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Response of drip fertigation, intra row seeding of legume and planting geometry on growth, yield attributes and yield of summer maize

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Abstract
Field experiment was conducted on Research farm, Indira Gandhi Krishi Vishwavidyalay, Raipur during summer 2016 to study the response of drip fertigation intra row seeding of legume on growth, yield attributes and yield of summer maize. Experiment was laid in strip plot design with six vertical drip fertigation and intra row cowpea and three horizontal planting geometry with eighteen treatments. Drip fertigation 125% RDF + intra row cowpea with 60 x 20 cm planting geometry was found to be highest yielding among all treatments. growth characters like plant height, stem girth no of leaves plant^{-1}, LAI, leaf area CGR, RGR was found to be highest in drip fertigation 125%RDF and cowpea. Similarly planting geometry 60 x 20 cm was found to be the best in all these characteristics except LAI and light intensity in which 30 x 20 cm was found to be the best. All yield attributes like no of cob length, cob diameter, no of grains per cob,100 grain weight were found to be highest in drip fertigation 125%RDF and cowpea and among planting geometry 60 x 20 cm was found the best.

Keywords: drip fertigation, planting geometry, grain yield, growth characters, yield attributes

Introduction
Maize (*Zea mays* L.) is one of the most important crops of global economy. It has great importance to both as food for man and feed for animal. It occupies third position after wheat and rice. In India, maize is grown over an area of 8.67 million ha with an annual production of about 21.60 million tonnes and an average productivity of about 2492 kg ha^{-1} (Anonymous, 2012) [2]. In Chhattisgarh, maize occupies an area of 102.70 thousand ha with an annual production of about 185.8.0 thousand tonnes and an average productivity of 1809 kg ha^{-1} (Anonymous, 2010) [1]. Water is the vital source for crop production and is the most limiting factor in production system. Irrigation efficiency is not more than 40% in India.
Drip fertigation 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) [12]. Plant distribution in the field, as affected by plant density or row spacing has been one area that has received a great deal of attention over the last several decades. As plant densities continue to increase, an obvious course of action would be to narrow row spacing, distribute plants more equi-distantly across the field and reduce interplant competition. Plant populations affect most growth parameters of maize even under optimal growth conditions and therefore it is considered a major factor determining the degree of competition between plants (Sangakkara *et al*., 2004) [8]. The grain yield per plant is decreased in response to decreasing light and other environmental resources available to each plant (Luque *et al*., 2006) [4]. Optimum corn population is essential for maximum economic gain, as well better utilization of fertility, soil, water and climatic effects (Larson and Hansway, 1977). It is said that nutrient supplying capacity of soil declines steadily under continuous and intensive cropping. Thus, to make farming sustainable, intercropping is a very fruitful idea. Short duration vegetables grown in between the agricultural crops are the recent advancement to fulfil the requirement of vegetables without any reduction of agricultural area. Intercropping of legumes with corn is well compatible and profitable cropping system (Shivay and Singh, 2000) [9].

Material and Methods
Field experiment was conducted on Research farm, Indira Gandhi Krishi Vishwavidyalaya,

Raipur during summer 2016 to study the response of drip fertigation intra row seeding of legume and planting geometry on growth, yield attributes and yield 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. Six fertigation and intra row cowpea treatments include (F_1) Drip fertigation 100% RDF,(F_2) Drip fertigation 125%RDF, (F_3) Surface irrigation (furrow) 100%RDF, (F_4) Drip fertigation 100 % RDF + intra row cowpea (F_5) Drip fertigation 125% RDF + intra row cowpea (F_6) Surface irrigation (furrow) 100%RDF + intra row cowpea and three horizontal treatments planting geometry include (S_1) 30 x 20 cm, (S_2) 45 X 20 cm, (S_3) 60 x 20 cm. The RDF taken was 120: 60: 40 N: P_2O_5: K_20 kg ha^{-1}. The climate of Raipur is dry sub-humid to semi-dry with maximum temperature of 46 °C during summer and minimum temperature of 6 °C during winter season. The soil of the experimental site was sandy loam. 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.

Result and Discussion

Growth parameters

The results revealed that plant population was not significantly influenced by fertigation and planting geometry at 20 DAS but planting geometry significantly influenced plant population at harvest and maximum was found in planting geometry 30 x 20 cm. In general, plant height and stem girth increased with an advancement of crop age with remarkable increase up to 75 DAS and the after slow increase was recorded. Significantly higher plant height and stem girth was recorded in drip fertigation 125% RDF and cowpea which was statistically at par with drip fertigation 100% RDF and cowpea and drip fertigation 125% RDF. Similar results was also reported by Hassan *et al* (2010). Amongst crop geometry significantly higher plant height and stem girth was reported in wider spacing of 60 x 20 cm whereas significantly lowest girth was recorded in narrow geometry of 30 x 20 cm. Better nutrition and solar radiation availability in wider spacing might be the reasons for better plant in wider row spacing. Significantly higher light interception was recorded in furrow irrigation 100% RDF and found statistically similar to furrow irrigation 100% RDF and cowpea, Crop growth and yield in maize depends on incident radiation intercepted by the canopy (Pommel *et al*., 2001). Interception of light by a crop canopy is strongly related to total canopy leaf area. Among geometry higher inception value was recorded in 30 x 20 cm whereas highest values were recorded in 60 x 20 cm spacing.

Number of leaves $plant^{-1}$ and leaf area $plant^{-1}$ was found significantly higher in drip fertigation 125% RDF and cowpea which was found at par with drip fertigation 100% RDF and cowpea and drip fertigation 125% RDF whereas lowest was observed in furrow irrigation 100%RDF. Similar trend was observed in LAI. With better availability of nutrients for uptake in drip fertigation treatments enhance growth and development of plants including leaf area thereby leaf area index. Planting geometry 60 x 20 cm recorded the highest no of leaves $plant^{-1}$ and leaf area $plant^{-1}$ which was similar with 45 x 20 cm and lowest was recorded in 30 x 20 cm. Crop geometry of 30 cm x 20 cm showed remarkably the maximum leaf area index which was significantly superior to crop geometry of 45 cm x 20 cm and 60 x 20 cm spacing at all the observational stages. The higher population lead to more leaf area and thereby more leaf area index. Canopy functions (e.g. photosynthesis) improve as leaf area index (LAI) increases until LAI reaches approximately 5 for many maize hybrids, but decrease with further LAI increase (Tokatlidis and Koutroubas, 2010) [11].

Drip fertigation 125% RDF and cowpea recorded highest dry weight CGR and RGR which was found at par with drip fertigation 100% RDF and cowpea and drip fertigation 125% RDF whereas lowest was observed in furrow irrigation 100%RDF. 60 x 20 cm planting geometry recorded highest dry weight CGR and RGR. Significantly higher dry matter production with increased fertilizer dose and split application was also repeated by Reddy *et al.* (2017) [7] in Maize. Significantly higher plant dry weight was recorded in plant spacing of 60 x 20 c.m. plant spacing. Better availability of nutrients for plant uptake, solar radiation, and wider leaves are the factor that responsible for more dry matter accumulation is wider spaced crop. Similar trend in CGR was repeated by Krishnasamy *et al.* (2010) [3].

Yield parameters and yield

Drip fertigation 125% RDF recorded the maximum no of cobs $plant^{-1}$, followed by all other treatment. Similar results were reported by Krishnasammy *et al* (2012). 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) [5] and Sampathkumar *et al.* (2010) [7]. 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 other 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) [10] no of grins per cob also recorded the same pattern as cob length and cob diameter.

Grain yield

Significantly higher grain yield (59.12q ha^{-1}) was recorded in drip fertigation 125% RDF and cowpea which was at per with drip fertigation 100% RDF and cowpea (57.21 q ha^{-1}) and F2 drip fertigation 125% RDF (56.92q ha^{-1}) while superior over rest of the treatments. Similar trend was observed in Stover yield but it was at par with drip fertigation 100% RDF and cowpea. Drip fertigation certainly improved availability of nutrients in root zone for plant uptake leading to better development of plants and dry matter production and thus enhanced grain yield in drip fertigation treatments. Cowpea further improved nutrient availability by fixing atmospheric nitrogen in soil thereby crop biomass and yield of crop.

Planting geometry 60 x 20 cm was found to be highest grain yielding which was found similar to planting geometry 45 x 20 cm. Better spacing led to better growth characteristics of plant and thus better grain yield. Interaction of drip fertigation 125% RDF and 60 x 20 cm planting geometry was found to be the highest yielder. Harvest index computed from grain and stover yield didn't differ significantly.

Table 1: Plant height, Plant height, stem girth and light intensity as influenced by drip fertigaton and intra row cowpea and plant geometry

Treatments	Plant Population (000^{-1} ha)		Plant height (cm)				Stem girth (cm)			Light Interception (%)		
	20 DAS	At harvest	25 DAS	50 DAS	75 DAS	At harvest	50 DAS	75 DAS	At Harvest	25 DAS	50 DAS	75 DAS
Fertigation and intra row seeding												
F1: Drip Ferti.100% RDF	118.66	111.97	12.66	119.93	170.88	188.71	6.93	7.19	7.49	45.73	39.92	35.85
F2: Drip Ferti.125% RDF	118.67	112.00	12.82	123.26	173.95	191.82	7.29	7.60	7.70	44.21	42.81	38.44
F3: Furrow irri.100% RDF	118.71	112.01	11.87	115.47	167.64	184.60	6.71	6.70	7.08	51.06	46.37	41.64
F4: Drip Ferti. 100% RDF + cowpea	118.71	112.02	12.12	124.45	176.34	191.93	7.20	7.38	7.59	46.71	37.25	33.45
F5: Drip Ferti.125% RDF + cowpea	118.47	111.80	13.49	128.15	178.18	196.27	7.34	7.86	8.06	45.92	38.48	34.55
F6: Furrow irri. 100% RDF + cowpea	118.66	110.48	11.87	116.12	170.22	184.85	6.75	6.73	7.33	49.93	45.03	40.44
SEm ±	0.08	2.31	0.44	1.95	1.50	1.74	0.12	0.12	0.09	2.65	2.07	1.86
CD(P=0.05)	NS	NS	NS	6.14	4.74	5.50	0.38	0.38	0.27	NS	6.52	5.85
Crop geometry												
S30: 30 cm x 20 cm	164.40	153.54	12.94	123.18	174.04	192.17	6.35	6.38	7.00	53.19	45.31	40.69
S45: 45 cm x 20 cm	109.46	103.51	12.14	121.76	173.57	189.11	7.26	7.32	7.57	46.14	41.76	37.50
S60: 60 cm x 20 cm	82.08	78.08	12.33	118.76	171.87	187.81	7.50	8.03	8.05	42.45	37.86	34.00
SEm±	0.21	1.87	0.50	1.55	1.29	2.13	0.12	0.06	0.03	1.69	1.05	0.94
CD(P=0.05)	0.84	7.34	NS	NS	NS	NS	0.48	0.23	0.11	6.64	4.10	3.68

Table 2: number of leaf plant^{-1}, leaf area plant^{-1} and LAI as influenced by drip fertigaton and intra row cowpea and plant geometry

Treatments	Number of Leaves Plant^{-1}				Leaf area (cm^2) plant^{-1}				Leaf area index		
	25 DAS	50 DAS	75 DAS	At Harvest	25DAS	50DAS	75 DAS	At Harvest	25 DAS	50 DAS	75 DAS
Fertigation and intra row seeding											
F1: Drip Ferti.100% RDF	4.76	9.69	13.15	10.90	61.54	462.73	488.95	439.60	1.43	4.93	5.25
F2: Drip Ferti.125% RDF	5.07	10.14	13.23	10.36	66.31	496.58	525.57	480.29	1.45	5.26	5.49
F3: Furrow irri.100% RDF	4.72	9.30	12.76	10.39	53.16	455.60	402.27	434.11	1.27	4.86	4.19
F4: Drip Ferti. 100% RDF + cowpea	4.99	10.07	13.21	10.74	62.73	472.98	498.26	468.92	1.49	4.91	4.85
F5: Drip Ferti.125% RDF + cowpea	5.27	10.43	13.95	10.40	67.48	501.03	536.85	484.67	1.63	5.27	5.96
F6: Furrow irri. 100% RDF + cowpea	4.74	9.41	12.83	10.62	55.36	467.88	424.60	441.65	1.05	4.82	4.23
SEm ±	0.18	0.15	0.14	0.27	2.52	11.37	8.00	1.77	0.09	0.12	0.19
CD(P=0.05)	NS	0.49	0.44	NS	7.94	35.83	25.20	5.59	0.27	0.37	0.61
Crop geometry											
S30: 30 cm x 20 cm	4.91	9.69	12.75	10.23	58.73	448.92	462.35	430.17	1.84	6.33	6.38
S45: 45 cm x 20 cm	4.86	9.65	13.38	10.69	59.61	482.00	478.57	469.31	1.26	4.76	4.65
S60: 60 cm x 20 cm	5.01	10.18	13.44	10.79	64.95	497.48	497.32	475.13	1.05	3.9	3.96
SEm±	0.11	0.11	0.09	0.15	2.75	6.32	4.85	2.33	0.07	0.11	0.09
CD(P=0.05)	NS	0.42	0.33	NS	NS	24.81	19.03	9.14	0.28	0.42	0.37

Table 3: Crop dry weight, Crop growth rate and Relative growth rate as influenced by drip fertigaton and intra row cowpea and plant geometry

Treatments	Dry weight (g plant^{-1})				Crop growth rate(g plant^{-1}day^{-1})				Relative growth rate (g g^{-1} plant^{-1}day^{-1})			
	25 DAS	50 DAS	75 DAS	At Harvest	0-25 DAS	25-50 DAS	50-75 DAS	75DAS to Harvest	0-25 DAS	25-50 DAS	50-75 DAS	75DAS to Harvest
Fertigation and intra row seeding												
F1: Drip Ferti.100% RDF	5.77	54.04	147.23	168.22	0.23	1.93	3.73	1.10	0.030	1.699	2.085	2.121
F2: Drip Ferti.125% RDF	6.07	61.11	154.32	190.73	0.24	2.15	3.78	1.37	0.031	1.751	2.118	2.175
F3: Furrow irri.100% RDF	4.92	48.14	139.42	154.31	0.20	1.92	3.46	0.60	0.027	1.645	2.077	2.083
F4: Drip Ferti. 100% RDF + cowpea	5.89	57.94	148.10	188.29	0.24	1.94	3.75	1.43	0.031	1.730	2.111	2.170
F5: Drip Ferti.125% RDF + cowpea	6.17	63.39	157.68	201.48	0.25	2.29	3.77	1.75	0.031	1.769	2.126	2.195
F6: Furrow irri. 100% RDF + cowpea	4.97	51.93	142.51	162.82	0.20	1.88	3.62	0.81	0.028	1.685	2.085	2.107
SEm ±	0.29	2.22	1.31	2.45	0.01	0.10	0.11	0.08	0.001	0.019	0.005	0.006
CD(P=0.05)	0.90	6.98	4.13	7.73	0.04	0.31	NS	0.24	0.003	0.059	0.015	0.019
Crop geometry												
S30: 30 cm x 20 cm	5.22	50.20	141.25	161.20	0.21	1.80	3.64	0.80	0.028	1.666	2.081	2.104
S45: 45 cm x 20 cm	5.58	56.49	150.62	177.39	0.22	2.04	3.77	1.07	0.030	1.716	2.108	2.141
S60: 60 cm x 20 cm	6.09	61.58	152.76	194.33	0.24	2.22	3.65	1.66	0.031	1.757	2.112	2.181
SEm±	0.26	1.19	1.22	2.34	0.01	0.05	0.06	0.08	0.001	0.010	0.004	0.006
CD(P=0.05)	NS	4.67	4.79	9.20	NS	0.19	NS	0.32	0.004	0.039	0.014	0.024

Table 4: No of cobs per plant, cob length, cob diameter, no of rows per cob, no of grins per cob, test weight, grain yield, Stover yield and harvest index of maize as influenced by drip fertigaton and intra row cowpea and plant geometry

Treatments	No. of cobs plant^{-1}	Cob length (cm)	Cob diameter (cm)	No. of rows cob^{-1}	No of grains cob^{-1}	100 grain weight (g)	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest Index (%)
Fertigation and intra row seeding									
F1: Drip Ferti.100% RDF	1.49	14.53	13.96	14.73	429.13	25.79	54.76	115.06	32.22
F2: Drip Ferti.125% RDF	1.50	14.76	14.56	15.12	450.36	26.40	56.92	124.24	31.26
F3: Furrow irri.100% RDF	1.46	14.00	12.92	15.37	387.66	24.04	42.28	92.41	31.43
F4: Drip Ferti. 100% RDF + cowpea	1.47	14.85	14.13	15.86	465.03	26.42	57.21	128.72	30.89
F5: Drip Ferti.125% RDF + cowpea	1.49	15.25	14.49	15.58	473.29	26.36	59.12	136.62	30.20
F6: Furrow irri. 100% RDF + cowpea	1.47	13.91	13.30	14.84	420.66	24.31	44.11	96.24	31.61
SEm ±	0.01	0.25	0.17	0.22	14.65	0.65	0.71	2.54	0.41
CD(P=0.05)	0.03	0.78	0.55	0.70	46.15	NS	2.23	8.00	NS
Crop geometry									
S30: 30 cm x 20 cm	1.43	13.34	12.96	14.43	364.62	24.56	46.69	107.64	30.65
S45: 45 cm x 20 cm	1.50	14.86	14.32	15.54	467.86	25.93	54.19	116.66	32.02
S60: 60 cm x 20 cm	1.51	15.44	14.40	15.78	480.52	26.18	56.33	122.35	31.14
SEm±	0.01	0.34	0.29	0.15	18.42	0.55	0.58	4.27	1.06
CD(P=0.05)	0.05	1.35	1.14	0.60	72.33	NS	2.30	NS	NS
Interaction (F X S)	NS	NS	NS	NS	NS	NS	S	NS	NS

Table 5: 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

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