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To Study the effect of Irrigation Levels and Nutrient on Production of Turmeric (*Curcuma longa* L.) under Drip Environment

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ABSTRACT: A present field investigation was entitled was conducted at the instructional farm of Barrister Thakur Chhedilal, College of Agriculture and Research Station, Bilaspur (C.G.) during *kharif* season 2021-22. The experimental treatment consists three drip irrigation levels at I_1: 100 % PE, I_2: 80 % PE, I_3: 60 % PE and control plot (I_4) with surface irrigation and same as three levels of nutrient management with F_1: 100 % RDF through soil application, F_2: 100 % RDF through water soluble fertilizer (WSF), F_3: 75 % RDF through WSF and farmer control. The turmeric cultivar Narendra was used and each treatment was replicated thrice in strip plot design. A major problem associated with drip irrigation systems is the clogging of emitters, Clogging can reduce emission rates and cause poor uniformity of water application. Clogging also increases the maintenance costs, as it becomes necessary to check, repair or replace clogged emitters and other components. Chemical treatment and proper filtration of water was prevent or correct emitter clogging.

The results of experiment show pre harvest observation *viz.*, plant height, number of leaves, dry matter production and crop growth rate and post-harvest observation *viz.*, number of mother and finger rhizome, length and girth of mother and finger rhizomes, rhizome yield (t ha^{-1}) and irrigation observation *viz.*, water expense, water expense efficiency (WEE) and number of irrigations in turmeric. Under drip irrigation level treated with 100 % PE (I_1) and fertigation level at 100 % RDF (F_2) through water soluble fertilizer in turmeric were found significantly superior among entire treatments with regard of above specified character. Irrigation level I_3 and nutrient management F_1 observed significantly inferior among entire treatments.

Drip irrigation scheduling with 100 % PE in every two days and WSF through drip irrigation with 100 % RDF, is recommended for obtain maximum turmeric production (25.10 t ha^{-1} and 25.88 t ha^{-1}), maximum net returns (Rs 1079480 ha^{-1} and Rs 1116074 ha^{-1}) and Benefit: cost ratio (6.15 and 6.27) together with WEE (72.31 Kg ha-mm^{-1}) and 77.21 Kg ha-mm^{-1}) in drip irrigation systems.

Keywords: Drip, Fertigation, Irrigation, Turmeric.

INTRODUCTION

Spices are a high-value export crop and turmeric being the most important and popular as well as a traditional spices item of export. Turmeric, also known as "Indian saffron," is a tropical high-value rhizomatous spice crop cultivated mostly in India. Turmeric (*Curcuma longa* L.) is a perennial herbaceous spice crop commonly also known as "golden spice". Turmeric is an herbaceous perennial plant with over 70 species that belongs to the Zingiberaceae family. It is primarily found in South - East Asia. Turmeric is used as a spice and condiment, as well as a dyeing material and cosmetic and pharmaceutical industries, particularly in the creation of anti-cancer drugs.

India is the world's leading producer and exporter of turmeric. Other producers are Thailand, Taiwan, Central and Latin America. Turmeric production in India accounts for roughly 78-80 percent of global turmeric production. Needless to say, this makes turmeric farming a viable and profitable enterprise in India.

Turmeric production is estimated to be over 11 lakh tonnes per year worldwide. India leads the global production scene with an 80% share, followed by China (8%), Myanmar (4%), Nigeria (3%), and Bangladesh (3%). The United States (6,318.45 tonnes) and the United Arab Emirates (5,938.10 tonnes) are the top turmeric importers from India (Agricultural Market Intelligence Centre, PJTSAU Rajendranagar, Hyderabad).

Turmeric production in India is about 10.64 lakh tonnes of turmeric in an area of 2.91 lakh ha with productivity of 3656 kg ha^{-1} during 2020-21. Turmeric occupied about 6.42 percent of the total area under spices and condiments in India and contribute 9.96 percent share to total spices and condiments production (Spices Board of India).

In India major producing turmeric states are Telangana Odessa followed by Maharashtra and Karnataka. Telangana contribute highest area is 55,443 ha, followed by Odessa 27,864 ha, and Tamil Nadu 18,296 ha, West Bengal has 17,711 hectares. (Agricultural Market Intelligence Centre, Rajendranagar, Hyderabad). Chhattisgarh it is grown on 1.15 million hectares, with a production of 0.96 million MT and a productivity of 0.84 t ha^{-1} (Anonymous, 2020). Due to high remunerative crop area of turmeric production is increases day by day in Chhattisgarh.

Due to long duration crop being a *kharif* crop maximum portion of vegetative growth period covered by rainfed but remaining growing part irrigation is must for letter yield irrigation with surface method distributed the water unevenly in entire field, so some part affected due to excess water, however at the same time other part of field facing deficit moisture, resulted poor yield. On the other hand water use efficiency is very low in surface method of irrigation.

In turmeric that under drip irrigation, the plant height and growth was enhanced and concluded that this might be due to better availability of soil moisture during entire crop growth period and the lowest growth observed in conventional irrigation method (Sadarunnisa *et al.,* 2010).

The drip irrigation always maintained the soil moisture near the field capacity, that the reason water is available throughout the crop growth period at optimum levels of moisture without subjecting to water scarcity or drought to the plants and thus helps in superior rhizome growth. (Spehia *et al.,* 2013).

A drip irrigation level 100 % PE maintains adequate soil physical condition for plant growth by maintaining appropriate soil water balance in plant roots zone throughout the entire crop growth stage, which leads to high growth attributes, due to ideal turgidity of cells, leading to cell elongation and cell wall development (Satyareddi and Angadi 2014).

Fertigation (application of fertilizer with the irrigation water) allows applying small amounts of fertilizer in each fertigation event that contributes to high flexibility in fertigation frequency. In this method liquid fertilizer as well as water soluble fertilizers are used. Higher rhizome yields under fertigation was probably due to optimal availability of nutrients and water at all the growth periods in leading to more cell division and cell elongation and also due to the complete solubility and mobilization of WSF at regular intervals in split application (Sood and Singh 2003). The combination of N, P and K or K and N give 4-6 times higher shoot dry matter production and eight to nine times superior yield (Akamine *et al*., 2007). The higher rhizome yield at 100 % RDF applied through water soluble fertilizer and 120 % PE, this may be due to higher uptake of nitrogen, phosphorus and potassium and high-water availability throughout the crop period by drip irrigation (Archana and Maragatham 2017).

Fertigation is a tool to supply the plant with its daily demand of water and nutrient as required at specific growth stage throughout its growth and development to achieve maximum efficiency of the fertilizer applied. It enables users to put the fertilizers in the plant root zone in desired frequency, amount and concentration at appropriate time (Elfving, 1982).

Turmeric is a long duration crop which response more too enhancing application of fertilizers. The nutrient *i.e*., nitrogen, phosphorus and potassium are considered as one of the key elements in deciding the quality and yield potential of high yielder variety (Haque *et al.*, 2007).

As water and fertilizer are supplied evenly to all the crops through fertigation there is possibility for getting 25-50 per cent higher yield and which helps to save a minimum of 25 per cent of nutrients. By this way, along with less amount of water and time, labour and energy use is also reduced substantially.

MATERIALS AND METHODS

The experiment was conducted at the instructional farm of Barrister Thakur Chhedilal, College of Agriculture and Research Station, Bilaspur (C.G.) during *kharif* season 2021-22. Bilaspur district is situated at Latitude 22.09˚N and Longitude, 82.15˚E. The region falls under the Eastern plateau and hill region (Agro-climatic zone-VII) of India.

Bilaspur is characterized as slightly moist hot zone. An average annual rainfall of 1164.6 mm is generally recorded and mostly concentrated during the period from June to September. Physical properties of soil in the experimental field was clayey loam in texture and soil pH was neutral (7.0) in reaction. Mechanical analysis of the soil revealed that sand was 30.42 percent, clay 45.86 percent and silt 23.72 percent. In experiment field the available nitrogen content was low (237 kg N ha^{-1}) and available phosphorous content was medium (14.32 kg ha^{-1}), the available potassium content was medium (204.96 kg ha^{-1}). Electrical conductivity was 0.19 dsm^{-1} and organic carbon percentage was 0.6. Both the drip and surface irrigation treatment plots were separated by buffer channels of 1.0 m width to avoid border effect and Gross plot size was 7.6 m × 4.0 m area. Drip system consisting of main, sub-main and laterals was laid out in the experimental plot. The laterals of 12 mm diameter were laid 1.0 m apart with spacing of 40 cm between two inline drippers. Dripper discharge rate was 2 L h^{-1} and total number was 25000 ha^{-1} required. The investigation field, strip plot design with three replications. The treatment plot was divided into three irrigation levels.

The experimental treatments, Irrigation levels comprised were I_1: 100 % PE, I_2: 80 % PE and I_3: 60 % PE and I_4: control (surface irrigation) and treatment (factor-B, nutrient management) *i.e.* F_1: 100 % RDF through soil application, F_2: 100 % RDF through WSF and F_3: 75 % RDF through WSF. Full dose of phosphorus and potassium, while split dose of nitrogen is applied as per treatment and recommended dose for turmeric was 180: 60: 120 kg NPK ha^{-1}. Nitrogen, Phosphorus and Potash were applied through urea, single super phosphate (SSP), phosphoric acid and murate of potash (MOP) fertilizers, respectively. Remaining dose of nitrogen was applied through top dressing. Other hand fertigation is done as per treatment and applied throughout the cropping period once in three days. Nitrogen, Phosphorus and Potash were applied through (water soluble fertilizer) urea, phosphoric acid and murate of potash (MOP) fertilizers, respectively.

RESULTS AND DISCUSSION

Growth attributes. The growth and yield components *viz.*, plant height (cm), dry matter production (g) $plant^{-1}$ CGR (g m^{-2} $plant^{-1}$ (Table 1) in various stages of turmeric.

(i) Plant height (cm). The plant height of turmeric observed in initial stage *i.e.,* at 30 and 60 DAP without any application of irrigation water found non-significant at each treatment, this might be due to water requirement were met uniformly from well distributed rainfall during July to September. The maximum plant height 52.17, 84.74, 122.28, 143.69 and 161.40 cm, respectively, was recorded at 90, 120, 150, 180 DAP and maturity by 100 % PE (I_1) and statistically at par with 80 % PE (I_2). However, lowest plant height 42.86, 77.53, 109.70, 131.64 and 147.58 cm, respectively, recorded by 60 % PE (I_3). In case of nutrient managemnt at 30 and 60 DAP the maximum average plant height of 17.84 cm and 29.31 cm, respectively, recorded in treatment 100 % RDF applied to the soil (F_1) and minimum plant height was recorded in 75 % RDF through water soluble fertilizer (F_3). At 90, 120, 150, 180 DAP and maturity, the maximum average plant height recorded in F_2 (100 % RDF applied through WSF) *i.e.,* 55.13, 90.12, 124.59, 146.79 and 164.11 cm, respectively and the minimum plant height 44.88, 77.72, 112.40, 131.84, and 150.87 cm, were observed in F_1 (100 % RDF through soil application) at 90, 120, 150, 180 DAP and maturity, respectively**.**

(ii) Dry matter production (g $plant^{-1}$). The dry at initial stage at 30 and 60 DAP without any application of irrigation water, was found non-significant among each treatment. The average dry matter 14.50, 35.54, 62.03, 106.09 and 185.82 g $plant^{-1}$ was observed at 90, 120, 150, 180 DAP and maturity, respectively, was found highest among all scheduled, at 100 % PE (I_1) followed by 80 % PE (I_2), while lowest mean dry matter (g $plant^{-1}$) was recorded in I_3 (60 % PE) *i.e.,* 11.95, 30.45, 55.01, 96.07 and 170.70 g $plant^{-1}$. Drip irrigation favours increased dry matter production with increased growth parameter and photosynthetic activity in turmeric Subramanian *et al.,* (2001).

Regarding to nutrient management, at 30 and 60 DAP was recorded maximum average dry matter (g $plant^{-1}$) 3.62 and 5.74 in treatment 100 % RDF applied to the soil (F_1) which was followed F_2 (100 % RDF through drip) and minimum dry matter (g $plant^{-1}$) was recorded in F_3 (75 % RDF through water soluble fertilizer). At 90, 120, 150, 180 DAP and maturity maximum average dry matter recorded in F_2 (100 % RDF applied through WSF) *i.e.,*15.27, 36.74, 66.14, 109.75 and 188.16 g $plant^{-1}$, respectively and it was significantly superior from other treatments.The minimum dry matter 12.14, 31.50, 54.94, 98.08 and 174.45 g $plant^{-1}$, respectively, were observed in F_1 (100 % RDF through soil application) at 90, 120, 150, 180 DAP and maturity, respectively**.**

At initial stage bulk quantity of nutrient as basal dose with soil application may produce higher dry matter (g $plant^{-1}$), in F_1 whereas at later growth stage continuous supply of water-soluble fertilizers through drip gave the higher dry matter (g $plant^{-1}$) in F_2 and F_3 treatment.

(iii) Crop growth rate (g m^{-2} day^{-1}). The crop growth rate was observed in initial stage *i.e.,* at 30 to 60 DAP was found non-significant. The maximum crop growth rate of 2.49, 5.84, 7.36, 12.24 and 22.15 g m^{-2} day^{-1} registered was at 60 to 90, 90 to 120, 120 to 150, 150 to 180 DAP and 180 to maturity, respectively, which was highest among all treatments scheduled at 100 % PE (I_1) followed by 80 % PE (I_2), while lowest mean crop growth rate was recorded in I_3 (60 % PE) *i.e.,* 1.86, 5.14, 6.82, 11.40 and 20.73 gm^{-2} day^{-1}.

At 30 to 60 DAP, maximum average crop growth rate was observed (0.59 g m^{-2} day^{-1}) by treatment 100 % RDF applied to the soil (F_1) followed by F_2 (100 % RDF through drip) and minimum crop growth rate was recorded in F_3 (75 % RDF through water soluble fertilizer). From 60 to 90, 90 to 120, 120 to 150, 150 to 180 DAP and 180 to maturity stage maximum average crop growth rate were recorded in F_2 (100 % RDF applied through WSF) *i.e.,* 2.75, 5.96, 8.17, 12.11 and 21.78 g m^{-2} day^{-1}, respectively followed by 75 % RDF through WSF (F_3), however the minimum crop growth rate 1.78, 5.38, 6.51, 11.98 and 21.21 g m^{-2} day^{-1} were observed in F_1 (100 % RDF through soil application).

A drip irrigation level 100 % PE maintains adequate soil physical condition for plant growth by maintaining appropriate soil water balance in plant roots zone throughout the entire crop growth stage, which leads to high growth attributes, due to ideal turgidity of cells, leading to cell elongation and cell wall development (Satyareddi and Angadi 2014).

(iv) Irrigation observation. The highest water expenses 583.41 mm was recorded in I_4 treatment (surface irrigation) followed by I_1 (365.88 mm) and the lowest water expenses was recorded 279.32 mm in I_3 (60% PE). In case of nutrient management, water expenses *i.e.,* 322.60 mm was recorded in each treatment (F_1, F_2 and F_3) and it shows that nutrient management has no significant effect on water expense. In case of irrigation levels, the maximum water expense efficiency (73.38 kg ha-mm^{-1}) was recorded in I_3 (60 % PE) followed by I_2 (72.31 kg ha-mm^{-1}) and minimum water expense efficiency (33.61 kg ha-mm^{-1}) was observed in I_4 treatment. The highest water expense efficiency 77.21 kg ha-mm^{-1} was recorded in F_2 (100 % RDF through water soluble fertilizer) followed by F_3 (75 % RDF through WSF), while lowest water expense efficiency (64.53 kg ha-mm^{-1}) was recorded in F_1 (100 % RDF through soil application).

Yield characteristics. The yield and yield components were significantly influenced by different treatments during experimental trail, given in Table 3.

(i) Effect of irrigation levels. The treatment I_1 (100 % PE) produced highest number of mother rhizomes (3.0), number of fingers (12.27 $plant^{-1}$), length of mother and finger rhizome (7.34 cm, 14.79 cm), girth of mother and finger rhizome (9.30 cm and 8.23cm) and statically at par with I_2 (80 % PE), while minimum number of mother rhizomes (2.44), number of fingers (9.42 $plant^{-1}$), length of mother and finger rhizome (6.30 cm, 11.62 cm, respectively), girth of mother and finger rhizome (9.30 cm and 6.26 cm, respectively).

The drip irrigation always maintained the soil moisture near the field capacity, that the reason water is available throughout the crop growth period at optimum levels of moisture without subjecting to water scarcity or drought to the plants and thus helps in superior rhizome growth (Spehia *et al.,* 2013).

(ii) Effect of nutrient management. The significantly maximum number of mother rhizome $plant^{-1}$ (3.12), number of fingers (12.81 $plant^{-1}$), length of mother and finger rhizome (7.48 cm, 14.63 cm, respectively), girth of mother and finger rhizome (11.33 cm and 8.06 cm, respectively) was obtained from 100 % RDF applied through water soluble fertilizers (F_2), which is statistically none significantly with F_3 treatment (75 % RDF applied through WSF). However, minimum the number of mother rhizomes (2.47 $plant^{-1}$), number of fingers (10.03 $plant^{-1}$), length of mother and finger rhizome (6.34 cm and 11.40 cm, respectively), girth of mother and finger rhizome (9.57 cm and 6.86 cm, respectively) was registered with 100 % RDF applied through soil application (F_1).

Rhizome yield (t ha^{-1}) and economics of turmeric. The rhizome yield (t ha^{-1}) was significantly affected by different irrigation levels and nutrient management and showed in Table 3. Drip irrigation levels at 100 % PE (I_1) treatment recorded maximum rhizome yield (25.10 t ha^{-1}), gross return (Rs. 1255000 ha^{-1}) , net return (Rs. 1079480 ha^{-1}) and benefit cost ratio (6.15), which is statistically at par with treatment I_2 (80 % PE), Whereas, minimum average rhizome yields (20.96 t ha^{-1}), gross return (Rs. 1011500 ha^{-1}), net return (Rs 835980 ha^{-1}) and benefit cost ratio (5.15) were reported by I_3 (60 % PE) and also nearby same rhizome yield was observed in surface irrigation (I_4) 21.77 t ha^{-1}.

Among the nutrient management the maximum rhizome yield (25.88 t ha^{-1}) was recorded in F_2 (100 % RDF applied through WSF) and it was significantly superior over the other treatments. While lowest average rhizome yield of turmeric was recorded 20.96 t ha^{-1} in F_1 (100 % RDF through soil application).

Table 1: Growth parameter and Number of rhizome $plant^{-1}$ of turmeric as influenced by irrigation and nutrient management.

Treatments		Growth parameter			Number of rhizome $plant^{-1}$	
		Plant height (cm)	Number of leaves $plant^{-1}$	Dry matter production (g)	Mother rhizome	Finger rhizome
I_1	100 % PE	161.40	12.76	185.82	3.00	12.27
I_2	80 % PE	158.69	11.90	183.03	2.82	11.59
I_3	60 % PE	147.58	10.21	170.70	2.44	9.82
SEm (±)		**2.47**	**0.41**	**3.02**	**0.08**	**0.39**
CD (0.05)		**9.70**	**1.60**	**11.84**	**0.31**	**1.54**
F_1	100% RDF through soil application	150.87	10.89	174.45	2.47	10.03
F_2	100% RDF through WSF	164.11	12.63	188.16	3.12	12.81
F_3	75% RDF through WSF	152.69	11.35	176.93	2.68	10.84
SEm (±)		**3.58**	**0.43**	**3.58**	**0.13**	**0.49**
CD (0.05)		**9.95**	**1.20**	**9.94**	**0.37**	**1.36**
I_4	Surface irrigation	153.13	**11.05**	**353.73**	2.59	10.01

Table 2: Water expenses (mm) and Water expense efficiency (kg ha-mm^{-1}) of turmeric as influenced by irrigation and nutrient management.

Treatments		Number of irrigation	WE (mm)	WEE (Kg ha-mm^{-1})
Irrigation levels				
I_1	100 % PE	70	365.88	68.32
I_2	80 % PE	70	322.60	72.31
I_3	60 % PE	70	279.32	73.78
Nutrient management				
F_1	100% RDF through soil application	70	322.60	64.53
F_2	100% RDF through WSF	70	322.60	77.21
F_3	75% RDF through WSF	70	322.60	71.94
I_4	Surface irrigation (Control)	07	583.41	33.61

Table 3: Rhizome length and girth per plant of turmeric as influenced by irrigation and nutrient management.

Treatments		Rhizome length (cm)		Rhizome girth (cm)	
		Mother rhizome	Finger rhizome	Mother rhizome	Finger rhizome
I_1	100% PE	7.34	14.69	11.24	8.23
I_2	80% PE	6.76	13.02	10.09	7.26
I_3	60% PE	6.30	11.62	9.30	6.26
SEm (±)		**0.20**	**0.45**	**0.29**	**0.25**
C.D. (0.05)		**0.79**	**1.78**	**1.15**	**0.99**
F_1	100% RDF through soil application	6.34	11.40	9.57	6.86
F_2	100% RDF through WSF	7.48	14.63	11.33	8.06
F_3	75% RDF through WSF	6.57	13.30	9.68	6.98
SEm (±)		**0.29**	**0.68**	**0.52**	**0.35**
C.D. (0.05)		**0.79**	**1.89**	**1.46**	**0.97**
I_4	Surface irrigation	**6.52**	**12.32**	**9.69**	**6.76**

Table 4: Effect of irrigation levels and nutrient management on economics of turmeric.

Treatments	Total cost (Rs.ha^{-1})	Rhizome yield (t ha^{-1})	Gross return (Rs.ha^{-1})	Net return (Rs.ha^{-1})	B:C ratio
Irrigation levels					
I_1	175520	25.10	1255000	1079480	6.15
I_2	175520	23.22	1161000	985480	5.61
I_3	175520	20.23	1011500	835980	4.70
Nutrient management					
F_1	173362	20.96	1048000	874638	5.04
F_2	177926	25.88	1294000	1116074	6.27
F_3	175274	21.75	1087500	912226	5.20
I_4 (Control)	177142	21.77	1088500	911358	5.15

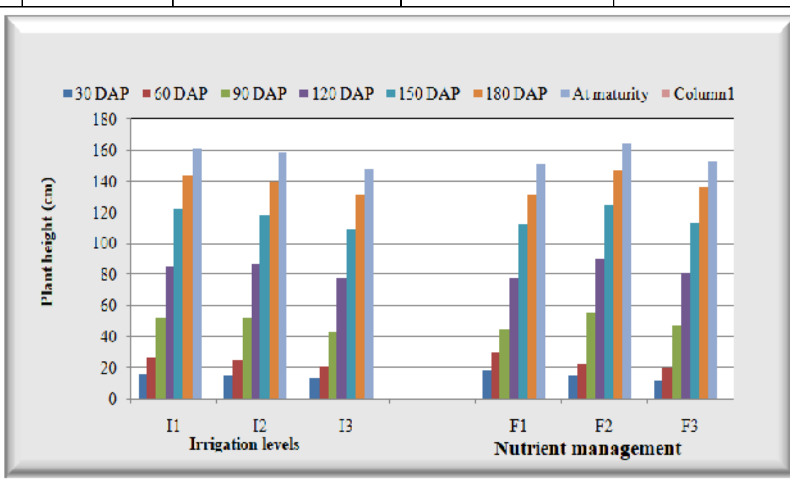

Fig. 1. Plant height.

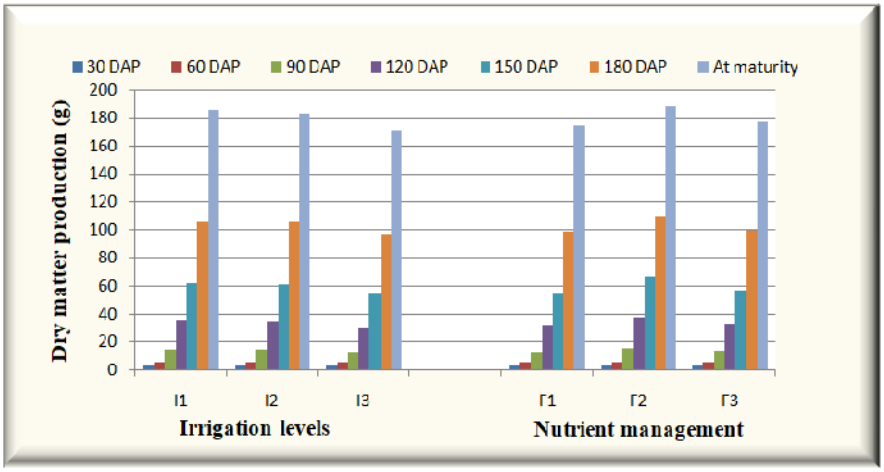

Fig. 2. Dry matter production.

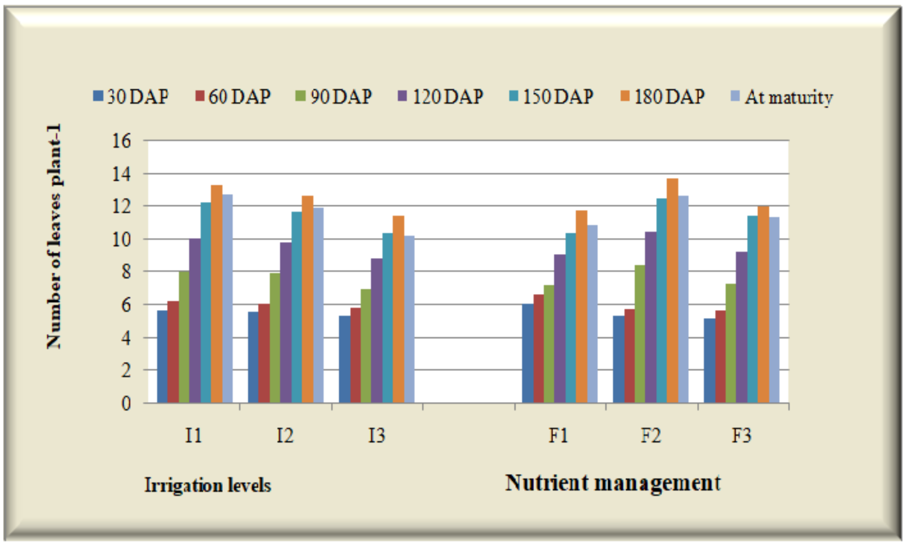

Fig. 3. Number of leaves.

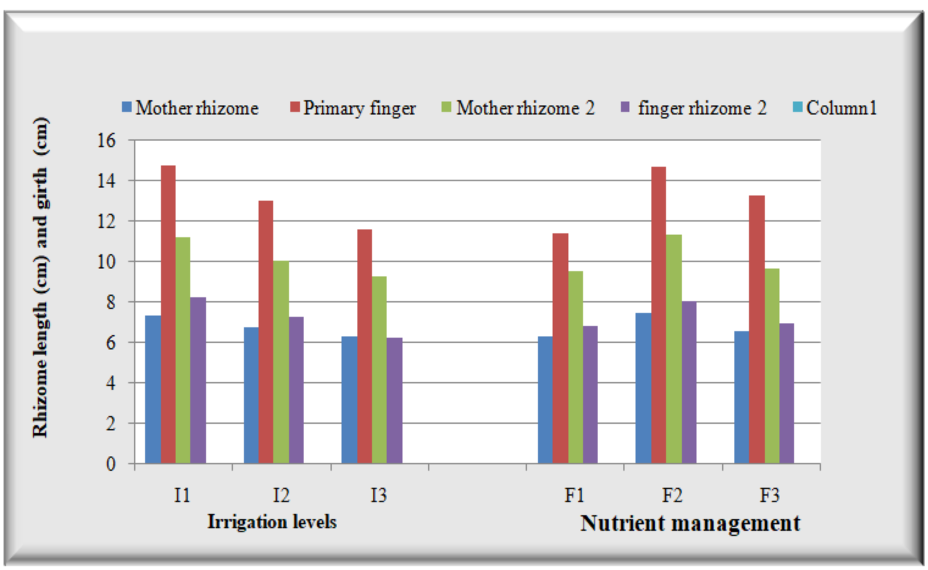

Fig. 4. Rhizome length and girth.

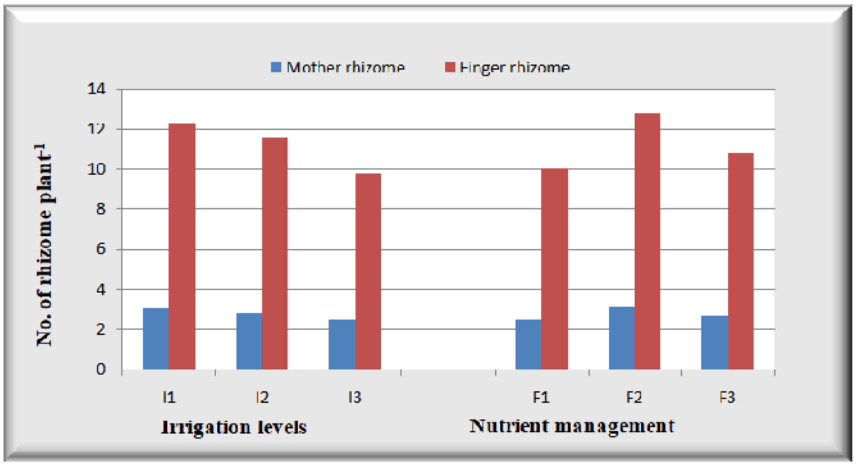

Fig. 5. Number of rhizome.

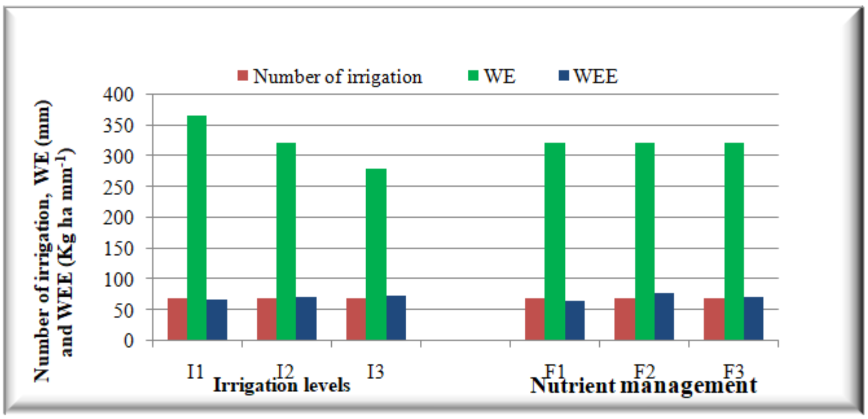

Fig. 6. Irrigation parameter.

CONCLUSION

In the drip irrigation levels it was concluded that 100 % PE (I_1) and 80 % PE (I_2) found equally effective in terms of growth characters **(**plant height, number of leaves, dry matter production, crop growth rate) and yield parameter (number of mother and finger rhizome, weight of mother and finger rhizomes plant^{-1}) and as compared to other drip irrigation and surface irrigation. In nutrient management, 100 % RDF through WSF was superior increase of growth characters (plant height, dry matter production, crop growth rate) and yield parameter (number of mother and finger rhizome, weight of mother and finger rhizomes plant^{-1}). Drip irrigation level at 80 % pan evaporation (at alternate days) and nutrient management at 75 % RDF applied through water soluble fertilizer is recommended to achieve maximum turmeric yield 25.49 t ha^{-1}, net return Rs 1097777 ha^{-1} and Benefit: cost ratio 5.67 and WEE 74.76 kg ha-mm^{-1}, under drip irrigation.

FUTURE SCOPE

Tuemeric required assured water supply almost throughout the year (8-9 months) on the other hand but irrigation with surface methods is high water demanding methods of irrigation and their water use efficiency is very low and high cost compare to other irrigation and when water is applied through this method not uniformly distributed in each side of the field so at the time of easily accessibility by drip irrigation, over irrigation and scare condition reduced the yield.

The emerging water scarcity in the present-day agriculture, demands the introduction of water saving methods to avoid reduction in turmeric area. Drip irrigation considered as one of the latest innovative methods of irrigation, which enables slow and precise application of water and nutrients to precise locations, avoiding soil erosion and wastage of water by deep percolation.

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