation technology for local climatic and edaphic factors is important for successful production (Ishimine *et al*., 2003). The yield of the turmeric can be increased by adapting improve production technology like proper plant spacing. Spacing is being one of the most important factors which actively influence the inter plant competition, growth and ultimate yield of turmeric (Manjunathgoud *et al*., 2002). Plant spacing is an important agronomic attribute since it is believed to have effects on light interception during which photosynthesis takes place which is the energy manufacturing medium using green parts of the plant. (Pratop and Singh 2007) reported that closer spacing at 30x15 and 30x20 cm gave maximum plant height, whereas maximum number of tillers per main shoot and weight of fresh rhizome per clump was highest at 30x30 and 45x30 cm spacing. Plant height, fresh rhizome yield relative growth rate crop growth rate and oil yield increased with wider spacing, whereas number of plantlets, leaf length, breadth ratio and leaf area density increased with closer spacing (Gopichand *et al.,* 2006). And (Shashidhar *et al.*, 1997) reported that close spacing produced the tallest plants (23.2 cm) and total dry weight also increased, medium spacing produced plants with the highest number of leaves (10.79) and highest leaf area (28.58 dm^2), and wide spacing produced plants with the highest number of tillers (2.03). Plant spacing is an important agronomic attribute since it is believed to have effects on light interception during which photosynthesis takes place which is the energy manufacturing medium using green parts of the plant. Good plant spacing gives the right plant density, which is the number of plants, allowed on a given unit of land for optimum yield (Obi, 1991). The present study was therefore, designed to evaluate the best plant spacing for obtaining economical yield of turmeric for its commercial uses.

MATERIALS AND METHODS

Experiment was carried out to observe the effect of plant spacing on the production of turmeric at Faculty of Agriculture, Gomal University D. I. Khan. The experiment was laid out in a randomized complete block design (RCBD) with five different plant spacing replicated thrice. The plot size was 5m x 15m ($75m^2$) with row to row distance of 30cm. The details of plant spacing are (30x10, 30x20, 30x30, 30x40 and 30x50cm^2). Healthy turmeric fingers were sown in field (on ridges) on 3rd March 2009. After the sowing, they were irrigated soon and the irrigation was applied after every 6-7 days and fortnightly in summer and winter, respectfully. Fertilizer was applied @ 60-50-120 NPK kg ha^{-1}. All phosphorus and potash were applied one month after sowing. Nitrogen was applied in two equal split doses i.e. first dose was applied one month after sowing and the second dose was applied 60 days after sowing. Sources of nitrogen, phosphorus and potash were Urea**,** Triple super phosphate (TSP) and Sulphate of potash (SOP), respectively. Data on days taken to sprouting (Days were counted from sowing to sprouting and the average was recorded), plant height (plant height of three randomly selected plants from each treatment was measured from the soil surface to the tip of flag leaf with the help of measuring tape in centimeters and average was calculated), number of leaves per plant (Numbers of leaves per plant was counted from three randomly selected plants in each treatment and the average was calculated), leaf length (Leaf length of three randomly selected leaves was measured in cm with measuring tape), leaf diameter (leaf diameter of three randomly selected leaves were measured in cm with measuring tape and average was calculated), number of tiller per plant (The numbers of tillers per plant was counted from three randomly selected plants in each treatment and the average was calculated), number of finger per plant (The numbers of fingers per plant was counted from three randomly selected plants in each treatment and the average was calculated), finger length (finger length was measured in cm with the help of digital venire calipers and average was calculated), finger weight (selected fingers were weighed using the electric balance and average was computed), finger diameter (diameter of selected fingers from each treatment was measured in mm with the help of digital venire calipers and average was computed) *and* turmeric yield (Yield of each treatment was recorded in kg and computed. According to formula given below: Yield (kg ha^{-1}) = 10000 x plot yield (gm)/Plot size. The data collected was analyzed statistically using Analysis of Variance technique as described by (Steel *et al*., 1997). Duncan's Multiple Range test (Duncan, 1955) was adopted to detect the statistical differences at 5% probability level among different treatment means.

RESULTS AND DISCUSSION

Days taken to sprouting: The data revealed significant effect of different plant spacing on days taken to sprouting, as shown in Table I. Significantly maximum days to sprouting (87.00) were recorded in T_1 (30x10 cm^2) and T_2 (30x20 cm^2), closely followed by T_3 (30x30 cm^2) with 86.33 days and all these three treatments were statistically at par to each other, whereas the minimum days to sprouting (82.00) were taken by T_5 (30x50 cm^2). Similar results were reported by Bahadar *et al.* (2000) who also found significant results for days to finger sprouting as affected by different plant spacing.

Plant height (cm): Highly significant data showed that maximum plant height (67.73 cm) was recorded in T_5 (30x50 cm^2) followed by T4 (30x40 cm^2) with 66.02 cm tall plants. Intermediate results were recorded in T_3

(30x30 cm^2) and T_2 (30x20 cm^2) with 58.03 and 52.08 cm long plants, respectively, as shown in table I. Minimum plant height (50.61cm) was observed in T_1 (30x10 cm^2). The reason for taller plants in T_5 could be due to higher plant spacing and lower competition amongst the turmeric plants. Similar results were quoted by (Hossain *et al*. 2005) whom were of opinion that low plant spacing was insufficient for the proper growth of turmeric plant. Similarly, (Islam *et al.* 2002) reported maximum plant height having wider spacing in turmeric. A number of scientists including (Abbas *et al.*, 2009), Ahmad *et al.,* (2009 and Jilani *et al.,* (2010) also reported maximum plant height with wider row spacing in different agronomic

Number of leaves per plant: Spacing interval had significant effect on the number of leaves per plant, as shown in table I. The maximum number of leaves per plant (8.000) was recorded in T_5 (30x50 cm^2) followed by T_4 (30x40 cm^2) and T_3 (30x30 cm^2) with 6.667 and 6.333 leaves per plant, respectively and both these treatments were statistically at par to one another. While result worked out in T_2 (30x20 cm^2) and T_1 (30x10 cm^2) were statistically at par with others, which were also revealing the minimum number of leaves (4.333) recorded in T_1 (30x10 cm^2). These results are in agreement with the previous findings of Islam *et al.* (2002) who also reported highest number of leaves (10.43) when the turmeric plants had wider (60x30 cm) spacing. Similarly, Pratap and Singh (2007) also reported maximum number of leaves per main shoot from wider plant spacing.

Leaf length (cm): Data showed that turmeric leaf length was significantly influenced by different plant spacing. Among treatments, the maximum leaf length (35.22cm) was recorded in T_5 (30x50 cm^2), followed by T_4 (30x40 cm) and T_3 (30x30 cm) with 33.17 and 31.13 cm long leaves, respectively. T_2 (30x20 cm^2) resulted into 30.21cm leaf length. Whereas, the minimum leaf length (27.11cm) was recorded in T_1 (30x10 cm^2). Similar results were shown by (Rubio *et al.* 2003) that shading with neighboring plant is the principal and significant factor of their competition because it had greatly affected the leaf development.

Leaf diameter (cm): The data revealed a significant effect of different plant spacing on leaf diameter of turmeric plant, as shown in table I. Significantly, maximum leaf diameter (9.917cm) was recorded in T_5 (30x50cm) very closely followed by T_4 (30x40cm) and T_3 (30x30cm) with 9.287 8.763 cm leaf diameter, respectively. All these three treatments were statistically similar at par to each, whereas the minimum leaf diameter (5.277cm) was observed in T_1 (30x10cm). Similarly Manjunathgoud *et al.* (2001) reported that maximum leaf diameter was studied on wider plant spacing in turmeric.

Number of Tillers per plant: Spacing interval had significant effect on the number of tiller per plant. The maximum number of tiller per plant (5.667) was recorded in T_5 (30x50 cm) very closely followed by T_4 (30x40 cm) with 4.667 tiller per plant. Statistically similar results were also reported in T3 (30x30 cm) and T2 (30x20 cm) with 3.333 and 2.333 tiller per plant. The minimum number of tiller (1.667) was recorded in T_1 (30x10 cm). Due to increase in plant spacing, number of tillers emerged also were increased, whereas closer spacing 30cm x 10cm recorded significantly lower number of tillers per plant. Increase in plantlet number with wider spacing could be attributed to better utilization of resources and lesser plant to plant competition (Singh *et al* ., 2000). Our results are also in agreement with the previous findings of (Gopichand *et al.* 2006) and (Ali *et al.*, 2010) who reported that plant spacing significantly increased the number of plantlets/ plant, as wide spacing increased the number of plantlet/plant. Similarly, (Pratap and Singh 2007) also reported maximum number of tillers per main shoot at wider spacing.

Number of fingers per plant: Spacing interval had significant effect on the number of fingers per plant. Significantly maximum number of fingers per plant (15.67) was recorded in T_5 (30x50 cm) followed by T_4 (30x40 cm) with 14.00 fingers per plant. Intermediate results were observed in T3 (30x30 cm) and T2 (30x20 cm) producing 12.33 and 10.67 fingers per plant, respectively. Whereas, the minimum number of fingers (7.33) was recorded in T_1 (30x10 cm). This was probably due to better availability of plant nutrients, moisture and light in wider spaced plant. (Manjunathgoud *et al.* 2001) also reported maximum number of fingers per plant with wider plant spacing. (Bahadur *et el.* 2000) also reported wider spacing increased average finger/ plant which in turn produced maximum fresh and dry yield of the plant.

Finger length (cm): Highly significant data depicted maximum finger length (5.367cm) in T_5 (30x50 cm) followed by T_4 (30x40 cm) with 4.147 cm long fingers and both these spacing showed significant behavior against each other. Intermediate result was noticed in T3 (30x30 cm) and T2 (30x20 cm) with 3.490 and 2.430 cm long fingers, respectively. Whereas, the minimum finger length (1.667cm) was recorded in T_1 (30x10 cm). Contradictory to our results Bahadur *et al.* (2000) reported non-significant behavior for different plant spacing to finger length of turmeric.

Finger weight (g): Spacing interval had significant effect on finger weight of turmeric plant. The maximum finger weight (76.10 g) was recorded in T_5 (30x50 cm) followed by T_4 (30x40 cm) which also produced more (71.49gm) finger weight, as shown in table II. Significant different results were also observed in T_3 (30x30 cm) and T_2 (30x20 cm) producing 3.490 and 2.430 g finger weight,

respectively. Minimum finger weight (1.667g) was recorded in T_1 (30x10 cm). Our results are in agreement with the previous findings of (Pratap and Singh 2007) stating that weight of fresh rhizome/clump was highest at wider spacing in turmeric plant.

Finger diameter (mm): Significantly maximum finger diameter (4.220mm) was recorded in T_5 (30x50cm), followed by T_4 (30x40 cm) with 3.407 mm finger diameter, as shown in table II. Intermediate response was shown by T_3 (30x30 cm) and T_2 (30x20 cm) producing finger diameter of 2.653 and 1.840 mm, respectively. However, the minimum finger diameter (0.8067mm) ~~w~~as recorded in T_1 (30x10 cm). Similar results were also quoted by Hossain *et al.* (2005) who stated that when turmeric was planted at a closer spacing (20cm), rhizome could not exposed properly, which ultimately resulted in smaller rhizome compared with that planted with a longer spacing.

Turmeric yield (kg ha^{-1}): The data revealed significant effect of different plant spacing on yield of turmeric. Significantly maximum yield (2184.0 kg) was recorded in T5 (30x50cm). Significantly similar results for turmeric yield were found in T4 (30x40 cm), T_3 (30x30 cm) and T_2 (30x20 cm) with 1037.0, 803.5 and 598.0 kg ha^{-1}, respectively, as shown in table II. Minimum yield (371.1 kg ha^{-1}) was recorded in T_1 (30x10 cm). Our findings are supported by (Gopichand *et al.* 2006) and Hore and Chattopadhyay (2003) who reported that highest yield of turmeric rhizome were recorded from wider plant spacing. (Rashid *et al.* 1996, Bahadar *et al.* (2000) and (Carvalho *et al.* 2001) also found higher turmeric fresh yield with wider spacing, while with closer spacing, its yield had indicated declining trend. At closer spacing, the yield and yield contributing factors were minimum due to competition between plants for nutrients, sunlight, fertilizer and water etc.

Table 1: Days to sprouting, plant height (cm), leaves per plant, leaf length (cm) and leaf diameter (cm) of turmeric plant as affected by different plant spacing.

Spacing (cm^2)	Days taken to sprouting	Plant height (cm)	Leaves per plant	Leaf length (cm)	Leaf diameter (cm)
T_1=30x10	87.00 a	50.61 e	4.333 c	27.11 e	5.277 c
T_2=30x20	87.00 a	52.08 d	4.667 c	30.21 d	7.483 b
T_3=30x30	86.33 a b	58.03 d	6.333 b	31.13 c	8.763 a b
T_4=30x40	85.00 b	66.02 b	6.667 b	33.17 b	9.287 a
T_5=30x50	82.00 c	6773 a	8.000 a	35.22 a	9.917 a
LSD value	**1.899**	**0.958**	**1.165**	**0.809**	**1.576**

Means followed by different letter(s) are significant at 5% level of significance.

Table 2:Stem per plant, finger per plant, finger length (cm), finger weight (g), finger diameter (mm) and yield (kg/ha) of turmeric plant as affected by different plant spacing.

Spacing (cm2)	stem /plant	Finger/ plant	Finger length (cm)	Finger weight (g)	Finger diameter (mm)	Yield kg/ha
T1=30x10	1.667 c	7.33 e	1667 e	39.21 e	0.86 e	371.1 c
T2=30x20	2.333 b c	10.67 d	2.430 d	44.17 d	1.840 d	598 b c
T3=30x30	3.333 b	12.33 c	3.490 c	59.14 c	2.653 c	803.5 b c
T4=30x40	4.667 a	14.00 b	4.147 b	71.49 b	3.407 b	1037 b
T5=30x50	5.667 a	15.67 a	5.367 a	76.10 a	4.220 a	2184 a
LSD value	1.031	1.375	0.913	0.618	0.425	465.2

Means followed by different letter(s) are significant at 5% level of significance.

Conclusions: On the basis of overall results obtained, plant spacing 30x50cm^2 was found to be technically suitable and economically viable for commercial and profitable production of turmeric (*Curcuma longa* L) under the agro-climatic condition of Dera Ismail Khan. But one year field data is not sufficient to reach any conclusion. It might have been due to better weather conditions, next year those may not be available.

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