International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(2): 1895-1898

Received: 17-01-2019
Accepted: 19-02-2019

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Performance of *Kharif* maize under different lateral arrangement and nutrient management practices using drip irrigation system

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Abstract
Field experiment was conducted at Indira Gandhi Krishi Vishwavidyalaya, Raipur during *kharif*, 2017 to study the performance of maize under different lateral arrangement and nutrient management practices using drip irrigation system. The lateral arrangement and conventional practice and four nutrient management (50, 100, 150% RDF and STCR- based fertilizer recommendation) were included as treatments in this study. Crop imposed with lateral at 45 cm (W_1) recorded maximum grain yield, yield attributing characters and water use efficiency than rest of the treatments. In respect to nutrient management STCR- based fertilizer recommendation (N_4) recorded maximum grain yield and yield attributing characters and it was found statistically at par with 150% RDF (N_3). Gross return and net return were higher under lateral arrangement at 45 cm (W_1), whereas B:C ratio was higher under conventional practice (W_3). In respect to nutrient management the gross return net return and B:C ratio were higher under STCR- based fertilizer recommendation (N_4). Maize crop responded well to higher dose of fertilizer and STCR- based fertilizer recommendation is more quantitative, precise and meaningful because maize as a plant having higher nutritive demand. The results of this study revealed that, lateral arrangement at 45 cm (W_1) with STCR- based fertilizer recommendation (N_4) could be the optimal management practice for getting higher yield and economical returns of maize.

Keywords: Maize, lateral arrangement, nutrient management, grain yield, STCR

1. Introduction

Maize is one of the most important cereal crops in the world after wheat and rice, and has great importance in the world agricultural economy. It has many possible uses such as food, feed, fodder for livestock and raw material for industry. Corn oil is becoming popular due to its non-cholesterol character. In addition, its products like corn starch, corn flakes, gluten germ cake, lactic-acid, alcohol, and acetone are either directly consumed as food or used by various industries like paper, textile, foundry and fermentation (Nazir *et al*., 1994) [9]. Drip irrigation allows precise timing and uniform distribution of fertilizer nutrients. Maize is one of the amenable crops for a drip irrigation system, which is an efficient system of irrigation (Zhu *et al*., 2007) [18]. In Indian agriculture, water is becoming a scarce natural resource particularly due to changing the climate. Agriculture is the largest freshwater user, consuming about 83 percent of the total available water (Lawgali, 2008) [6]. Increased demand for fresh water in industrial and domestic sectors will result in a reduction of water diversions to agriculture (Seckler *et al*., 1998) [14]. Owing to various reasons, the demand for water for different purposes has been continuously increasing in India, but the potential water available for future use has been decreasing at a faster rate (Saleth, 2000) [11]. This indicates us day after day population will be increased and available water for agriculture will be decreased. There is a need to increase the food production by efficient use of agricultural inputs especially water and fertilizer. Considering the low potential of water resource and growing of water demand for other than agricultural purpose, it is necessary to adopt water-saving technologies like micro-irrigation to avoid water stress for future generation. It has been proved by studies that drip and sprinkler methods of irrigation help to save water and improve water use efficiency (INCID, 1998). By introducing drip with fertigation, it is possible to increase the yield of crops by 3 times from the same quantity of water. There was an increase in the use efficiency of nitrogen, phosphorus and potassium to 95, 45 and 80 per cent, respectively (Satisha, 1997) [13]. When fertilizer is applied through the drip, it is observed that besides the yield increase of about 30 per cent of the fertilizer could be saved (Sivanappan and Ranghaswami, 2005) [16].

Drip fertigation improves crop productivity by 60-100 percent (Sritharan, 2010) [17]. However study has been carried out for judicious use of important resources like water and fertilizer in precision agriculture.

2. Materials and Methods

A field experiment was conducted at Indira Gandhi Krishi Vishwavidyalaya, Raipur during *kharif* (July -October) season of 2017. Experimental soil was clay with 1.40 g cc $^{-1}$, 31.24 and 16.34 per cent bulk density, field capacity and permanent wilting point, respectively. Soil fertility was low (225.24 kg ha^{-1}), medium (14.26 kg ha^{-1}) and high (343.73 kg ha^{-1}) for available nitrogen, phosphorus and potassium. The experiment comprised 3 lateral arrangements in horizontal strips *viz* W_1- laterals at 45 cm (1LPH/0.3 meter spacing),W_2- laterals at 90 cm (2LPH/0.3 meter spacing) and W_3- conventional practice and 4 nutrient management practices in vertical strips *viz* N_1- 50% RDF, N_2- 100% RDF (120:60:40 kg ha^{-1} NPK) N_3- 150% RDF, N_4- STCR- based fertilizer recommendation (188:64:50). The experiment was laid out in strip plot design with three replications. Maize hybrid NMH 731was sown with a spacing of 45cm X 20 cm. Maize was sown at the rate of 25 kg ha^{-1}. Seeds were hand dibbled at the rate of two seeds per hole after emergence thinning was done. Drip irrigation plots were irrigated through drip irrigation system as per treatments (Open pan evaporation). It was calculated for every day with the help of meteorological data recorded by meteorological observatory of Indira Gandhi Krishi Vishwavidyalaya, Raipur. Water requirement of crop was calculated with help of following formula:

$$WR = (Ep \times Kc \times Kp) - eR$$

Where, WR = water requirement, Ep = Pan evaporation (mm day^{-1}), Kc = The crop factor, Kp= The pan factor (0.75) and eR = effective rainfall

Table 1: Kc value for different period

Days	Stage	Kc value
1-19	Initial stage	0.40
20-49	Development stage	0.80
50-89	Mid-stage	1.15
90-94	Late stage	0.70

(Brouwer and Heibloem, 1986)

Fertilizer in the conventional plot was applied as basal dose in the form of single super phosphate and muriate of potash. Nitrogen was applied in the form of urea in three equal splits *i.e.,* basal, at knee height and tasseling stage of crop. However, nutrient from drip fertigation was applied in the form of urea, phosphoric acid and sulphate of potash as a source of nitrogen, phosphorus and potassium. Fertilizers were applied through drip as per treatments with 5 day interval schedule.

Healthy crop stand was ensured by adopting recommended package & practice and need based plant protection practices. Yield attributes *viz.*, number of cobs plant^{-1}, cob length (cm), cob diameter (cm), number of grain rows cob^{-1}, number of grains cob^{-1}, grain weight (g cob^{-1}) and grain yield were recorded. The water use efficiency, soil moisture content and economics were also computed. The data pertaining to the experiment were subjected to statistical analysis suggested by Gomez and Gomez (1984).

3. Results and Discussion

Yield attributes of maize were significantly influenced by lateral arrangements and nutrient management except number of cob plant^{-1} (Table 2). Different lateral arrangements did significantly influence the cob length (cm), cob diameter (cm), number of rows cob^{-1}, number of grains cob^{-1} and grain weight (g cob^{-1}). The lateral spacing at 45 cm (W_1) was recorded higher value of cob length (cm), cob diameter (cm), number of grain rows cob^{-1} and number of grains cob^{-1} and grain weight (g cob^{-1}) which was significantly superior over rest of the treatments and the lowest value was recorded with conventional practice (W_3). Higher value of yield attributes were recorded with lateral at 45 cm (W_1) because of better availability of nutrients and soil moisture in closed lateral spacing over broader lateral spacing and conventional practices which led to production of more foliage, uptake of more nutrients and conversion of more biomass in terms of dry matter and partitioning in to the cobs. In case of nutrient management, STCR- based fertilizer recommendation (N_4) recorded significantly higher values of yield attributes over rest of the treatments, except 150% RDF (N_3). The yield attributes increased with increases in fertility doses because increase physiological process in crop plants leading to higher growth and increased photosynthates to sink (Arun Kumar *et al*. 2007). The maximum grain yield (73.63 q ha^{-1}) was recorded with laterals at 45 cm (1LPH/0.3 meter spacing; W_1), which was significantly superior over laterals at 90 cm (2LPH/0.3 meter spacing; W_2) and conventional practice (W_3). While minimum grain yield (66.73 q ha^{-1}) was recorded with conventional practice (W_3). In case of nutrient management practices, maximum grain yield (77.11 q ha^{-1}) was recorded with the application of STCR- based fertilizer recommendation (N_4) which was significantly higher than application at 100% RDF; N_2 (66.66 q ha^{-1}) and 50% RDF; N_1 (60.70 q ha^{-1}) respectively. However, it was statistically at par with the application of 150% RDF; N_3 (75.98 q ha^{-1}). Further, the lowest grain yield (60.70 q ha^{-1}) was recorded with 50% RDF (N_1). Fertilizer recommendations based on the concept of STCR- has been more quantitative, precise and meaningful. The higher grain yield of maize depends upon better translocation of photosynthates from source to sink and higher growth attributing characters like higher number of leaves, leaf area and higher dry matter production and its accumulation into different parts of plant and yield attributing characters like grain weight cob^{-1}, number of seeds cob^{-1}, number of grain rows cob^{-1}, and cob length. The application of 150% RDF also showed high grain yield (75.98 q ha^{-1}) due to the fact that higher dose of fertigation resulted higher availability of nutrient in the soil solution which led to greater uptake and better translocation of photosynthates from source to sink which is directly responsible for the yield. Similar linear response to higher doses of fertilizers was obtained by Sampathkumar and Pandian (2010) [12], Selva Rani (2009) [15], Muthukrishnan and fanish (2011) [8] and Fanish (2013) [3].

In lateral arrangement treatments, significantly higher water use efficiency of maize was recorded with laterals at 45 cm (1LPH/0.3 meter spacing; W_1) which was superior over laterals at 90 cm (2LPH/0.3 meter spacing; W_2) and conventional practice (W_3). However, the lowest WUE was recorded under conventional practice (W_3). The application of STCR- based fertilizer recommendation (N_4) gave significantly higher WUE over rest of the treatment, except application of 150% RDF (N_3) which was found statistically on par. Further, the lowest WUE was recorded when crop was imposed with 50% RDF (N_1). The increase in nutrient level resulted higher water use efficiency. As water applied for each treatment was same the variation in water use efficiency is due to variation in grain yield. WUE was increased with increase in nutrient levels due to increase in maize yield. Similar result was recorded by Manoharrao (2016) [7], Roy and Tripathi (1987) [10] and Selva Rani (2009) [15]. Lateral arrangement and nutrient management practices did not show any significant difference on soil moisture content at different depths. This might be due to the high amount of rainfall received during the growing period. Soil moisture content was higher on top 0-15 cm in all treatments. On the contrary, as the soil depths increased from 15-30 and 30-45 cm there was a reduction in soil moisture percentage in all treatments."

Table 1: Yield attributes and yields of maize as influenced by lateral arrangement and nutrient management

Treatments	Number of cobs plant^{-1}	Cob length (cm)	Cob diameter (cm)	Number of grain rows cob^{-1}	Number of grains cob^{-1}	Grain weight (g) cob^{-1}	Grain Yield (q ha^{-1})
Lateral Arrangement							
W_1: Laterals at 45 cm (1LPH/0.3 metre spacing)	1.00	19.79	4.80	14.60	529.68	140.11	73.63
W_2: Laterals at 90 cm (2LPH/0.3 metre spacing)	1.00	18.95	4.70	14.23	510.79	134.32	69.97
W_3: conventional practice	1.00	18.75	4.62	14.02	499.95	130.58	66.73
S.Em ±	0.00	0.21	0.01	0.08	3.28	1.32	0.89
CD (P=0.05)	NS	0.83	0.08	0.34	12.89	5.21	3.52
Nutrient Management							
N_1: 50% RDF	1.00	17.87	4.49	13.67	463.88	121.66	60.70
N_2: 100% RDF (120:60:40) kg ha^{-1} $N:P_2O_5:K_2O$	1.00	18.78	4.69	14.11	510.01	132.57	66.66
N_3: 150% RDF	1.00	19.76	4.80	14.62	534.08	140.94	75.98
N_4: STCR- based fertilizer recommendation (for 8 tonne)	1.00	20.01	4.86	14.73	545.93	144.83	77.11
S.Em ±	0.00	0.27	0.05	0.13	9.92	2.46	0.15
CD (P=0.05)	NS	0.94	0.16	0.44	34.31	8.50	0.53

Table 2: Effect of lateral arrangement and nutrient management on water use efficiency and economics of maize

Treatment	Water use efficiency (Kg ha^{-1} mm^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
Lateral Arrangement				
W_1: Laterals at 45 cm (1LPH/0.3 meter spacing)	37.85	146931	97116	1.96
W_2: Laterals at 90 cm (2LPH/0.3 meter spacing)	35.97	139327	92012	1.97
W_3: conventional practice	34.30	132771	96614	2.67
Nutrient Management				
N_1: 50% RDF	31.20	120975	83858	2.27
N_2: 100% RDF (120:60:40) kg ha^{-1} $N:P_2O_5:K_2O$	34.26	132978	89179	2.09
N_3: 150% RDF	39.06	151166	100686	2.07
N_4: STCR- based fertilizer recommendation (for 8 tonne)	39.64	153587	107268	2.36

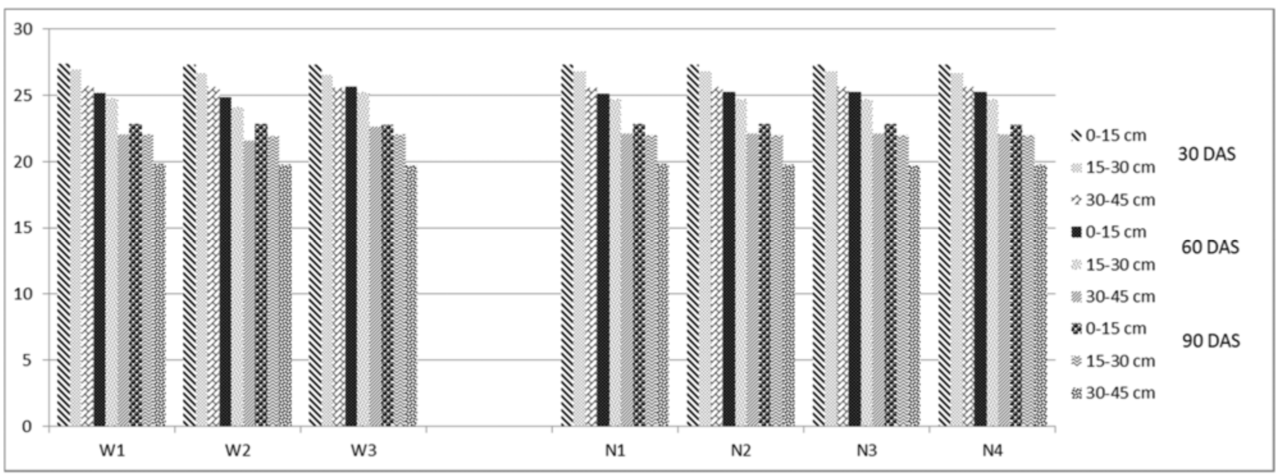

Fig 1: Soil moisture content (%) of maize as influenced by lateral arrangement and nutrient management at different intervals at various depths

Gross return and net return (146931 ₹ ha^{-1} and 97116 ₹ ha^{-1}) were higher under laterals at 45 cm (1LPH/0.3 meter spacing; W_1) whereas, the lowest gross return (132771 ₹ ha^{-1}) was recorded under conventional practice (W_3), while the lowest net return (92012 ₹ ha^{-1}) was recorded under laterals at 90 cm (2LPH/0.3 meter spacing; W_2). The benefit: cost ratio (B:C ratio) was higher (2.67) under conventional practice (W_3) whereas, the lowest B:C ratio (1.96) was observed under laterals at 45 cm (1LPH/0.3 meter spacing; W_1). Drip fertigation recorded lower B:C ratio because the cost of water soluble fertilizer and liquid fertilizer is too high which was used as a nutrient source in drip fertigation. As regard to nutrient management the higher gross return, net return and B:C ratio (153587 ₹ ha^{-1}, 107268 ₹ ha^{-1} and 2.36) were recorded with the application of STCR- based fertilizer recommendation (N_4). However, minimum gross return and net return (120975 ₹ ha^{-1} and 83858 ₹ ha^{-1}) was recorded under application of 50% RDF (N_1), while least B:C ratio (2.07) was observed with 150% RDF (N_3).

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