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Effect of drip fertigation on growth parameters of spring maize (*Zea mays* L.)

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Abstract
Maize (*Zea mays* L.) is the most versatile crop. It is an important cereal crop for food, feed and fodder. Worldwide, maize is cultivated on 177 million hectare area with total production of 967 million tonnes at a productivity of 5.46 t/ha (USDA, 2013-14). In India, maize is cultivated on 9.43 million hectare area, with production and productivity of 24.4 million tonnes and 2.58 t/ha, respectively (Yadav, 2015). Field experiment was conducted during spring (March-May) 2015 at G B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. It has been proved by studies that drip fertigation method helps to save water, improve WUE and significant effect on growth parameter of maize. At tasseling stage, 100% CPE irrigation regime produced significantly more number of leaves (13.0) than 60 and 80% CPE irrigation regimes.In drip fertigation, fertilizers applied in desired split dose throughout the growing period according to the crop requirement so that the losses were minimized and opportunity was provided to take more nutrients, which reflected on higher dry matter production in the present study. The dry weight density and volume density of roots increased as the irrigation depth was increased from 60% CPE level to 100% CPE level.

Keywords: *Zea mays* L, drip fertigation, growth parameters

1. Introduction
Maize (*Zea mays* L.) is the most versatile crop with wider adaptability in varied ecologies. It is an important cereal crop for food, feed and fodder. In terms of area, maize is the 3rd most important staple food crop in the world after wheat and rice, while for productivity it ranks first. Worldwide, maize is cultivated on 177 million hectare area with total production of 967 million tonnes at a productivity of 5.46 t/ha (USDA, 2013-14) [8, 10]. In India, maize is cultivated on 9.43 million hectare area, with production and productivity of 24.4 million tonnes and 2.58 t/ha, respectively (Yadav, 2015) [15]. Considering the limited potential of water resources and growing demand for water from different purposes, it has become essential to adopt water saving technologies so as to avoid the water stress in the future. It has been proved by studies that drip and sprinkler methods of irrigation helps to save water and improve water use efficiency (INCID, 1998) [5]. Drip system can control the rate of water application to achieve application efficiency as high as 92-95 per cent (Polak *et al*., 1997) [9].

2. Materials and Methods
A field experiment entitled “Effect of drip fertigation with mulching on growth parameters of spring maize (*Zea mays* L.)” was conducted during spring (March-May) 2015.

2.1 Experimental Site
The field experiment was conducted during the spring season, 2015 at G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand.

2.2 Climate of the Region
The climate of the region is broadly humid subtropical. The mean annual rainfall is about 1450 mm. Weather parameters prevailed during the crop season were obtained from the Meteorological Observatory located close to the experimental field at the N.E. Borlaug Crop Research Centre of the university.

2.3 Soil Characteristics
The soil of *Tarai* region (Mollisols) has developed from calcareous medium to moderately coarse textured.

Table 1: Physico- chemical characteristics of experimental soil

Sl. No.	Soil Properties	Value	Method used
1	Soil texture	Sandy loam	Hydrometer method (Deshpande *et al*., 1971) [2]
2	Bulk density (Mg/m^3)	1.46	Core method (Richards, 1954) [10]
3	Basic infiltration rate (cm/hr)	1.30	Double ring infiltrometer
4	pH (1:2.5 soil: water suspension)	6.97	Beckman Glass Electrode pH meter (Jackson, 1973) [7]
5	Organic Carbon (%)	1.02	Modified Walkley-Black method (Jackson, 1973) [7]
6	Available Nitrogen (kg/ha)	229.8	Alkaline $KMnO_4$ (Subbiah and Asija, 1956) [12]
7	Available Phosphorous (kg/ha)	26.1	Olsen's method (Olsen *et al*., 1954) [8]
8	Available Potassium (kg/ha)	282.5	Flame Photometric (Jackson, 1973) [7]

2.4 Experimental Details
The experiment was laid out in Split plot design with two control treatments having three replications. The treatments were consisted of three levels of drip irrigation scheduling based on CPE loss, two levels of fertilizer dose and two different P and K fertilizer application schedule. The control treatments were surface flood irrigation with and without mulch. The details of the treatments are as follows:

Table 2: Treatment combinations

Symbols	Treatments
T_1	60% CPE with 75% recommended fertilizer dose and PK in equal splits
T_2	60% CPE with 75% recommended fertilizer dose and PK in 70/30 splits
T_3	60% CPE with 100% recommended fertilizer dose and PK in equal splits
T_4	60% CPE with 100% recommended fertilizer dose and PK in 70/30 splits
T_5	80% CPE with 75% recommended fertilizer dose and PK in equal splits
T_6	80% CPE with 75% recommended fertilizer dose and PK in 70/30 splits
T_7	80% CPE with 100% recommended fertilizer dose and PK in equal splits
T_8	80% CPE with 100% recommended fertilizer dose and PK in 70/30 splits
T_9	100% CPE with 75% recommended fertilizer dose and PK in equal splits
T_{10}	100% CPE with 75% recommended fertilizer dose and PK in 70/30 splits
T_{11}	100% CPE with 100% recommended fertilizer dose and PK in equal splits
T_{12}	100% CPE with 100% recommended fertilizer dose and PK in 70/30 splits
T_{13}	Flood irrigation at IW:CPE ratio 1.0
T_{14}	Flood irrigation at IW:CPE ratio 0.80 with mulch

Table 3: Effect of drip irrigation levels and NPK dose on plant height, no. of leaves/plant, LAI, Dry matter accumulation, root dry weight density and root volume density

Treatment	Plant height (cm)		No. of leaves/plant		LAI		Dry matter acuumulation (t/ha)		Root dry weight density (mg/cc)	Root volume density (mm^3/cc)
Drip irrigation level	Knee high	Tasseling	Knee high	Tasseling	Knee high	Tasseling	Tasseling	Harvest		
60% CPE	97.9	144.7	4.7	11.2	1.90	3.18	5.94	16.06	2.5	34.9
80% CPE	98.1	147.2	5.2	12.1	1.95	3.44	6.51	16.62	3.2	38.6
100% CPE	98.7	149.7	5.5	13.0	2.04	3.49	6.66	17.76	3.9	42.0
SEm ±	1.5	1.4	0.3	0.3	0.05	0.07	0.11	0.27	0.2	1.2
CD at 5%	NS	NS	NS	0.8	NS	0.21	0.33	0.84	0.5	3.7
NPK Dose										
75% RDF	97.5	146.5	4.8	11.8	1.89	3.28	6.25	16.42	2.9	36.7
100% RDF	98.8	148.1	5.4	12.4	2.03	3.46	6.49	17.22	3.5	40.3
SEm ±	1.2	1.2	0.2	0.2	0.04	0.05	0.09	0.22	0.1	0.9
CD at 5%	NS	NS	NS	NS	0.13	0.17	NS	0.69	0.4	3.0

2.5 Observations and Sampling Procedure
2.5.1 Growth parameters
The observations on growth and development parameters such as plant height, leaf area, dry matter accumulation, etc. were recorded at knee high, tasseling and harvesting stages.

2.5.2 Plant height
Four plants were selected randomly and tagged in each net plot from 2nd and 4th row. The plant height of these plants was measured with the help of meter scale. The values were averaged and expressed in cm. The plant height before tasseling was measured from the ground surface to the tip of the newly emerged leaf, whereas after tasseling, it was recorded from ground surface to the ligule of the upper most fully opened leaf.

2.5.3 Number of green leaves/plant
The total number of fully expanded leaves was counted from the tagged plants marked for height observation. Average number of leaves/ plant was computed by dividing the total number of leaves by four.

2.5.4 Dry matter accumulation
Two plants from sampled row were selected and cut just above the ground level with the help of sickle. These cut plants were allowed to sundry for 48 hours. After sun drying, these plants were dried in the oven at 65 ±5 ^{0}C temperature for 48-72 hours or till the samples attained a constant weight and then dry matter yield was calculated and reported as t/ha.

2.5.5 Leaf area index (LAI)
All the leaves from the plants harvested for dry matter yield were removed. There length and width was measured with the help of scale. A correction factor with the help of graph paper was found out to convert leaf length and width to obtain area of leaf. It was multiplied by the number of leaves per plant to get leaf area per plant. LAI was calculated by dividing the leaf area per plant by the land area occupied by a plant.

2.5.6 Root dry weight and volume density
To get the root dry weight density, firstly dry weight of roots was taken of each treatment. After that, weight of the roots were divided by volume of the core and expressed in mg/cc. Root of maize plant was taken by each plot from sampled row with the help of core. Then these roots were thoroughly washed in running water to remove all the dust. After that volume of root from each treatment was taken by placing the root in 1 lit beaker filled with water. Replaced volume of water was reported as volume of the root. After that, to calculate the root volume density, root volume was divided by volume of the core and expressed in mm^3/cc.

3. Results and discussion
3.1 Plant height
The plant height of maize did not differ statistically by drip irrigation levels at any stage of crop growth except harvest. At this stage, the plant height was significantly higher at 100% CPE (157.0 cm) than 60 % CPE but remained at par with 80% CPE (153.7 cm). At all the stages of growth, the plant height increased with increase in depth of irrigation through drip, being the highest at 100% CPE level. The significant reduction in plant growth with decreased amount of irrigation seems to be the resultant of water stress. The results are in close accordance with the findings of Golparvar and Karimi (2011) [3] and Thorat *et al.* (2011) [13].

3.2 Number of leaves
Different drip irrigation regimes were failed to produce significant effect at knee high stage but were significant at tasseling stage for number of leaves per plant. At tasseling stage, 100% CPE irrigation regime produced significantly more number of leaves (13.0) than 60 and 80% CPE irrigation regimes. Flood irrigation IW:CPE 0.80 with mulch possessed more number of leaves than flood IW:CPE 1.0 at both the stages of crop growth. The higher number of green leaves in mulched plot was might be due to better moisture regime throughout the crop period which resulted in higher metabolic activities of plants. These results are in accordance with the findings of Bhatt *et al.* (2004) [1].

3.3 Dry matter accumulation
Variable drip irrigation levels caused significant effect on dry matter accumulation at knee high, tasseling and harvesting stages. At knee high stage, 100% CPE (1.65 t/ha) produced significantly higher dry matter than 60% CPE (1.54 t/ha) but it was at par with 80% CPE. At tasseling stage also, similar trend was noted to that of knee high stage. At harvesting stage, 100 % CPE was found significantly superior (17.76 t/ha) over both the moisture regimes *i.e.* 60 and 80% CPE. Where as in drip fertigation, fertilizers applied in desired split dose throughout the growing period according to the crop requirement so that the losses were minimized and opportunity was provided to take more nutrients, which reflected on higher dry matter production in the present study. The same result was reported by Vanitha (2008) [14].

3.4 Leaf Area Index
Drip irrigation levels did not affect the LAI of maize crop significantly at knee high stage but did affect at tasseling stage. At knee high stage, the LAI increased as the amount of water increased per irrigation being the highest at 100% CPE (2.04). Under control treatments, flood irrigation at IW: CPE 0.80 with much had more LAI than non-mulched one. The higher LAI value under higher moisture regimes was largely associated with the increased number of leaves and size. Sampath kumar *et al.* (2013) [13].

3.5 Root dry weight density and root volume density
The dry weight density and volume density of roots increased as the irrigation depth was increased from 60% CPE level to100% CPE level. The mean increase was more from 60% CPE to 80% CPE than 80% CPE to 100% CPE. Drip irrigation depth equal to 100% CPE brought significant increase in the root dry weight and volume density over 60% CPE, but remained at par with 80% CPE. Further 60% CPE did not differ significantly with 80% CPE for both the root growth parameters. Drip fertigation with water soluble fertilizer improve the root system by inducing new secondary roots which are succulent and actively involved in physiological responses.

4. Conclusion
From findings of present investigation based on cob weight without husk it can be inferred that spring maize in sandy loam soil should be irrigated at 80% CPE. It should be fertilized at 90:45:30 N, P_2O_5, K_2O kg/ha with PK application as 70% up to tasseling and 30% thereafter. In flood irrigation use of mulch is quite beneficial.

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