

Original Research Article

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Effect of Land Configuration, Irrigation Level and Nutrient Management on Growth, Yield and Economics of Turmeric (*Curcuma longa* L.)

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ABSTRACT

A field experiment was carried out to study the effect of land configuration, irrigation level and nutrient management on growth, yield and economics of turmeric (*Curcuma longa* L.) 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 experimental results revealed that, broad bed furrow land configuration, irrigation level 40 mm CPE and application of 100% RDF+ 25 % RDN through vermicompost recorded significantly more number of tillers, plant height, number of functional leaves, leaf area and dry matter plant-1 of turmeric. The entire yield attributes and economics i.e. number of fresh mother rhizomes, weight of fresh mother rhizomes, and yield of fresh mother rhizomes, yield of fresh primary fingers, yield of fresh secondary fingers, total yield of turmeric ha⁻¹ and yield of cured fingers ha⁻¹, gross monetary returns, net monetary returns and benefit cost ratio ha⁻¹ were recorded significantly superior in broad bed furrow of land configuration, irrigation level 40 mm CPE, application of 100 % RDF + 25 % RDN through vermicompost and treatment combination of 40 mm CPE with 100% RDF + 25% RDN through vermicompost.

Keywords

Organic manures,
Curcuma longa L.,
rhizome yield, CPE

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Introduction

Turmeric (*Curcuma longa* L.) is one of the second most important spice crops in foreign

exchange earnings after chilli. India is the largest producer of turmeric, supplying 94% of the world's demand. India also dominates the world production scenario contributing to

approximately 78% of world's total production producing 6,00,000 tonnes of turmeric annually. India produced about 9.43 lakh tonnes of turmeric from 1.85 lakh hectare in year 2015-16. Turmeric occupies 6% of the total area under spices and condiments in India (Anonymous, 2015). India has been a traditional producer, consumer and exporter of turmeric, but the productivity of turmeric in India is lowest in the world.

Integrated nutrient management envisaging conjunctive use of inorganic and organic sources of nutrient is a novel system of plant nutrient use for sustaining soil health and crop productivity. The integrated nutrient management ensures the better and sustainable yield while correcting some secondary and micronutrients deficiencies and it also increases the nutrient use efficiency. Moreover, integrated nutrient management is of immense importance in high value crop like turmeric and by improving the productivity of this crop, the socio-economic status of the farmers of the state can be improved further.

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). Suitability of different land configurations depends on soil type and rainfall pattern. Unique physical properties of heavy clay soils are the greatest limitations to the agricultural production. In spite of sufficient water and favourable weather conditions, the productivity of such soils is threaten owing to low infiltration, poor internal drainage, narrow workable moisture range, variable moisture availability, inadequate seeding emergence and loss of soil structure. Such soils require a careful management to prevent soil quality

deterioration in order to tap potential production. 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. However, shortage of water for irrigation is being increasingly exploited due to pressures from depleting groundwater levels, rising alternative demands, water quality degradation and economics. Nutrient availability in the soil-plant system is dictated by complex interactions between plant roots, soil microorganisms, chemical reactions and pathways of losses.

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 growth, yield and economics 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. The quantity of fertilizers to be applied were

calculated on gross plot basis. 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. The quantity required was calculated based on the results of analysis. 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 Carbendazim 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. For irrigating the plots at different irrigation levels control valves was opened in each replication and plots were irrigated. 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. Irrigations were applied as per irrigation levels after planting. The depth of each irrigation was 10 cm in case of ridges and furrow and broad bed furrow planting which was measured with water meter which was fitted on pvc pipe line. Weedicide application, weeding, earthing up and plant protection measures were undertaken as and when required as per recommendation. The crop was harvested at full physiological maturity. Five plants in each treatment per replication were tagged randomly for recording the observations on seedling, growth and yield

parameters and mean values were subjected to statistical analysis. Biometric observations recorded during the course of investigation along with sample size and recording time. Data collected during the course of investigation were statistically analyzed by adopting standard procedure of 'Analysis of Variance' by Panse and Sukhatme (1967). The growth parameters like number of tillers plant⁻¹, plant height, number of functional leaves plant⁻¹, leaf area plant⁻¹ and dry matter plant⁻¹ were recorded. The data on Yield attributes, yield and economics were taken on number of mother rhizomes per plant, weight of mother rhizomes per plant, yield of fresh mother rhizomes ha⁻¹ (q), yield of fresh primary fingers ha⁻¹ (q), yield of fresh secondary fingers ha⁻¹ (q), total yield of turmeric (Mother + Primary+ Secondary) ha⁻¹ (q), yield of cured fingers ha⁻¹ (q), Gross monetary returns (Rs. / ha), Net monetary returns (Rs. / ha) and B : C ratio.

Results and Discussion

Effect of land configuration on growth characters

The effect of land configuration on number of tillers per plant, plant height, number of leaves plant⁻¹, leaf area plant⁻¹ and plant dry matter plant⁻¹ was statistically significant during both the years of investigation. Planting of turmeric on broad bed furrow recorded the maximum number of tillers plant⁻¹ (1.78 and 1.86), plant height (98.29 and 101.71 cm), number of leaves plant⁻¹ (9.80 and 10.99), leaf area plant⁻¹ (44.70 and 48.77 dm²) and plant dry matter plant⁻¹ (78.05 and 85.64g) compared to that ridges and furrow method during the year 2014 and 2015 respectively (Table1).

The present findings of number of tillers per plant are in consonance with the previous observation of Leva *et al.*, (2013a) in turmeric. Better growth and greater partitioning in

groundnut genotypes when grown on broad bed as compared to flat bed sowing was also observed by Talwar *et al.*, (2002).

Effect of irrigation levels on growth characters

The differences among the irrigation levels treatments were significant during 2014 and 2015. Irrigation level 40 mm CPE recorded significantly more number of tillers plant⁻¹ (2.25 and 2.33), plant height (100.23 and 104.52 cm), number of leaves plant⁻¹ (10.02 and 11.45), leaf area plant⁻¹ (46.95 and 50.07 dm²) and dry matter plant⁻¹ (81.01 and 90.31g) over 60 mm and 80 mm CPE irrigation levels in the year 2014 and 2015 (Table1).

Similar results were observed by Manjunathgoud *et al.*, (2002), and Akamine *et al.*, (2007) in turmeric. Singh (2010c) reported that at harvest number of leaves per plant were significantly higher in the crop grown at 1.25 IW: CPE irrigation regime as compared to 1.00, 0.75 and 0.50 IW: CPE in potato.

Effect of nutrient management on growth characters

Treatments of nutrient management significantly influenced the number of tillers plant⁻¹, plant height, number of functional leaves plant⁻¹, leaf area plant⁻¹, and dry matter plant⁻¹ during 2014 and 2015. The highest number of tillers plant⁻¹ (2.00 and 2.11), plant height (97.57 and 101.51 cm), number of functional leaves plant⁻¹ (9.88 and 11.37), leaf area plant (45.34 and 50.76 dm²) and dry matter plant⁻¹ (79.55 and 85.28 g) were recorded with 100% RDF +25 % RDN through vermicompost compared to other treatments (Table 1). Since, the number of tillers is an important yield attribute in turmeric, it would influence the yield and mother rhizomes as reported by Kamal and Yousuf (2012) and Singh (2015) in ginger.

Similar results in plant height were also noticed in turmeric by Tripathi *et al.*, (2014), Singh S.P. (2013), Padmadevi *et al.*, (2012), Parmeet *et al.*, (2012), Manhas *et al.*, (2011), Grima *et al.*, (2008), Hikaru *et al.*, (2007), Ram and Singh (2007) and Meenakshi *et al.*, (1999).

Interaction effect on growth characters

From the data placed at Table 4, it was evident that number of tillers plant⁻¹, plant height plant⁻¹, number of functional leaves plant⁻¹, leaf area plant⁻¹ and plant dry matter plant⁻¹ were affected significantly due to interaction between irrigation level 40 mm CPE with 100% RDF +25 % RDN through vermicompost.

Treatment combination of irrigation level 40 mm CPE with 100% RDF +25 % RDN through vermicompost recorded maximum number of tillers plant⁻¹ (3.00 and 3.00), plant height plant⁻¹ (101.96 and 107.47 cm), number of functional leaves plant⁻¹ (10.80 and 12.57), leaf area plant⁻¹ (48.82 and 54.36 dm²) and plant dry matter plant⁻¹ (89.95 and 95.41 g) and was significantly superior over rest of the treatment combinations during 2014 and 2015 (Table 4).

Maximum number of tillers is in line with the findings of Tripathi *et al.*, (2014). Similar finding was reported by Sandeep Kumar Tripathi *et al.*, (2019). Anonymous (2013 a.) also found increase in leaf area of turmeric due to combination of nutrient management with irrigation.

Effect of land configuration on yield

Significant differences were noticed for yield, yield attributes and economics of turmeric due to the land configuration.

The number of mother rhizomes plant⁻¹,

weight of mother rhizomes plant⁻¹, fresh mother rhizomes ha⁻¹ (q), yield of fresh primary fingers ha⁻¹, fresh secondary fingers yield, total yield of turmeric and yield of cured fingers of turmeric were significantly influenced due to land configuration. Broad bed furrow method of planting recorded significantly highest number of mother rhizomes plant⁻¹. (1.79, 1.78 and 1.78), mother rhizome weight (67.30, 78.60 and 72.95 g plant⁻¹), yields of fresh mother rhizomes (66.47, 77.63 and 72.05 q ha⁻¹), fresh primary finger yield (119.97, 142.24 and 130.96 q ha⁻¹), fresh secondary fingers yield (38.48, 47.71 and 43.23 q ha⁻¹), 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 2 and 3). The results corroborate the earlier findings of Gill *et al.*, (2009).

Haque *et al.*, (2002) in garlic, observed significant improvement in growth attributes as well as yield of crops under similar kind of land configurations. Jayapaul *et al.*, (1996) and Ardesna *et al.*, (2013) revealed similar results in their investigations regarding yields of fresh mother rhizomes.

The results corroborate the earlier findings of 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 number of mother rhizomes plant⁻¹, weight of mother rhizomes plant⁻¹, yield of fresh mother rhizomes ha⁻¹, yield of fresh primary fingers ha⁻¹, yield of fresh secondary fingers, total fresh rhizomes yield and yield of cured fingers of turmeric during individual years.

Frequent irrigation recorded maximum number of mother rhizomes plant⁻¹ (2.25, 2.38 and 2.31), weight of mother rhizomes plant⁻¹ (89.87, 102.80 and 96.33 g), yield of fresh mother rhizomes ha⁻¹ (88.76, 101.53 and 95.14 q ha⁻¹), yield of fresh primary fingers ha⁻¹ (128.86, 157.61 and 143.24 q ha⁻¹), Yield of fresh secondary fingers (45.42, 54.64 and 50.03 q ha⁻¹), 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 2 and 3).

The yield of fresh mother rhizomes results are in accordance to those reported by Singh *et al.*, (1998). The yield of fresh primary fingers results are in conformity with Verma *et al.*, (2003). Rathod *et al.*, (2010) in turmeric also found the increase in yield under more frequent irrigations (40 mm) might be due to its favourable effect on growth and yield contributing characters viz., plant height, number and weight of rhizomes plant⁻¹. 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 number of mother rhizomes plant⁻¹, weight of mother rhizomes plant⁻¹, yield of fresh mother rhizomes ha⁻¹, yield of fresh primary fingers ha⁻¹, fresh secondary finger yield, total fresh rhizomes yield of turmeric and yield of cured fingers during the experimentation. The highest number of mother rhizomes plant⁻¹ (2.00, 2.00 and 2.00), weight of mother rhizomes plant⁻¹

(80.04, 91.89 and 85.97 g), yield of fresh mother rhizomes per ha⁻¹ (79.05, 90.75 and 84.90 q ha⁻¹), yield of fresh primary fingers ha⁻¹ (126.13, 154.32 and 140.23 q ha⁻¹), fresh secondary finger yield (42.21, 51.79 and 47.00 q ha⁻¹), the 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 2 and 3). Similar type of results was also reported by Sarkar *et al.*, (2011) for number of mother rhizomes plant⁻¹. Mannikeri (2006) also reported increase in yield of turmeric when organic is used in combination with inorganic fertilizers.

Sanwal (2007) and Sarma *et al.*, (2015) recorded the maximum weight of mother, primary and secondary rhizomes and yield.

Venkatesha *et al.*, (1998) in turmeric and 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. Higher dry rhizome recovery in turmeric with organic amendments 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 number of mother rhizomes plant⁻¹ (3.00, 3.00 and 3.00), weight of mother rhizomes plant⁻¹ (123.47, 136.32 and 129.89 g), yield of

fresh mother rhizomes ha⁻¹ (121.95, 134.63 and 128.29 q), yield of fresh primary fingers ha⁻¹ (145.46, 179.03 and 162.25 q ha⁻¹), yield of fresh secondary fingers ha⁻¹ (55.68, 65.88 and 60.78 q), total fresh rhizomes yield of turmeric ha⁻¹ (327.13, 384.29 and 355.71 q 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 I₁xN₄ i.e. irrigation level 40 mm CPE with 100% RDF + 25 % RDN through vermicompost over other treatment combinations during the study period (Table 5 and 6).

Khan *et al.*, (1999) reported that interaction of irrigation and nitrogen was significant in turmeric and recorded highest rhizome yield. The yield of fresh primary fingers results are in conformity with Tripathi Sandeep *et al.*, (2015).

The results of total fresh rhizomes yield of turmeric are in accordance with the findings of 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).

Economic studies

Effect of land configuration

The data revealed that there were significant differences in the gross monetary returns, net monetary returns and benefit: cost ratio among different treatments of land configuration.

Significantly higher gross monetary returns (421883, 467429 and 444656 Rs ha⁻¹), net monetary returns (267742, 304161 and 285952 Rs ha⁻¹) and higher benefit:cost ratio (2.71, 2.83 and 2.77) were recorded with broad bed method of planting as compare to ridges and furrow method (Table 3).

Table.1 Growth attributes influenced by land configuration, irrigation levels and nutrient management during 2014 and 2015

Treatment/Year	Number of tillers plant ⁻¹		Plant height plant ⁻¹ (cm) at 180 DAP		Number of functional leaves plant ⁻¹ at 180 DAP		Leaf area plant ⁻¹ (dm ²) at 180 DAP		Dry matter plant ⁻¹ (g) at harvest	
	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016	2014-2015	2015-2016
I) Main plot treatments										
a) Land configuration										
L1: Ridges and furrow	1.64	1.67	94.92	98.55	9.32	10.57	43.86	46.82	73.03	78.73
L2: Broad bed furrow	1.78	1.86	98.29	101.71	9.80	10.99	44.70	48.77	78.05	85.64
S. E. (m) ±	0.03	0.06	0.25	0.30	0.13	0.13	0.15	0.30	0.92	0.94
C. D. at 5%	0.11	0.18	0.79	0.93	0.41	0.42	0.49	0.96	2.91	2.96
b) Irrigation levels										
I1: 40 mm CPE	2.25	2.33	100.23	104.52	10.02	11.45	46.95	50.07	81.01	90.31
I2: 60 mm CPE	1.79	1.83	96.55	99.70	9.73	10.67	44.22	46.80	74.88	81.00
I3: 80 mm CPE	1.08	1.13	93.03	96.17	8.93	10.22	41.67	46.52	70.72	75.24
S. E. (m) ±	0.04	0.07	0.31	0.36	0.16	0.16	0.19	0.37	1.13	1.15
C. D. at 5%	0.13	0.22	0.97	1.14	0.51	0.51	0.60	1.17	3.56	3.62
II) Sub plot treatments										
c) Nutrient management										
N1: 100% RDF (200:100:100 NPK kg/ha)	1.61	1.54	96.74	99.88	9.45	10.67	44.13	47.99	75.01	81.60
N2: 75% RDF +25 % RDN through vermicompost	1.22	1.50	94.53	97.68	9.00	10.19	42.96	43.30	69.12	76.75
N3: 125% RDF	2.00	1.94	97.56	101.45	9.86	10.99	44.70	49.19	78.47	85.11
N4: 100% RDF +25 % RDN through vermicompost.	2.00	2.11	97.57	101.51	9.88	11.37	45.34	50.76	79.55	85.28
S. E. (m) ±	0.07	0.11	0.45	0.48	0.20	0.26	0.32	0.55	1.32	1.40
C. D. at 5%	0.21	0.32	1.29	1.37	0.58	0.74	0.93	1.57	3.79	4.01
Interaction effect										
L x I										
S. E. (m) ±	0.05	0.10	0.43	0.51	0.22	0.23	0.37	0.74	1.59	1.62
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
L x N										
S. E. (m) ±	0.10	0.15	0.63	0.67	0.28	0.36	0.64	0.09	1.86	1.97
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
I x N										
S. E. (m) ±	0.12	0.19	0.77	0.82	0.35	0.44	0.79	1.33	2.28	2.41
C. D. at 5%	0.36	0.55	2.22	2.37	1.009	1.27	1.60	2.71	6.56	6.93
L x I x N										
S. E. (m) ±	0.18	0.27	1.09	1.17	0.49	0.62	1.11	1.89	3.23	3.42
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
GM	1.71	1.76	96.60	100.13	9.56	10.78	44.28	47.79	75.54	82.18

Table.2 Yield attributes influenced by land configuration, irrigation levels and nutrient management during 2014 and 2015

Treatment / Year	Number of mother rhizomes plant ⁻¹			Weight of mother rhizomes plant ⁻¹ (g)			Yield of fresh mother rhizomes (q ha ⁻¹)			Yield of fresh primary fingers (q ha ⁻¹)			Yield of fresh secondary fingers (q ha ⁻¹)		
	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															
L₁: Ridges and furrow	1.64	1.64	1.64	57.77	70.21	63.99	57.06	69.34	63.20	111.13	129.57	120.35	33.90	42.21	38.05
L₂: Broad bed furrow	1.79	1.78	1.78	67.30	78.60	72.95	66.47	77.63	72.05	119.97	142.24	130.96	38.48	47.71	43.23
S. E. (m) ±	0.03	0.03	0.03	1.28	1.37	0.86	1.26	1.35	0.85	1.73	2.19	1.62	0.85	0.79	0.70
C. D. at 5%	0.11	0.10	0.10	4.03	4.31	2.49	3.98	4.26	2.46	4.94	6.26	4.72	2.67	2.48	2.05
b) Irrigation levels															
I₁: 40 mm CPE	2.25	2.38	2.31	89.87	102.80	96.33	88.76	101.53	95.14	128.86	157.61	143.24	45.42	54.64	50.03
I₂: 60 mm CPE	1.79	1.75	1.77	60.87	72.22	66.54	60.12	71.52	65.82	120.20	141.26	130.73	37.75	46.04	41.89
I₃: 80 mm CPE	1.08	1.00	1.04	36.86	48.21	42.54	36.41	47.61	42.01	97.14	108.86	103.00	25.41	34.19	29.08
S. E. (m) ±	0.04	0.04	0.04	1.57	1.68	1.05	1.55	1.65	1.04	2.12	2.68	1.98	1.04	0.96	0.86
C. D. at 5%	0.13	0.12	0.12	4.94	5.28	3.05	4.88	5.21	3.02	6.06	7.66	5.78	3.26	3.04	2.51
CV %	-						12.28	11.03	10.60	8.98	9.65	10.93	14.03	10.50	14.71
II) Sub plot treatments															
c) Nutrient management															
N₁: 100% RDF (200:100:100 NPK kg/ha)	1.61	1.50	1.56	54.01	65.35	59.68	53.34	64.54	58.94	113.21	129.84	121.53	34.57	42.14	38.36
N₂: 75% RDF +25 % RDN through vermicompost	1.22	1.44	1.33	46.18	57.53	51.86	45.61	56.82	51.21	103.65	120.17	111.91	32.42	40.72	36.57
N₃: 125% RDF	2.00	1.89	1.94	69.91	82.86	76.39	69.05	81.84	75.44	118.61	139.31	128.96	35.56	45.19	40.37
N₄: 100% RDF +25 % RDN through vermicompost.	2.00	2.00	2.00	80.04	91.89	85.97	79.05	90.75	84.90	126.13	154.32	140.23	42.21	51.79	47.00
S. E. (m) ±	0.07	0.08	0.06	2.09	2.61	1.50	2.06	2.57	1.48	2.51	2.91	1.93	1.29	1.27	1.13
C. D. at 5%	0.21	0.22	0.18	5.98	7.47	4.22	5.91	7.38	4.17	7.19	8.33	5.44	3.70	3.63	3.17
CV %							14.15	14.85	13.16	9.21	9.07	9.23	15.11	11.95	16.63
Interaction effect															
L x I															
S. E. (m) ±	0.05	0.05	0.05	2.21	2.36	1.48	2.18	2.34	1.46	2.99	3.78	2.80	1.46	1.36	1.22
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
L x N															
S. E. (m) ±	0.10	0.10	0.09	2.94	3.68	2.12	2.91	3.63	2.09	3.54	4.10	2.73	1.82	1.79	1.59
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
I x N															
S. E. (m) ±	0.12	0.13	0.11	3.61	4.51	2.60	3.56	4.45	2.5	4.33	5.03	3.35	2.23	2.19	1.95
C. D. at 5%	0.36	0.37	0.31	10.35	12.94	7.30	10.23	12.78	7.21	12.44	14.43	9.41	6.40	6.29	5.48
L x I x N															
S. E. (m) ±	0.18	0.18	0.15	5.10	6.38	3.67	5.04	6.30	3.63	6.13	7.11	4.73	3.15	3.10	2.75
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
GM	1.69	1.71	1.70	62.54	74.41	68.47	61.76	73.49	67.63	115.40	135.91	125.66	36.19	44.96	40.64

Table.3 Yield attributes influenced by land configuration, irrigation levels and nutrient management during 2014 and 2015.

Treatment / Year	Total yield of turmeric (Mother +Primary+ Secondary Rhizomes) (q ha ⁻¹)			Yield of cured fingers (q ha ⁻¹)			Gross monetary Returns ha ⁻¹ (Rs.)			Net monetary Returns ha ⁻¹ (Rs.)			B:C Ratio		
	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															
L₁: Ridges and furrow	204.61	244.14	224.38	26.81	35.36	31.08	370518	413778	392148	219319	254545	236932	2.43	2.56	2.50
L₂: Broad bed furrow	227.43	270.93	249.18	30.08	40.20	35.14	421883	467429	444656	267742	304161	285952	2.71	2.83	2.77
S. E. (m) ±	2.03	2.74	1.91	0.57	0.87	0.58	4579	7239	4069	4579	7239	3997	--	--	--
C. D. at 5%	5.80	7.86	5.58	1.64	2.49	1.68	13114	20700	11851	13130	20791	11642	--	--	--
b) Irrigation levels															
I₁: 40 mm CPE	266.33	317.69	292.01	34.36	46.61	40.48	513961	570756	542359	355203	401079	378141	3.22	3.34	3.28
I₂: 60 mm CPE	220.80	261.86	241.33	29.39	38.44	33.92	400123	439728	419925	246102	277062	261582	2.59	2.70	2.65
I₃: 80 mm CPE	160.80	193.04	176.99	21.59	28.28	24.93	274518	311327	292922	129287	159917	144602	1.89	2.06	1.97
S. E. (m) ±	2.48	3.35	2.35	0.70	1.06	0.71	5608	8866	4983	5608	8866	4895	--	--	--
C. D. at 5%	8.00	9.61	6.83	2.01	3.04	2.06	16078	25359	14515	16061	25383	14259	--	--	--
CV %	9.89	8.37	6.86	12.09	12.94	14.79	6.94	9.86	8.25	11.28	15.55	12.97	--	--	--
II) Sub plot treatments															
c) Nutrient management															
N₁: 100% RDF (200:100:100 NPK kg/ha)	203.64	239.48	221.56	26.80	35.00	31.00	361164	400697	380931	216795	248809	232802	2.49	2.61	2.55
N₂: 75% RDF +25 % RDN through vermicompost	183.96	220.42	202.19	24.99	32.57	28.78	326439	363515	344977	171470	201072	186271	2.10	2.23	2.16
N₃: 125% RDF	226.00	269.66	247.83	28.46	38.10	33.28	414496	463698	439097	266705	306949	286827	2.78	2.92	2.85
N₄: 100% RDF +25 % RDN through vermicompost.	250.49	300.57	275.53	33.54	45.24	39.39	482704	534504	508604	319153	360581	339867	2.91	3.03	2.97
S. E. (m) ±	3.51	3.77	2.56	0.76	1.15	0.66	8063	9641	5819	8063	9641	5771	--	--	--
C. D. at 5%	10.03	10.82	7.18	2.19	3.31	1.85	23126	27653	16351	23126	27653	16214	--	--	--
CV %	8.64	7.21	6.47	11.38	12.94	11.92	8.63	9.28	8.34	14.05	14.64	13.24	--	--	--
Interaction effect															
L x I															
S. E. (m) ±	3.51	4.73	3.31	0.99	1.50	1.00	7931	12540	7047	7931	12539	6923	--	--	--
C. D. at 5%	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	11403	13635	8230	11403	13634	8161	--	--	--
C. D. at 5%	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	13966	16699	10080	13966	16699	9995	---	--	--
C. D. at 5%	17.41	18.74	12.43	3.79	5.72	3.20	40056	47896	28321	40056	47896	28084	---	--	--
L x I x N															
S. E. (m) ±	8.58	9.24	6.26	1.86	2.82	4.52	19750	23616	14255	19750	23616	14136	--	--	--
C. D. at 5%	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	396201	440604	418402	243531	279353	261442	2.57	2.70	2.63

Table.4 Growth characters influenced by irrigation levels x nutrient management during 2014 and 2015.

Irrigation levels / Nutrient management	Number of tillers plant ⁻¹				Plant height plant ⁻¹ (cm)				Number of functional leaves plant ⁻¹				Leaf areaplant ⁻¹ (dm ²)				Dry matter plant ⁻¹ (g)			
	N ₁	N ₂	N ₃	N ₄	N ₁	N ₂	N ₃	N ₄	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				2014-2015				2014-2015			
I₁: 40 mm CPE	2.00	1.50	2.80	3.00	100.33	97.98	100.63	101.96	9.87	9.43	10.77	10.80	46.03	45.60	47.36	48.82	80.85	72.15	87.11	89.95
I₂: 60 mm CPE	1.70	1.20	2.00	2.00	96.25	94.39	97.24	98.32	9.47	8.93	9.93	10.10	44.15	43.91	44.29	44.52	71.93	69.08	77.48	77.96
I₃: 80 mm CPE	1.00	1.00	1.20	1.20	91.56	91.23	94.51	94.81	8.70	8.63	8.93	9.13	42.20	39.37	42.45	42.67	70.33	66.13	71.21	72.25
S. E. (m) ±	0.12				0.77				0.35				0.55				2.28			
C. D. at 5%	0.36				2.22				1.00				1.60				6.56			
	2015-16				2015-16				2015-16				2015-16				2015-16			
I₁: 40 mm CPE	2.00	2.00	2.80	3.00	103.48	101.13	106.00	107.47	10.83	10.20	12.50	12.57	48.70	47.28	50.12	54.36	91.08	79.53	95.22	95.41
I₂: 60 mm CPE	1.50	1.50	1.80	2.00	99.40	97.53	100.38	101.47	10.53	9.93	10.90	11.00	48.50	41.33	49.09	49.20	78.38	75.79	84.28	85.56
I₃: 80 mm CPE	1.00	1.00	1.20	1.30	94.70	94.37	97.66	97.95	10.33	9.57	10.43	10.53	46.77	41.28	48.07	48.83	74.91	74.54	75.32	76.15
S. E. (m) ±	0.19				0.82				0.44				0.94				2.41			
C. D. at 5%	0.55				2.37				1.27				2.71				6.93			

N₁: 100% RDF (200:100:100 NPK kg/ha), N₂: 75% RDF +25 % RDN through vermicompost, N₃: 125% RDF and N₄: 100% RDF +25 % RDN through vermicompost.

Table.5 Yield characters influenced by irrigation levels x nutrient management during 2014 and 2015.

Irrigation levels / Nutrient management	Number of mother rhizomes plant ⁻¹				Weight of mother rhizomes plant ⁻¹ (g)				Yield of fresh mother rhizomes ha ⁻¹ (q)				Yield of fresh primary fingers ha ⁻¹ (q)				Yield of fresh secondary fingers ha ⁻¹ (q)			
	N ₁	N ₂	N ₃	N ₄	N ₁	N ₂	N ₃	N ₄	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				2014-2015				2014-2015			
I₁: 40 mm CPE	2.00	1.50	2.83	3.00	78.02	56.91	101.10	123.47	77.06	56.20	99.85	121.95	120.07	118.96	130.96	145.46	44.00	37.27	44.71	55.68
I₂: 60 mm CPE	1.67	1.17	2.00	2.00	48.30	47.04	71.92	76.22	47.71	46.46	71.03	75.28	124.38	100.35	127.10	128.99	35.18	34.69	37.48	43.63
I₃: 80 mm CPE	1.00	1.00	1.17	1.17	35.69	34.61	36.72	40.44	35.25	34.18	36.27	39.94	95.19	91.65	97.76	103.95	23.82	22.51	27.31	27.98
S. E. (m) ±	0.12				3.61				3.56				4.33				2.23			
C. D. at 5%	0.36				10.35				10.23				12.44				6.40			
	2015-16				2015-16				2015-16				2015-16				2015-16			
I₁: 40 mm CPE	2.00	1.67	2.83	3.00	89.37	68.25	117.25	136.32	88.26	67.41	115.80	134.63	148.42	136.11	166.86	179.03	50.82	45.56	56.29	65.88
I₂: 60 mm CPE	1.67	1.50	1.83	2.00	59.65	58.38	83.27	87.57	58.91	57.66	82.24	86.48	139.28	119.10	146.97	159.69	43.48	42.99	45.78	51.93
I₃: 80 mm CPE	1.00	1.00	1.00	1.00	47.03	45.95	48.07	51.78	46.45	45.38	47.47	51.14	101.83	105.28	104.09	124.23	32.12	30.81	36.28	37.56
S. E. (m) ±	0.13				4.51				4.45				5.03				2.19			
C. D. at 5%	0.37				12.94				12.78				14.43				6.29			
	Pooled mean				Pooled mean				Pooled mean				Pooled mean				Pooled mean			
I₁: 40 mm CPE	2.00	1.58	2.83	3.00	83.69	62.58	109.17	129.89	82.66	61.81	107.83	128.29	134.24	127.54	148.91	162.25	47.41	41.41	50.50	60.78
I₂: 60 mm CPE	1.67	1.33	1.92	2.00	53.98	52.71	77.59	81.89	53.31	52.06	76.64	80.88	131.83	109.72	137.03	144.34	39.33	38.84	41.63	47.78
I₃: 80 mm CPE	1.00	1.00	1.08	1.08	41.36	40.28	42.39	46.11	40.85	39.78	41.87	45.54	98.51	98.47	100.93	114.09	27.97	26.66	31.79	32.77
S. E. (m) ±	0.11				2.60				2.56				3.35				1.95			
C. D. at 5%	0.31				7.30				7.21				9.41				5.48			

N₁: 100% RDF (200:100:100 NPK kg/ha), N₂: 75% RDF +25 % RDN through vermicompost, N₃: 125% RDF and N₄: 100% RDF +25 % RDN through vermicompost.

Table.6 Yield characters and economics influenced by irrigation levels x nutrient management during 2014 and 2015

Irrigation levels / Nutrient management	Total fresh rhizomes yield of turmeric ha ⁻¹ (q)				Yield of cured fingers ha ⁻¹ (q)				Gross monetary returns (Rs ha ⁻¹)				Net monetary returns (Rs ha ⁻¹)			
	N ₁	N ₂	N ₃	N ₄	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				2014-2015			
I₁: 40 mm CPE	244.86	215.09	278.24	327.13	30.99	28.32	32.96	45.17	456075	381212	529755	688804	307220	220749	376146	516698
I₂: 60 mm CPE	209.86	186.59	235.74	251.00	28.43	26.33	30.13	32.67	360933	339985	433679	465897	213812	184734	284111	301753
I₃: 80 mm CPE	156.19	150.20	164.03	173.34	20.98	20.31	22.28	22.77	266486	258121	280055	293412	129355	108928	139859	139008
S. E. (m) ±	6.07				1.32				13966				13966			
C. D. at 5%	17.41				3.79				40056				40056			
	2015-16				2015-16				2015-16				2015-16			
I₁: 40 mm CPE	291.09	252.20	343.19	384.29	42.61	36.91	46.20	60.71	510428	419527	603674	749399	351134	251287	436871	565026
I₂: 60 mm CPE	244.70	225.32	275.61	301.84	36.47	34.70	39.09	43.51	395249	380147	471438	512080	240890	216759	313452	337151
I₃: 80 mm CPE	182.65	183.74	190.19	215.59	26.51	26.09	29.01	31.50	296416	290874	315984	342034	154404	135171	170528	179568
S. E. (m) ±	6.53				1.99				16699				16699			
C. D. at 5%	18.74				5.72				47896				47896			
	Pooled mean				Pooled mean				Pooled mean				Pooled mean			
I₁: 40 mm CPE	267.98	233.64	310.72	355.71	36.80	32.62	39.58	52.94	483252	400369	566715	719101	329177	236018	406508	540862
I₂: 60 mm CPE	227.28	205.95	255.67	276.42	32.45	30.52	34.61	38.09	378091	360066	452558	488989	227351	200747	298781	319452
I₃: 80 mm CPE	169.42	166.97	177.11	194.47	23.75	23.20	25.65	27.13	281451	274497	298019	317723	141879	122050	155193	159288
S. E. (m) ±	4.42				1.13				10080				9995			
C. D. at 5%	12.43				3.23				28321				28084			

N₁: 100% RDF (200:100:100 NPK kg/ha), N₂: 75% RDF +25 % RDN through vermicompost, N₃: 125% RDF and N₄: 100% RDF +25 % RDN through vermicompost.

The results regarding land configuration also lend support to the earlier findings of Sinare B.T. *et al.*, (2016) and Hanamant M. Halli and S.S. Angadi (2018). The net monetary return findings confirm with the earlier findings of Patil *et al.*, (1991), Bheemappa *et al.*, (1994) in groundnut, Shete *et al.*, (2010) and Joshi *et al.*, (2018). Sudhakar *et al.*, (2017) in safflower and Hanamant and Angadi (2018) in turmeric recorded higher benefit:cost ratio from crops raised on broad bed furrow land configurations.

Effect of irrigation levels

The data in table 3 showed significant effect of irrigation levels treatment on gross monetary returns and net monetary returns per hectare and benefit: cost ratio.

Highest gross monetary returns (513961, 570756 and 542359 Rs ha⁻¹), net monetary returns per hectare (355203, 401079 and 378141Rs ha⁻¹) and benefit: cost ratio (3.22, 3.34 and 3.28) were recorded significantly in irrigation level 40 mm CPE as compared to others irrigation levels. The gross monetary returns results are in conformity with the earlier findings of Nisha Nandle (2018) in onion. Benefit: cost ratio results have also been reported by Chakraborty *et al.*, (2010) and Chauhan (2015).

Effect of nutrient management

Nutrient management treatments significantly influenced the gross monetary returns and net monetary returns per hectare and benefit: cost ratio during the experimentation (Table 3).

Significantly the highest gross monetary return (482704, 534504 and 508604 Rs ha⁻¹), net monetary return ha⁻¹ (319153, 360581 and 339867Rs ha⁻¹) and benefit: cost ratio (2.91, 3.03 and 2.97) were recorded in treatment N4 (100% RDF + 25 % RDN through

vermicompost) over all other treatments during the study period and in pooled data respectively (Table 3). Similar results have been reported by other investigators Rana *et al.*, (1993) and Sharma *et al.*, (2003) regarding gross monetary returns.

Interaction effect

Data presented in Table 6 showed that gross monetary returns and net monetary returns ha⁻¹ was affected significantly due to interaction between irrigation level and nutrient management during both the years and in pooled analysis.

The gross monetary returns and net monetary returns ha⁻¹ was noticed higher in I₁xN₄ treatment combination and recorded significantly highest gross monetary returns ha⁻¹ (688804, 749399 and 719101Rs ha⁻¹) and net monetary returns ha⁻¹ (516698, 565026 and 540862Rs ha⁻¹) during the course of study and in pooled data respectively over the other treatments (Table 6).

Combination of irrigation treatment with nutrient management resulted higher yield of turmeric and recorded higher gross monetary returns. Similar results was reported by Singh *et al.*, (2002) in potato regarding net monetary returns ha⁻¹.

Economic efficiency and the viability of crop cultivation are mainly the outcome of the yield of crop with higher management costs. Higher crop productivity with lesser cost of cultivation could result in better economic parameters like net returns and B: C ratio. Patra *et al.*, (1998) and Singh (2015) in ginger showed that soil application of organic manures i.e., farm yard manures & vermicompost, recommended dose of chemical fertilizers and integrated nutrient management i.e., organic and inorganic fertilizers showed significant effect with

higher benefit: cost ratio. Based on the findings of two years investigation, it can be concluded that for higher production and net profit 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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