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Influence of Land Configuration, Irrigation Level and Nutrient Management on Yield and Quality of Turmeric

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A B S T R A C T

A field experiment was carried out during *kharif* season of the year 2014-15 and 2015-16 at the Research Farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) to study the effect of land configuration, irrigation level and nutrient management on yield and quality of turmeric (*Curcuma longa* L.). A set of twenty four treatment combinations of land configuration, irrigation level and nutrient management (2 x 3 x 4) were laid out in a Split plot design with three replications. The experimental results revealed that total yield of turmeric ha^{-1} and yield of cured fingers ha^{-1}, were recorded significantly superior in broad bed furrow of land configuration, irrigation level 40 mm CPE (I1), application of 100 % RDF + 25 % RDN through vermicompost and treatment combination 40 mm CPE with 100% RDF + 25% RDN through vermicompost. The curcumin, oleoresin and curing percent did not influenced due to different land configuration treatments whereas irrigation level 40 mm CPE, application of 100% RDF + 25% RDN through vermicompost and treatment combination 40 mm CPE with 100% RDF + 25% RDN through vermicompost were significantly higher as compare to other treatments.

Introduction

India is the largest producer of turmeric in the world. Turmeric (*Curcuma longa* L.) is one of the second most important spice crops in foreign exchange earnings after chilli. Turmeric contains curumin (diferuloylmethene) (3-4%) is responsible for the yellow colour and its comprised of curcumin I (94%) and curcumin II (6%) and

curcumin III (0.3%) (Ruby *et al.,* 1995). The use of turmeric dates back nearly 4000 years, to the *Vedic* culture in India where it was used a culinary spice and had a religious significance.

Turmeric is used as coloring matter in pharmacy, confectionary and food industry (Purseglove *et al.,* 1981). Turmeric oil and oleoresin are also used to impart flavor in food and perfume industries. The major quantity of turmeric is utilized as condiment and a small quantity is used in medicines and cosmetics in India. The antibacterial effect of turmeric is due to three principal compounds viz. curcumin, curcuminoids and aromatic oil, out of which, curcumin is the most active therapeutic ingredient. Curcumin is now being used to treat cancer, arthritis, diabetes, Crohn's disease, cardiovascular diseases, osteoporosis, Alzheimer's disease, psorosis and other pathologies (Shishodia, 2005). Thus both turmeric and curcumin have potential for the development of modern medicines for the treatment of various diseases. Due to its increasing demand, not only for internal consumption but for export purpose also, the productivity and quality of crop needs to be upgraded (Medhi and Bora, 1993).

Land configuration helps for maximizing rainfall infiltration, minimizing erosion, total runoff, facilitates drainage and ultimately improves water use efficiency. The raised bed zone of broad bed and furrow system is better aerated with lower penetration resistance and favourable for deeper seed placement and better crop emergence (Jayapaul *et al.,* 1996). Land configuration, which involves different methods of seed bed preparations, is one of the most important management practices which increases input use efficiency and crop production.

Water and fertilizer are the two important inputs for agricultural production and are interrelated in their effects on plant growth and yield. In addition to the total quantity of water, availability of water at different stages of the plant growth can also affect the yield and quality of the crop. Inadequate moisture during the growth and development stage results not only in lower yields but also in poor quality.

Turmeric has a high demand for plant nutrients and generally responds to applied nutrients for yield & quality. The quantity of fertilizers (inorganic or organic) required by the crop depend on the variety as well as soil, and weather conditions prevailing during crop growth (Karthikeyan *et. al*., 2009). Soil fertility levels are maintained to match with crop's need and in proper proportions then crop productivity measured in terms of responses to fertilizers can only be sustained.

Turmeric is commercially cultivated however, the production of turmeric per unit land area in vidarbha is very low because of the poor knowledge on improved cultivation technology to the farmers. Considering the all above facts, the present investigation is therefore planned to study the effect of land configuration, irrigation level and nutrient management on yield and quality of turmeric.

Materials and Methods

A field experiment was carried out at the Research Farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) during *kharif* season of the year 2014-15 and 2015-16. A set of twenty four treatment combinations of land configuration, irrigation level and nutrient management (2 x 3 x 4) were laid out in a Split plot design with three replications. The Turmeric crop (variety - PDKV Waigaon) was raised using nutrient dose @ RDF 200:100:100 Kg NPK per hectare. Nitrogen, Phosphorus and Potassium were applied in the

form of urea, single super phosphate and muriate of potash respectively. The fertilizers as per treatments were applied at the spot of planting in rings and were thoroughly mixed in the soil with the help of weeding hook. Vermicompost was applied to different treatment plots. A seed rhizome was planted at 10 cm depth in the center of ridge in ridges and furrow method and three lines were planted on broad bed furrow at given spacing of 45 cm X 22.5 cm at the rate of 25 quintal ha^{-1}. At the time of planting mother rhizomes were treated with Carbendenzim 50 WP @ 1gm + Quinalphos 2 ml /l for 30 minutes. The irrigation system of pvc pipes consisted of main and sub-main of 75, 63 and 50 mm diameter were laid in each plot for irrigation. Control valves were fixed on main and sub-main pipeline. Water meter was fixed on main pipeline for measuring the discharge of water during the irrigation. Measured quantity of water was applied to each plot. During the year 2014-15, total 15, 10 and 08 irrigations were given to 40, 60 and 80 CPE irrigation levels where as 19, 14 and 10 irrigations were applied to 40, 60 and 80 CPE irrigation levels respectively in the year 2015-16

The depth of each irrigation was 10 cm in case of ridges and furrow and broad bed furrow planting. Earthing up, weedicide application and plant protection measures were undertaken as per recommendation in the experimental area. The crop was harvested at full physiological maturity. Five plants in each treatment per replication were tagged randomly for recording the observations on yield and quality parameters and mean values were subjected to statistical analysis. For quality analysis, rhizomes harvested from each treatment were boiled in pure water till rhizomes become soft and emit a typical turmeric odour after boiling. Then the rhizomes were dried under sun for about 8-10 days till consecutive weights agreed before grinding them in a mill. These powdered samples were analysed for curcumin and oleoresin content. The oleoresin content was estimated as per the procedure given by Ranganna (1986). Procedure suggested by Manjunath *et al.,* (1991) was followed for the estimation of curcumin content. Curing percentage of the rhizomes was recorded by weight of cured rhizome divided by fresh weight of the rhizome. Data collected during the course of investigation ware statistically analyzed by adopting standard procedure of 'Analysis of Variance' by Panse and Sukhatme (1967). Biometric observations recorded during the course of investigation along with sample size and recording time. The data on yield and quality were taken on total yield of turmeric (Mother + Primary+ Secondary) ha^{-1}, oleoresin, curcumin and curing percentage.

Results and Discussion

Effect of land configuration on yield

The fresh rhizomes yield and yield of cured fingers of turmeric were significantly influenced due to land configuration (Table 1). Broad bed furrow method of planting recorded significantly highest total fresh rhizomes yield of turmeric (227.43, 270.93 and 249.18 q ha^{-1}) and yield of cured fingers ha^{-1}(30.08, 40.20 and 35.14 q ha^{-1}) over the ridges and furrow planting during the year 2014 and 2015 respectively. (Table 1).The results corroborate the earlier findings of Gill *et al.,* (2009).

Better soil physical properties also provide favourable condition for development of rhizome. Similarly, Jayashree and Rao (2002) reported that land layout broad bed furrow (BBF) was the better practice in Vertisols than flat bed as the per cent age of transmission pores were more in BBF bed system. It is thus evident that broad bed furrow planting was superior over ridges and furrow method for realizing potential yield of turmeric. The

results corroborate the earlier findings of Anjaneyulu and Krishnamurthy (1979), Ramachandran and Muthuswami (1984) and Amzad *et al.,* (2005) who recorded markedly higher yield of turmeric when planted on broad bed furrow.

Effect of irrigation levels on yield

Irrigation levels produced significant effect on the total fresh rhizomes yield and yield of cured fingers of turmeric during individual years. Frequent irrigation recorded maximum total fresh rhizomes yield of turmeric (266.33, 317.69 and 292.01 q ha^{-1}) and yield of cured fingers (34.36,46.61 and 40.48 q ha^{-1}) in irrigation level 40 mm CPE, compared to other irrigation level treatments (Table 1).

The yield of fresh mother rhizomes results are in accordance to those reported by Singh *et al.,* (1998). Mahey *et al.,* (1986) observed similar type of results wherein, irrigation scheduled at 40 mm evaporation rate produced maximum rhizome yield over its increasing evaporation rate scheduled, as the farmers practice with more frequent irrigations which puts optimum moisture in the root zone resulting in more rhizome yield.

Effect of nutrient management on yield

Treatments of nutrient management significantly influenced the total fresh rhizomes yield of turmeric and yield of cured fingers during the experimentation.

The highest total fresh rhizomes yield of turmeric (250.49, 300.57 and 275.53 q ha^{-1}) and yield of cured fingers (33.54, 45.24 and 39.39 q ha^{-1}) were recorded with 100% RDF + 25 % RDN through vermicompost as compared to others treatments (Table 1).

Rao *et al.,* (2005) and Velmurugan *et al.,* (2007) have reported higher uptake of plant nutrients with the application of organic manures. The resultant increased photosynthates and their more preferential influx to the sink may be responsible for increased number and weight of mother and finger rhizomes per plant.

Mannikeri (2006) also reported increase in yield of turmeric when organic is used in combination with inorganic fertilizers. Majumdar *et al.,* (2003) in ginger also recorded increase in yield due to application of vermicompost with inorganic fertilizers.

Singh (2015) recorded highest rhizome yield in treatment having 100% NPK + FYM + poultry manure + vermicompost + wheat straw in ginger. Application of organic manure in large quantity favours low water content and higher dry matter which is likely due to more accumulation of nutrients and total soluble solids due to multifarious positive effect of organic soil conditioner.

Higher dry rhizome recovery in turmeric with organic ammendments was also reported by Rao *et al.,* (2005) and Sanwal *et al.,* (2007). These results are in agreement with Majumdar *et al.,* (2002), Manjunathgoud *et al.,*(2002), Kandiannan and Chandaragiri (2006), Krishnamoorthy *et al.,* (2015) and Leva *et al.,* (2013b).

Interaction effect on yield

The total fresh rhizomes yield of turmeric ha^{-1} (327.13, 384.29 and 355.71q ha^{-1}) and yield of cured fingers ha^{-1}(45.17, 60.71 and 52.94 q ha^{-1}) were significantly more in treatment combination $I_{1x}N_4$ i.e. irrigation level 40 mm CPE with 100% RDF +25 % RDN through vermicompost over other treatment combinations during the study period (Table 2). Khan *et al.,* (1999) reported that interaction of irrigation and nitrogen was significant in turmeric and recorded highest rhizome yield.

Table.1 Yield and quality attributes influenced by land configuration, irrigation levels and nutrient management during 2014-15 and 2015-16.

Treatment / Year	Total yield of turmeric (Mother +Primary+ Secondary Rhizomes) (q ha^{-1})			Yield of cured fingers (q ha^{-1})			Curcumin (%)			Oleoresin (%)			Curing (%)		
	2014-2015	2015-2016	Pooled mean	2014-2015	2015-2016	Pooled mean	2014-2015	2015-2016	Pooled mean	2014-2015	2015-2016	Pooled mean	2014-2015	2015-2016	Pooled mean
I) Main plot treatments															
a) Land configuration															
L_1: Ridges and furrow	204.61	244.14	224.38	26.81	35.36	31.08	5.38	5.55	5.47	7.32	7.86	7.59	18.34	20.36	**19.35**
L_2: Broad bed furrow	227.43	270.93	249.18	30.08	40.20	35.14	5.39	5.57	5.48	7.33	7.91	7.62	18.84	20.97	**19.90**
S. E. (m) ±	2.03	2.74	1.91	0.57	0.87	0.58	0.03	0.02	--	0.06	0.06	--	0.24	0.30	--
C. D. at 5%	5.80	7.86	5.58	1.64	2.49	1.68	NS	NS	--	NS	NS	--	NS	NS	--
b) Irrigation levels															
I_1: 40 mm CPE	266.33	317.69	292.01	34.36	46.61	40.48	5.45	5.65	5.55	7.48	8.08	7.78	19.59	21.73	**20.66**
I_2: 60 mm CPE	220.80	261.86	241.33	29.39	38.44	33.92	5.42	5.56	5.49	7.24	7.98	7.61	18.61	20.53	**19.57**
I_3: 80 mm CPE	160.80	193.04	176.99	21.59	28.28	24.93	5.29	5.47	5.38	7.06	7.58	7.32	17.57	19.73	**18.65**
S. E. (m) ±	2.48	3.35	2.35	0.70	1.06	0.71	0.04	0.03	--	0.08	0.07	--	0.29	0.33	--
C. D. at 5%	8.00	9.61	6.83	2.01	3.04	2.06	0.11	0.08	--	0.22	0.20	--	0.83	0.94	--
II) Sub plot treatments															
c) Nutrient management															
N_1: 100% RDF (200:100:100 NPK kg/ha)	203.64	239.48	221.56	26.80	35.00	31.00	5.26	5.42	5.34	7.17	7.69	7.43	18.18	20.14	**19.16**
N_2: 75% RDF +25 % RDN through vermicompost	183.96	220.42	202.19	24.99	32.57	28.78	5.42	5.57	5.50	7.35	8.01	7.68	18.33	20.38	**19.35**
N_3: 125% RDF	226.00	269.66	247.83	28.46	38.10	33.28	5.30	5.52	5.41	7.23	7.72	7.47	18.30	20.58	**19.44**
N_4: 100% RDF +25 % RDN through vermicompost.	250.49	300.57	275.53	33.54	45.24	39.39	5.57	5.72	5.64	7.55	8.12	7.84	19.55	21.56	**20.55**
S. E. (m) ±	3.51	3.77	2.56	0.76	1.15	0.66	0.07	0.06	--	0.09	0.09	--	0.34	0.37	--
C. D. at 5%	10.03	10.82	7.18	2.19	3.31	1.85	0.21	0.17	--	0.26	0.25	--	0.97	0.96	--
Interaction effect															
L x I															
S. E. (m) ±	3.51	4.73	3.31	0.99	1.50	1.00	0.053	0.036	--	0.110	0.101	--	0.408	0.520	--
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	--	NS	NS	--	NS	NS	**NS**
L x N															
S. E. (m) ±	4.95	5.33	3.61	1.07	1.62	0.93	0.102	0.091	--	0.134	0.125	--	0.476	0.473	--
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	--	NS	NS	--	NS	NS	**NS**
I x N															
S. E. (m) ±	6.07	6.53	4.42	1.32	1.99	1.13	0.125	0.111	--	0.164	0.153	--	0.583	0.579	--
C. D. at 5%	17.41	18.74	12.43	3.79	5.72	3.20	NS	NS	--	NS	NS	--	1.67	1.66	--
L x I x N															
S. E. (m) ±	8.58	9.24	6.26	1.86	2.82	4.52	0.176	0.158	--	0.232	0.216	--	0.825	0.819	--
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	--	NS	NS	--	NS	NS	**NS**
GM	**216.02**	**257.53**	**236.78**	**28.45**	**37.78**	**33.11**	**5.39**	**5.56**	**--**	**7.32**	**7.88**	**--**	**18.59**	**20.66**	**--**

Table.2 Yield attributes and curing (%) as influenced by irrigation levels and nutrient management during 2014-15 and 2015-16.

Irrigation levels / Nutrient management	Total fresh rhizomes yield of turmeric ha^{-1} (q)				Yield of cured fingers ha^{-1} (q)				Curing (%)			
	N_1	N_2	N_3	N_4	N_1	N_2	N_3	N_4	N_1	N_2	N_3	N_4
	2014-2015				**2014-2015**				**2014-2015**			
I_1: 40 mm CPE	244.86	215.09	278.24	327.13	30.99	28.32	32.96	45.17	18.78	18.08	19.02	22.48
I_2: 60 mm CPE	209.86	186.59	235.74	251.00	28.43	26.33	30.13	32.67	18.62	17.84	18.85	19.14
I_3: 80 mm CPE	156.19	150.20	164.03	173.34	20.98	20.31	22.28	22.77	17.50	17.33	17.67	17.77
S. E. (m) ±	6.07				1.32				0.58			
C. D. at 5%	17.41				3.79				1.67			
	2015-16				**2015-16**				**2015-16**			
I_1: 40 mm CPE	291.09	252.20	343.19	384.29	42.61	36.91	46.20	60.71	20.66	20.23	21.54	22.69
I_2: 60 mm CPE	244.70	225.32	275.61	301.84	36.47	34.70	39.09	43.51	20.51	19.99	20.34	21.10
I_3: 80 mm CPE	182.65	183.74	190.19	215.59	26.51	26.09	29.01	31.50	19.48	19.09	19.82	20.54
S. E. (m) ±	6.53				1.99				0.57			
C. D. at 5%	18.74				5.72				1.66			
	Pooled mean				**Pooled mean**							
I_1: 40 mm CPE	267.98	233.64	310.72	355.71	36.80	32.62	39.58	52.94				
I_2: 60 mm CPE	227.28	205.95	255.67	276.42	32.45	30.52	34.61	38.09				
I_3: 80 mm CPE	169.42	166.97	177.11	194.47	23.75	23.20	25.65	27.13				
S. E. (m) ±	4.42				1.13							
C. D. at 5%	12.43				3.23							

N_1: 100% RDF (200:100:100 NPK kg/ha), N_2: 75% RDF +25 % RDN through vermicompost, N_3: 125% RDF and N_4: 100% RDF +25 % RDN through vermicompost.

The results of total fresh rhizomes yield of turmeric are in accordance with the findings of Rathod (2010), Anonymous, 2013, Tripathi *et al.,* (2014) and Samir Bhatti *et al.,* (2019). The yield of cured fingers results are in agreement with Tripathi *et al.,* (2014) and Sandeep Kumar Tripathi *et al.,* (2019).

Effect of land configuration on quality of turmeric

The effect of different treatments of land configuration on curcumin, oleoresin content and dry rhizome recovery percentage of turmeric was found to be non-significant. Numerically broad bed furrow planting recorded higher mean curcumin content (5.48%), oleoresin content (7.62%) and dry rhizome recovery (19.90%) over the ridges and furrow method of planting. Similar type of results was observed by Ramachandran and Muthuswami (1984) and Kaur (2001) in turmeric. Similar results were also reported by Khan and Agarwal (1985) and Kumar and Gill (2009) in turmeric. Khan and Agarwal (1985) and Raghavaiah *et al.,* (1992) also reported that land configuration treatments had no significant effect on quality parameters of crops tested.

Effect of irrigation levels on quality of turmeric

There were significant differences in the curcumin, oleoresin content and dry rhizome recovery percentage among different irrigation levels. Data presented in table 1 on irrigation levels revealed that curcumin, oleoresin content and dry rhizome recovery percentage significantly influenced due to different irrigation levels during both the years. The highest mean curcumin content (5.55%), oleoresin content (7.78 %) and dry rhizome recovery (20.66 %) was recorded by treatment 40 mm CPE over the other treatments (Table 1).

These results are in conformity with Mohamed *et al.,* (2014), Amirjani. (2013) and Tripathi Sandeep *et al.,* (2015) and reported that curcumin in dry rhizomes increased when the plants irrigated every week compared to irrigation treatments every two or three weeks. The results of oleoresin corroborate the earlier findings of Hassan and Ali (2013) and Tripathi Sandeep *et al.,* (2015). The present findings of dry rhizome recovery percentage are in consonance with Mohamed *et al.,* (2014).

Effect of nutrient management on quality of turmeric

Treatments of nutrient management significantly influenced the curcumin, oleoresin content and curing percentage during the experimentation. Higher curcumin content (5.64%), oleoresin content (7.84%) and curing percentage (20.55) was recorded with 100% RDF + 25 % RDN through vermicompost which was significantly superior over the other treatments. Rao (2000) reported that curcumin content was more in organic and inorganic combinations over recommended doses of fertilizer alone. Similar results are in conformity with Manhas and Gill (2012) for oleoresin content in turmeric. Similar results are also in line with scientist Manhas and Gill (2012) and Karthikeyan (2009) for curing percentage in turmeric.

Interaction effect on quality of turmeric

Interaction effects were found to be non-significant during both the years of experimentation for curcumin and oleoresin content where as dry rhizome recovery percentage were recorded significantly higher in treatment combination I_1xN_4 i.e. irrigation level 40 mm CPE with 100% RDF +25 % RDN through vermicompost (22.48 and 22.69%) over other treatment combinations during the experimentation respectively.

Based on the findings of two years investigation, it can be concluded that for higher yield, curcumin, oleoresin and curing percentage from turmeric (var. PDKV-Waigaon) can be secured by planting on broad bed furrow with irrigation level of 40 mm CPE and application of 100% RDF + 25 % RDN through vermicompost in heavy black (clay) soil of Vidarbha region under irrigated condition.

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