

Original Research Article

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Influence of Deficit Irrigation Using Different Irrigation Methods and Fertilizer Levels on Performance of Turmeric

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ABSTRACT

A field experiment was conducted to study the influence of deficit irrigation using different irrigation methods and fertilizer levels on performance of turmeric varieties at University of Agricultural Sciences, Dharwad. The experiment was laid out in split-split plot design, keeping irrigation methods (Drip, sprinkler and ridges and furrow irrigation applied as deficit irrigation at 50% depletion of soil moisture) in main plot; varieties (cv. Cudappah and cv. Pratibha) in sub plot and fertilizer levels (180:90:90, 225:112.5:135 and 270:135:180 kg N:P₂O₅:K₂O ha⁻¹) in sub-sub plot. Higher growth observed in terms of leaf area, chlorophyll content at 150 DAP and total dry matter production at harvest were recorded with drip irrigation. Significantly higher total fresh rhizome, fresh mother rhizomes and cured finger rhizome yield were observed in drip irrigation method applied at 50 per cent depletion of soil moisture. Superiority of performance of cv. Cudappah variety was observed over cv. Pratibha in terms of leaf area, chlorophyll content TDM and yield. Application of 270:135:180 kg N:P₂O₅:K₂O ha⁻¹ resulted in higher fresh rhizomes, mother rhizomes and cured finger rhizome yield which was on par with application of 225:112.5:135 kg N:P₂O₅:K₂O ha⁻¹. Interaction influence of the irrigation methods, varieties and fertilizer indicated higher growth and yield in treatment applied with irrigation at 50 per cent soil moisture depletion through drip irrigation with cv. Cudappah and application of 270:135:180 kg N:P₂O₅:K₂O ha⁻¹ which was statistically on par with I₁V₁F₂ and I₁V₂F₃.

Keywords

Deficit irrigation,
Irrigation methods,
Fertilizer levels,
Turmeric yield and
Total dry matter
production.

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Introduction

Turmeric is one of the important spices grown for domestic consumption and export owing to its wide range of fields of utilities covering culinary to medicine. Globally, India occupies the first position in the world (Siddramappa, 2013) with an area of 1.90 lakh hectares and also produces 8.44 lakh tonnes (Anon., 2017). It is well understood that, moisture during the different growth stages play a major role in expressing full potentiality of crop. However, farmers often over irrigate through increased irrigation frequency and amount of water

applied causing deleterious effect on the applied nutrients, water and soil properties. Climate change and prevailing seasonal water deficit endeavours for improvement the agronomic practices for addressing the water deficit situation.

Deficit irrigation is one such approach to reduce the water consumption. In general different irrigation methods induce differential effect on the crop response and more so under deficit irrigation. Further, there

is always a need to maximize water use efficiency without scarifying production because of variation in rainfall characteristics, increasing competition for water, with increase in energy costs and competing demand in all the sectors. This can be achieved by use of improved pressurized irrigation methods over conventional irrigation practices (Chitra *et al.*, 2017).

Further balanced nutrition is essential part of the crop husbandry practice to moderate the prevailing soil water regime. Differential response of the genotypes exists due to their genetic makeup which needs to be exploited (Sandeep *et al.*, 2016). Influence on the interaction effect of different irrigation methods under deficit irrigation with varied nutrient levels and genotype is meagre. Hence, an experiment was conducted to study the “Influence of deficit irrigation using different irrigation methods and fertilizer levels on performance of turmeric”.

Materials and Methods

Experimental site was located at the Agricultural Research Station (ARS), Kalloli, University of Agricultural Sciences, Dharwad during 2013-14. Soil type observed in the experimental site was medium deep black clayey soil with alkaline in pH (8.3), low in available nitrogen (243 kg ha^{-1}), medium in available phosphorus (32 kg ha^{-1}) and high in available potassium (318 kg ha^{-1}). Experiment was laid in split split plot design with three replications. Treatments were assigned as below:

Main plot: Deficit irrigation at 50 % soil moisture depletion using different irrigation methods

I₁: Drip irrigation
I₂: Ridges and furrow irrigation
I₃: Sprinkler irrigation

Sub-plot: Varieties (V)

V₁: Cudappah
V₂: Pratibha

Sub-sub-plot: Fertilizers levels (F) #

F₁: 180:90:90 kg N: P₂O₅: K₂O ha⁻¹
F₂: 225:112.5:135 kg N: P₂O₅: K₂O ha⁻¹
F₃: 270:135:180 kg N: P₂O₅: K₂O ha⁻¹

Nitrogen and potassium were soil applied in five splits at monthly interval starting from planting. While entire P₂ O₅ was applied as basal dose at the time of planting. Fertilizer were applied with Urea, DAP and MOP as source of the nutrients. Drip irrigation was applied with 4 l hr^{-1} discharge emitter⁻¹ with lateral placed every two rows of the turmeric plants. All standard agronomic practices were followed uniformly across the treatments during the conduct of the experiment. Growth observed during the conduct of the experiment is expressed as leaf area ($\text{dm}^2 \text{ plant}^{-1}$) and chlorophyll content (SPAD values) at 150 DAP (days after planting) and total dry matter production per plant at harvest. Fresh rhizomes were harvested at maturity by digging and removing of the roots. Fresh rhizome yield presented is cumulative of the all the rhizomes harvested (Mother, primary, secondary and tertiary rhizomes). Fresh mother rhizomes were separated from the harvested rhizome and yield of the mother rhizomes were recorded separately as these were not subjected to curing process. Whereas, primary, secondary and tertiary rhizomes were subjected to curing process and the end product is presented as cured finger rhizome yield. The data collected from the experiment was subjected to statistical analysis and interpretation of data was done using the Fischer's method of analysis of variance technique as described by Gomez and Gomez (1984). The level of significance used in 'F' and 't' test was P =

0.05. The mean values for main plot, sub plot, sub sub plot and interactions were separately subjected to Duncan multiple range test (DMRT) using corresponding error mean sum of square and degrees of freedom.

Results and Discussion

Deficit irrigation through different irrigation methods induced differential response in fresh rhizome yield and the fresh mother rhizome yield (Table 3). Drip irrigation applied at 50 per cent available soil moisture depletion recorded higher yield response in comparison to other irrigation methods evaluated. Drip irrigation at 50 per cent soil moisture depletion resulted in better water regime with retention of moisture within the active root zone of turmeric which facilitated for better uptake of the nutrients. Drip irrigation might have resulted in improvement of the biometric parameters resulting in better maintenance of relative water content in leaves. This might have induced progressive effect on growth attributes, extended period of greenness of crop is an indicative of profuse expansion of photosynthetic area and translocation of the absorbed nutrients as indicated by leaf area and chlorophyll content at 150 DAP and TDM at harvest (Table 1). Yield response to drip irrigation at 50 per cent soil moisture depletion was significantly higher over other methods (Table 3). Drip irrigation recorded higher fresh rhizomes (25.85 t/ha), fresh mother rhizomes (5.86 t/ha) and cured finger rhizomes yield per ha (3.97 t/ha). Whereas, corresponding lower yield was recorded with furrow irrigation at 50 per cent soil moisture depletion. Furrow irrigation at 50 per cent soil moisture depletion might have resulted in the loss of added nutrients through leaching, runoff and other factors. On the contrary drip irrigation at 50 per cent soil moisture depletion might had facilitated for better development of rhizomes directly infusing higher nutrients into the rhizome resulting in

increment of both rhizome volume and weight in comparison to other irrigation methods evaluated. Presented results are in corroboration with the findings of Kaur and Brar (2016); Surepaddi *et al.*, (2016). Comparison among the varieties evaluated indicated progressive growth in cv. Cudappah induced higher translocation of the absorbed nutrients resulted in higher yield. Relatively higher absorption of soil moisture and nutrients on account of profused improvement in growth attributes as indicated by the higher leaf area and chlorophyll at peak growth stage and TDM at harvest might have contributed to increase in yield attributes of turmeric. Higher fresh rhizomes (24.33 t/ha); mother rhizomes (5.63 t/ha) and cured finger rhizomes yield (3.85 t/ha) were observed in Cudappah. Results are in corroboration with the findings of Salimath *et al.*, (2013). Graded levels of fertilizer levels resulted in significant variation in growth attributes as indicated by higher leaf area, chlorophyll content at peak growth stage (150 DAP) and TDM at harvest.

Application of 270:135:180 kg N: P₂O₅: K₂O per ha recorded significantly higher values of biometric parameters. Application of nitrogen and potassium in increased split applications resulted in response of the turmeric to higher levels of fertilizer against recommended dose of fertilizer (Jagadeeswaran *et al.*, 2005). Higher doses of nitrogen might have contributed to improvement in synthesis of protein which is important for buildup of new cells and consequently influenced the growth (Salisbury and Ross, 1969). Increased potassium levels increased the potassium content in plants which functionally acts as transporter of photosynthates to the economic parts contributing to increased yield. Additionally increased potassium application address the deficit irrigation situation by way of stomatal regulation improves capacity of the crop to resist drought and alleviate the negative effects on growth and development.

Table.1 Influence of irrigation methods, varieties and fertilizer levels on leaf area and Chlorophyll content (SPAD value) at 150 DAP and total dry matter production at harvest of turmeric

Treatment details	Leaf area (dm ² plant ⁻¹) at 150 DAP	Chlorophyll content (SPAD value) at 150 DAP	Total dry matter Production (g plant ⁻¹) at harvest
Main plot (Irrigation at 50 % soil moisture depletion)			
I ₁ : Drip irrigation	50.0a	31.2a	126.4a
I ₂ : Ridges and furrow irrigation	45.6b	28.7b	109.8c
I ₃ : Sprinkler irrigation	47.8ab	29.5b	112.2b
S.Em. ±	0.8	0.3	1.4
Sub plot (Varieties)			
V ₁ : Cudappah	48.9a	30.4a	123.2a
V ₂ : Pratibha	46.7b	29.3b	109.2b
S.Em. ±	0.5	0.3	1.6
Sub Sub plot (Fertilizer levels)			
F ₁ : 180:90:90 kg N: P ₂ O ₅ : K ₂ O ha ⁻¹	46.3c	29.2b	110.4c
F ₂ : 225:112.5:135 kg N: P ₂ O ₅ : K ₂ O ha ⁻¹	47.6b	29.9ab	116.1b
F ₃ : 270:135:180 kg N: P ₂ O ₅ : K ₂ O ha ⁻¹	49.6a	30.5a	121.9a
S.Em. ±	0.6	0.3	0.9

Means followed by the same letter (s) within a column are not significantly differed by DMRT (P = 0.05)

Table.2 Interaction effect of irrigation methods, varieties and fertilizer levels on leaf area and Chlorophyll content (SPAD value) at 150 DAP and total dry matter production at harvest of turmeric

Interaction Treatment (I x V x F)	Leaf area (dm ² plant ⁻¹) at 150 DAP	Chlorophyll content (SPAD value) at 150 DAP	Total dry matter production (g plant ⁻¹) at harvest
I ₁ V ₁ F ₁	49.7bc	31.1a-e	124.5cd
I ₁ V ₁ F ₂	51.3ab	32.0ab	131.6b
I ₁ V ₁ F ₃	54.9a	32.4a	139.9a
I ₁ V ₂ F ₁	47.1b-d	29.7a-e	113.8e-g
I ₁ V ₂ F ₂	48.2bc	30.7a-d	119.8de
I ₁ V ₂ F ₃	48.8bc	31.5a-c	128.9bc
I ₂ V ₁ F ₁	44.8cd	29.1a-e	113.9e-g
I ₂ V ₁ F ₂	46.1b-d	29.4b-e	119.7de
I ₂ V ₁ F ₃	47.9bc	29.9a-e	122.6cd
I ₂ V ₂ F ₁	42.1d	27.9e	97.5i
I ₂ V ₂ F ₂	45.6cd	28.3de	100.4i
I ₂ V ₂ F ₃	47.2b-d	25.9c	104.7hi
I ₃ V ₁ F ₁	46.1b-d	29.3c-e	114.6e-g
I ₃ V ₁ F ₂	48.4bc	30.0a-e	117.5d-f
I ₃ V ₁ F ₃	51.0ab	30.1a-e	123.9cd
I ₃ V ₂ F ₁	47.8bc	27.9e	98.1i
I ₃ V ₂ F ₂	46.2b-d	28.9c-e	107.7gh
I ₃ V ₂ F ₃	47.6bc	31.0a-c	111.4f-h
S.Em. ±	1.5	0.8	2.3

Means followed by the same letter (s) within a column are not significantly differed by DMRT (P = 0.05)

Irrigation methods (I) - at 50 % soil moisture depletion

I₁: Drip irrigation

I₂: Ridges and furrow irrigation

I₃: Sprinkler irrigation

Varieties (V)

V₁: Cudappah

V₂: Pratibha

Fertilizer levels (F)

F₁: 180:90:90 kg N: P₂O₅: K₂O ha⁻¹

F₂: 225:112.5:135 kg N: P₂O₅: K₂O ha⁻¹

F₃: 270:135:180 kg N: P₂O₅: K₂O ha⁻¹

Table.3 Influence of irrigation methods, varieties and fertilizer levels on fresh rhizome, fresh mother rhizome and cured finger rhizome yield of turmeric

Treatment details	Fresh rhizome Yield (t ha ⁻¹)	Fresh mother rhizome yield (t ha ⁻¹)	Cured finger rhizome yield (t ha ⁻¹)
Main plot (Irrigation at 50 % soil moisture depletion)			
I ₁ : Drip irrigation	25.85a	5.86a	3.97a
I ₂ : Ridges and furrow irrigation	22.42b	5.25b	3.37b
I ₃ : Sprinkler irrigation	22.98b	5.37b	3.46b
S.Em. ±	0.42	0.05	0.06
Sub plot (Varieties)			
V ₁ : Cudappah	24.33a	5.63a	3.85a
V ₂ : Pratibha	23.16b	5.35b	3.35b
S.Em. ±	0.34	0.08	0.08
Sub Sub plot (Fertilizer levels)			
F ₁ : 180:90:90 kg N: P ₂ O ₅ : K ₂ O ha ⁻¹	22.07c	5.17b	3.39b
F ₂ : 225:112.5:135 kg N: P ₂ O ₅ : K ₂ O ha ⁻¹	24.14b	5.56a	3.65a
F ₃ : 270:135:180 kg N: P ₂ O ₅ : K ₂ O ha ⁻¹	25.04a	5.74a	3.76a
S.Em. ±	0.25	0.06	0.05

Means followed by the same letter (s) within a column are not significantly differed by DMRT (P = 0.05)

Table.4 Interaction effect of irrigation methods, varieties and fertilizer levels on fresh rhizome, fresh mother rhizome and cured finger rhizome yield of turmeric

Interaction Treatment (I x V x F)	Fresh rhizome yield (t ha ⁻¹)	Fresh mother rhizome yield (t ha ⁻¹)	Cured finger rhizome yield (t ha ⁻¹)
I ₁ V ₁ F ₁	24.75cd	5.68cd	4.00bc
I ₁ V ₁ F ₂	27.13a	6.17ab	4.26ab
I ₁ V ₁ F ₃	28.18a	6.38a	4.45a
I ₁ V ₂ F ₁	23.00d-g	5.22de	3.45e-g
I ₁ V ₂ F ₂	25.18bc	5.65cd	3.76f
I ₁ V ₂ F ₃	26.85ab	6.04a-c	3.91b
I ₂ V ₁ F ₁	21.27g-i	4.93e	3.46e-g
I ₂ V ₁ F ₂	23.25c-g	5.37de	3.71f
I ₂ V ₁ F ₃	24.17c-e	5.53d	3.80b
I ₂ V ₂ F ₁	20.50i	4.94e	2.89i
I ₂ V ₂ F ₂	22.47e-i	5.32de	3.15g-i
I ₂ V ₂ F ₃	22.87d-h	5.40de	3.21c
I ₃ V ₁ F ₁	22.00f-i	5.28de	3.54d-g
I ₃ V ₁ F ₂	23.90c-f	5.60cd	3.70c-f
I ₃ V ₁ F ₃	24.35c-e	5.71b-d	3.76b
I ₃ V ₂ F ₁	20.90hi	4.97e	3.01hi
I ₃ V ₂ F ₂	22.92d-h	5.26de	3.33f-h
I ₃ V ₂ F ₃	23.80c-f	5.39de	3.42bc
S.Em. ±	0.61	0.15	0.13

Means followed by the same letter (s) within a column are not significantly differed by DMRT (P = 0.05)

Irrigation methods (I) - at 50 % soil moisture depletion

I₁: Drip irrigation
I₂: Ridges and furrow irrigation
I₃: Sprinkler irrigation

Varieties (V)

V₁: Cudappah
V₂: Pratibha

Fertilizer levels (F)

F₁: 180:90:90 kg N: P₂O₅: K₂O ha⁻¹
F₂: 225:112.5:135 kg N: P₂O₅: K₂O ha⁻¹
F₃: 270:135:180 kg N: P₂O₅: K₂O ha⁻¹

Imperatively increased K₂O levels increase the yield irrespective of irrigation methods (Ati *et al.*, 2012). Further phosphorus facilitates plant to respond to N and K₂O fertilization. Increased response of the applied nitrogen with increase in potassium levels contributing to the improvement in crop growth was observed (Aulakh and Malhi, 2005). Higher fresh rhizomes yield (25.04 t/ha); fresh mother rhizomes yield (5.74t/ha) and cured finger rhizome yield (3.76 t/ha) were observed with application of 270:135:180 kg N: P₂O₅: K₂O per ha over other fertilizer levels. However it was on par with 225:112.5:135 kg N: P₂O₅: K₂O ha⁻¹. Propelled improvement in crop growth and yield was also due synergetic effect of NxPxK interaction in turmeric. Turmeric is high responsive crop to applied potassium which might have reflected to the increased KN ratio in the applied fertilizer (0.67) as compared to application of 180:90:90 kg N:P₂O₅:K₂O per ha (0.50). This may be due to higher increased response in terms of the yield attributes.

Response of particular variety to irrigation and fertilizers is a genotypic character. Seyie *et al.*, (2013) and Tiwari *et al.*, (2014) recorded similar observation of differential yield response in genotypes to graded level of fertilizers. Cv. Cudappah responded better in comparison to cv. Pratibha with fertilizer levels and drip irrigation. Drip irrigation at 50 per cent depletion of the soil moisture depletion with fertilizers induced significant variation in the performance of turmeric across both the varieties evaluated. Higher levels of soil applied fertilizers to drip irrigated plot resulted in higher growth and yield attributes in comparison to surface irrigation (Table 2 and 4). Similar results were observed by Sadarunnisa *et al.*, (2010). Irrigation, variety and fertilizer interactions differed significantly with respect to plant growth and yield characteristics as evidenced

by the leaf area, chlorophyll content and total dry matter accumulation (Table 2). Drip irrigation at 50 per cent soil moisture depletion with application of 270:135:180 kg N: P₂O₅: K₂O per ha in cv. Cudappah (I₁V₁F₃) higher growth fresh rhizome (28.18 t/ha), fresh mother rhizome yield (6.38 t/ha) and cured finger rhizome yield (4.45 t/ha). It was on par with drip irrigation at 50 per cent soil moisture depletion with application of 225:112.5:135 kg N:P₂O₅:K₂O per ha in cv. Cudappah (I₁V₁F₂) and drip irrigation at 50 per cent soil moisture depletion with application of 225:112.5:135 kg N:P₂O₅:K₂O per ha in cv. Cudappah (I₁V₂F₃). Furrow irrigation at 50 per cent soil moisture depletion with application of N: P₂O₅: K₂O per ha in Cv. Pratibha (I₂V₂F₁) which was on par I₃V₂F₁ (Table 4). Whereas, Sadarunnisa *et al.*, (2010) and Patel *et al.*, (2012) obtained higher yields in drip irrigation with higher fertilizer over furrow irrigation with different fertilizers. Aulakh and Malhi (2005) indicated positive interaction effect of nitrogen with other nutrients in presence of water. Thus synergistic effect of higher levels of applied nutrients and drip irrigation method on Cv. Cudappah combination might have proved to be positive in imparting the progressive growth and yield of turmeric.

Application of N: P₂O₅: K₂O fertilizer levels upto 225:112.5:135 kg N: P₂O₅: K₂O per ha coupled with split application of N and K₂O in balanced proportion with higher potassium ratio and drip method of irrigation resulted in higher fresh rhizome yield, fresh mother rhizome yield and cured finger rhizome yield in both the varieties tested.

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