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Response of Drip Fertigation, Intra Row Seeding of Legume and Planting Geometry on Water Use and Yield of Summer Maize

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A B S T R A C T

Field experiment was conducted on Research farm, Indira Gandhi Krishi Vishvavidyalaya Raipur during summer 2016 to study the response of drip fertigation intra row seeding of legume and planting geometry on soil health productivity and net return of summer maize. The experiment was laid in strip plot design with six vertical drip fertigation and intra row cowpea and three horizontal planting geometry with eighteen treatments. Six fertigation and intra row cowpea treatments include (F1) Drip fertigation 100% RDF, (F2) Drip fertigation 125%RDF, (F3) Surface irrigation (furrow) 100%RDF, (F4) Drip fertigation 100 % RDF + intra row cowpea (F5) Drip fertigation 125% RDF + intra row cowpea (F6) Surface irrigation (furrow) 100%RDF + intra row cowpea and three horizontal treatments include (S1) 30 x 20 cm, (S2) 45 X 20 cm, (S3) 60 x 20 cm. Highest water use efficiency was found in drip fertigation 125 % RDF + intra row cowpea which was comparable with drip fertigation 100 % RDF + cowpea and drip fertigation 100% RDF.

Introduction

Water is the vital source for crop production and is the most limiting factor in Indian agricultural scenario. Though, India has the largest irrigation network, the irrigation efficiency has not been achieved more than 40 per cent. Due to water scarcity, the available water resources should be very effectively utilized through water saving irrigation technologies. As water is a vital natural resource available on the earth, it is in constant demand for domestic use, animal husbandry and agriculture as well as industrial consumption. A major quantity of water is utilized in agriculture sector, however utilizable water resources in India are not enough to irrigate the entire cultivable area. Losses of water and nutrient through leaching and surface runoff, water logging and salinity effect are the disadvantages associated with conventional irrigation methods. Hence, concerted efforts are needed to minimize the use of this precious water. Water scarcity is an increasingly important issue of the whole world. The world climate change impact leading to increasing temperature and decreasing rainfall will lead to water scarcity even more. The pressure for the most efficient use of water for agriculture is intensifying with the increased competition for water resources among various sectors with mushrooming population. In spite of having the largest irrigated area in the world, India too has started facing severe water scarcity in different regions. Drip irrigation allows precise timing and uniform distribution of fertilizer nutrients. Maize is one of the amenable crops for drip irrigation system, which is an efficient system of irrigation (Zhu *et al.,* 2007). By definition, fertigation is the precise application of water soluble fertilizer through sprinkler and drip irrigation. It is an efficient and agronomical sound method of providing soluble plant nutrients directly to the active plant root zone. Drip irrigation with fertigation offers a vast potential for optimum utilization of water and fertilizers (Raina *et al.,;* 1999). Research work on drip irrigation conducted so far in India and abroad proved that this method lead not only to appreciable saving of water, but also results in achieving higher crop yields as compare to surface irrigation method. Besides, this drip irrigation has quite a large number of beneficial aspects such as maximum production per unit of water, improvement on quality of produce, less evaporation losses, uniform water distribution, easy operation and suitable for all type of soils.

Materials and Methods

Field experiment was conducted on Research farm, Indira Gandhi Krishi Vishvavidyalaya Raipur during summer 2016 to study the response of drip fertigation intra row seeding of legume and planting geometry on soil health productivity and net return of summer maize. The experiment was laid in strip plot design with six vertical drip fertigation and intra row cowpea and three horizontal planting geometry. Raipur has a dry sub-humid to semi-dry climatic condition. The source of rainfall is south-western monsoon. It receives an average annual rainfall of 1400 mm The weekly maximum temperature raised up to 46°C during summer and minimum temperature reaches as low as to 6°C during winter season. Maize MM2562 hybrid was taken as test crop. The furrows were opened at 20 cm apart and 2 seeds per hill were dibbled in furrows to a depth of 4 cm. After establishment of crop at 10 days of emergence, thinning was done by leaving one seedling per spot to maintain required plant density as per treatment. The come up irrigation was given just after planting. Irrigation treatments were imposed from 10 days after planting (DAP). Irrigation was scheduled according to the treatment. Five plants were selected at random and tagged these plants were used to record the growth, yield attributes and yield. The data pertaining to the experiment were subjected to statistical analysis suggested by Gomez and Gomez (1984).

Results and Discussion

Irrigation water applied

Water was applied as per the predefined treatments. Value of irrigation water applied was significantly highest (1026 mm) in furrow irrigation with 100% RDF and cowpea over rest of the treatments but at par with furrow irrigation with 100 RDF (1010 mm). All the drip fertigation treatments were statistically similar.

These treatment utilized 644-675 mm irrigation water which was nearly half to that of traditional furrow/ flood irrigation. It indicates that maize area can be doubled adopting drip fertigation over furrow/ flood irrigation with same quantity of irrigation water and additive advantage of 134-140% higher grain yield. Reduction in water consumption due to drip method of irrigation over the surface method of irrigation varies from 30 to 70 percent and productivity gain in the range of 20 to 90 per cent for different crops (Anitta Fanish *et al.,* 2011). A properly designed drip fertigation system delivers water and nutrient at a rate, duration and frequency, so as to maximize crop water and nutrient uptake, while minimizing leaching of nutrients and chemicals from the root of agricultural field (Gardenas *et al.*, 2005) (Table 1).

Rainfall

During growing season of maize 45 mm rains were received. Irrigation water compensated with rainfall during rain events.

Total water use

Irrigation applied and rainfall received during crop growing season was taken in total water use. At harvest of rice and maize visual soil moisture status was nearly similar hence soil moisture contribution was not taken into account of water use. The furrow irrigation treatments used 1055-1071 mm water whereas this quantity in drip fertigation was 689-720 mm. No remarkable difference in total water use was found in different planting densities.

Water use efficiency

Significantly higher water use efficiency (WUE) was obtained in drip fertigation with 125% RDF and cowpea and closely followed by all drip fertigation treatments. Significantly lower values of WUE recorded in furrow irrigation over drip fertigation. The maximum WUE was 9.0 kg ha^{-1}-mm in drip fertigation with 125% RDF and cowpea. Amongst crop geometry, remarkably highest WUE (7.96 kg ha^{-1}-mm) was recorded in 60 x 20 cm spacing.

For production of one kg grain 1137-1207 litres water required in drip fertigation whereas these value for furrow irrigation were 2328-2463 litres. In narrow spacing significantly more water required for production of one kg grain of maize compare to wider spacing.

Table.1 Influenced by fertigation and intra row legume and crop geometry on water use and water use efficiency of summer maize

Treatments	Irrigation applied (mm)	Rainfall (mm)	Total water use (mm)	Water use efficiency (kg ha^{-1}-mm)	Water use for production of maize (litres kg^{-1})
Fertigation and intra row seeding					
F1: Drip Ferti.100% RDF	644	45	689	8.57	1180
F2: Drip Ferti.125% RDF	675	45	720	8.50	1207
F3: Furrow irri.100% RDF	1010	45	1055	4.24	2463
F4: Drip Ferti. 100% RDF + cowpea	659	45	704	8.74	1151
F5: Drip Ferti.125% RDF + cowpea	664	45	709	9.00	1137
F6: Furrow irri. 100% RDF + cowpea	1026	45	1071	4.35	2328
SEm ±	11		11	0.14	36
CD(P=0.05)	35		35	0.43	115
Crop geometry					
S30: 30 cm x 20 cm	785	45	830	6.45	1757
S45: 45 cm x 20 cm	779	45	824	7.30	1442
S60: 60 cm x 20 cm	776	45	821	7.96	1534
SEm±	6		6	0.10	29
CD(P=0.05)	NS		NS	0.38	114
Interaction (FxS)	NS		NS	NS	NS

Table.2 Influenced by drip fertigation and intra row legume and crop geometry on cob length cob diameter and no of grains cob^{-1}

Treatments	Cob length (cm)	Cob daimeter (cm)	No of grains cob^{-1}	100 grain weight (g)
Fertigation and intra row seeding				
F1: Drip Ferti.100% RDF	14.53	13.96	429.13	25.79
F2: Drip Ferti.125% RDF	14.76	14.56	450.36	26.40
F3: Furrow irri.100% RDF	14.00	12.92	387.66	24.04
F4: Drip Ferti. 100% RDF + cowpea	14.85	14.13	465.03	26.42
F5: Drip Ferti.125% RDF + cowpea	15.25	14.49	473.29	26.36
F6: Furrow irri. 100% RDF + cowpea	13.91	13.30	420.66	24.31
SEm ±	0.25	0.17	14.65	0.65
CD(P=0.05)	0.78	0.55	46.15	NS
Crop geometry				
S30: 30 cm x 20 cm	13.34	12.96	364.62	24.56
S45: 45 cm x 20 cm	14.86	14.32	467.86	25.93
S60: 60 cm x 20 cm	15.44	14.40	480.52	26.18
SEm±	0.34	0.29	18.42	0.55
CD(P=0.05)	1.35	1.14	72.33	NS
Interaction (FxS)	NS	NS	NS	NS

Table.3 Influenced by fertigation and intra row legume and crop geometry on grain yield, stover yield and harvest index of summer maize

Treatments	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest Index (%)
Fertigation and intra row seeding			
F1: Drip Ferti.100% RDF	54.76	115.06	32.22
F2: Drip Ferti.125% RDF	56.92	124.24	31.26
F3: Furrow irri.100% RDF	42.28	92.41	31.43
F4: Drip Ferti. 100% RDF + cowpea	57.21	128.72	30.89
F5: Drip Ferti.125% RDF + cowpea	59.12	136.62	30.20
F6: Furrow irri. 100% RDF + cowpea	44.11	96.24	31.61
SEm ±	0.71	2.54	0.41
CD(P=0.05)	2.23	8.00	NS
Crop geometry			
S30: 30 cm x 20 cm	46.69	107.64	30.65
S45: 45 cm x 20 cm	54.19	116.66	32.02
S60: 60 cm x 20 cm	56.33	122.35	31.14
SEm±	0.58	4.27	1.06
CD(P=0.05)	2.30	NS	NS
Interaction (FxS)	S	NS	NS

Table.4 Interaction between fertigation & intra row seeding and crop geometry on yield (q ha^{-1}) of summer maize

Fertigation and intra row seeding	Crop geometry			
	S30	S45	S60	Mean
F1: Drip Ferti.100% RDF	49.98	51.28	63.01	54.76
F2: Drip Ferti.125% RDF	44.88	61.43	64.46	56.92
F3: Furrow irri.100% RDF	34.91	54.31	37.63	42.28
F4: Drip Ferti. 100% RDF + cowpea	52.65	55.94	63.04	57.21
F5: Drip Ferti.125% RDF + cowpea	54.93	52.97	69.44	59.12
F6: Furrow irri. 100% RDF + cowpea	42.77	49.19	40.38	44.11
Mean	46.69	54.19	56.33	
			SEm±	CD (P=0.05)
Two horizontal strip means at the same level of vertical strip			1.57	4.84
Two vertical strip means at the some lever of horizontal strip			0.49	1.48

Grain yield and yield parameters

Significantly higher grain yield (59.12q ha^{-1}) was recorded in F5 which was at per with F4 (57.21 q ha^{-1}) and F2 (56.92q ha^{-1}) while superior over rest of the treatments. Drip fertigation certainly improved availability of nutrients in root zone for plant uptake leading to better development of plants and dry matter production. The improved dry matter production enhanced grain yield in drip fertigation treatments (Table 3 and 4).

Cowpea further improved nutrient availability by fixing atmospheric nitrogen in soil thereby crop biomass and yield of crop. Hence better availability of nutrients in F5 lead to more uptake and better growth and development of plants resulted in remarkably higher yield of summer maize. Growth and yield attributes followed the pattern of grain yield. Stover yield was significantly higher in F5 than other treatments but at par with F4. Harvest index computed from grain and stover yield didn't differ significantly.

Cob length cob diameter and no of grains cob^{-1} was recorded highest in drip fertigation 125% RDF and cowpea which was at par with drip fertigation 100% RDF and cowpea, drip fertigation 125% RDF and drip fertigation 100% RDF Little variation in number of grains per cob was recorded indicating genetic characteristics of variety under test. Similar results were reported by Maske *et al.*, (2015) and Sampathkumar *et al.*, (2010) (Table 2).

Better availability of nutrients in drip fertigation treatments may be reasons for longer cob over flood irrigation and split application of fertilizers.

Drip fertigation 100% RDF and cowpea recorded highest no of rows cob^{-1} which was found similar to all othe treatments except drip fertigation 100% RDF and furrow irrigation 100 % RDF and cowpea. 100 grain weight was found to be non-significantly influenced by fertigation.

Planting geometry 60 x 20 cm recorded the highest no of cobs plant^{-1} cob length and cob diameter which was found similar with 45 x 20 cm and the lowest was observed in 30 x 20 cm. Similar results were reported by Thavaprakash *et al.*, (2009) no of grins per cob also recorded the same pattern as cob length and cob diameter and the findings were supported by Mahapatra (2008), Oktem and Oktem (2005).

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