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Full Length Research Paper

Effects of different irrigation regimes and nitrogenous fertilizer on yield and growth parameters of maize

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A field experiment was carried out to find out the response on yield and yield contributing parameters of maize (cv. Bornali) to water stress and nitrogenous fertilizer. The experiment included two factors such as five irrigation regimes and four nitrogen levels. Texturally, the soil was silty loam. Yield and yield contributing characters were significantly affected due to the application of irrigation and nitrogen. The highest grain yield of 6.77 t/ha was obtained with IW/CPE ratio of 0.5 and 5.61 t/ha by the application of 70 kg N/ha. Interactions between IW/CPE ratio of 0.5 and 70 kg N/ha were the best combination for yield and yield contributing characters of maize.

Key words: Irrigation, water stress, nitrogen, yield, maize.

INTRODUCTION

In Bangladesh, maize is the third most important cereal crop and covers 2834 hectares of land with an annual production of 3000 tons (BBS, 1997). Proper growth and development of maize needs favorable soil moisture in root zone. The moisture content in the soil gradually decreases with the passing of time during dry season. Limited water supply during the growing season results in soil and plant water deficits and reduces maize yields (Gordon et al., 1995; Patel et al., 2006). Proper time and supplemental irrigation should be realized in irrigation scheduling for the most effective use of available water in optimizing maize production. Water deficit has little effect on timing of emergence, number of leaves per plant but delayed tasseling initiation and silking, reduced plant height and vegetation growth of maize (Abrecht and Carberry, 1993; Singh et al., 2007).

Heading to milking stage is the most important sensitive period of water stress and has ultimate impact on grain yield (Shaozong and Mingannang, 1992; Hussain et al., 2008). Improper scheduling of irrigation results not only in wastage of water but decrease the crop growth and yield. Nitrogen for maize cultivation is equally important to realize the yield potential (Talukder, 1985; Ghulam et al., 2005; Sajedi et al., 2009). Among different elements of Bangladesh soil, nitrogen is the key input for achieving higher yield of maize; but nitrogenous fertilizer may be increased to a certain level and thereafter it has got adverse effect (Gupta and Gautam, 1994; Singh et al., 1996). Irrigation water dissolved the fertilizers and made available to the crop for proper growth and development. Therefore, an attempt has been made to evaluate the effect of irrigation and nitrogen on the performance of maize.

MATERIALS AND METHOD

The experiment was conducted to evaluate the response of maize (cv. Bornali) to water stress and nitrogenous fertilizer. The experiment included two factors, namely i) five irrigation regimes with IW/CPE ratios of 0.0 (I_0), 0.2 (I_1), 0.5 (I_2), 0.8 (I_3) and 1.0 (I_4) was applied at 37, 58 and 75 days after sowing (DAS) and ii) four nitrogen doses that is 00 (N_0) , 70 (N_1), 100 (N_2) and 120 (N_3) N kg/ha. The experiment was laid out in a split plot design with 3 replications assigning 5 irrigation treatments to main plots and 4 fertility treatments to sub-plots at random. Texturally, the soil was silt loam. The land was prepared by power tiller. Seeds were sown on 19 November 2006 by dropping seeds by hand with 70 × 25 cm

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Table 1. Effect of irrigation regimes on the yield and yield contributing characters of maize.

IW/CPE ratio	Plant height (cm)	Root length (cm)	Ear length (cm)	Ear breadth (cm)	Ears/plant (no.)	Kernels/Ear (no.)	100 Kernel weight (g)	Grain weight (t/ha)	Stover yield (t/ha)
0	249.80c	26.42b	18.46b	4.04b	1.12	310.30d	24.40d	3.85d	6.84d
0.2	265.90ab	29.50a	19.72a	4.88a	1.35	372.50a	26.69c	5.77b	9.53b
0.5	271.50a	28.87a	19.51a	4.78a	1.38	351.00b	31.75a	6.77a	11.13a
0.8	273.50a	29.50a	18.34b	4.23b	1.38	333.10bc	31.05b	5.61b	8.35c
1.0	256.80bc	29.38a	18.25b	4.30b	1.20	327.10cd	27.03c	4.80c	7.87c
S_X	2.05	0.17	0.11	0.06	-	4.34	0.12	0.10	0.11
Level of significance	0.01	0.01	0.01	0.01	NS	0.01	0.01	0.01	0.01

Figure in a column having common letter(s) do not differ significantly but dissimilar letter differ significantly, NS = Not significant.

spacing. The unit plot size was 4 × 1.5 m (6 sq.m). Triple superphosphate (TPS) and muriate of potash (MP) were applied at the rate of 100 kg P_2O_5 and 80 kg k_2O/ha, respectively (BRAC, 1997).

One third of the nitrogen along with whole TSP and MP were applied at the time of final land preparation. The rest two third of urea was top dressed in two equal splits at 35 and 65 days after sowing. The maize was harvested on 6 April 2007. Intercultural operations were made as at when necessary, to keep the crop free from weeds and to protect from diseases. Soil moisture was determined at 34, 39, 54, 60, 73 and 77 DAS from each main plot. Soil samples were also collected from unit plots during land preparation and at harvest to determine the physico-chemical properties of soil. Plant height, root length, ear length, ear breath, ear/plant, kernel/ear, 100 kernel weight, grain and straw yields were recorded. Data were analyzed following analysis of variance technique and mean difference were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of irrigation regimes on the yield and yield contributing characters of maize are presented in Table 1. The yield and yield parameters were significantly affected due to application of irrigation water. The highest plant height (273.50 cm) was observed with IW/CPE ratio of 0.8 irrigation treatment and the lowest (249.80 cm) in control. Availability of well distribution soil moisture at different growth stages due to irrigation, enhanced the growth of plant. Similar effect of irrigation on plant height was also reported by Gordon et al. (1995) and Ne Smith and Ritche (1992). Root lengths were significantly increased with the application of irrigation water. The highest root length (29.50 cm) was produced in IW/CPE ratio of 0.2 and 0.8 irrigation treatments and was statistically similar with other irrigation treatments except control (26.42 cm). Similar results were found by Dai et al. (1990). Due to application of irrigation water, ear length was significantly increased. The highest ear length (19.72 cm) was produced by IW/CPE ratio of 0.2 irrigation treatment and was statistically similar with the ratio of 0.5 irrigation treatment. The lowest ear length (18.25 cm) was obtained with IW/CPE ratio of 1.0 irrigation treatment and was statistically identical with 0.8 and control. Ear breadth was significantly affected by irrigation water and followed similar trend as in ear length. Number of kernels/ear were significantly affected due to application of irrigation water. IW/CPE ratio of 0.2 irrigation treatment produced the highest kernel number/ear (372.50) and the lowest (310.30) in control. A significant variation was recorded for 100 kernel weight owing to differences in irrigation treatments. Influence of irrigation on grain yield was statistically significant. The highest grain yield (6.77 t/ha) was obtained with IW/CPE ratio of 0.5 irrigation treatment and the lowest (4.80 t/ha) under no stress condition (IW/CPE = 1). The grain yields were strongly supported by the yield contributing characters. It can be seen that yield increased up to a certain level of irrigation and then decreased. The results are in conformity with the findings of Talukder (1985), Chowdhury and Islam (1993), Zirkov et al. (1995). Different irrigation regimes were found to have significant effect on straw yields. Straw yields significantly increased and followed similar pattern as in grain yield. Chowdhury and Macksoud (1997) also found similar results.

The results on the yield and yield parameters of maize due to application of nitrogenous fertilizers are presented in Table 2. Significantly, the highest plant height (269.40 cm) was found with 70 kg N/ha and was statistically indicated (269.40 cm) with 100 kg N/ha. No significant differences were

Table 2. Effect of nitrogen regimes on the yield and yield contributing characters of maize.

Nitrogen (kg/ha)	Plant height (cm)	Root length (cm)	Ear length (cm)	Ear breadth (cm)	Ears/plant (no.)	Kernels/Ear (no.)	100 Kernel weight (g)	Grain weight (t/ha)	Stover yield (t/ha)
Control	254.20b	28.75	18.78c	4.27c	1.17b	332.72	28.44ab	4.93b	8.21b
70	269.40a	28.38	18.88bc	4.51ab	1.31ab	341.47	27.90b	5.61a	8.88a
100	269.30a	28.91	19.21a	4.32bc	1.33a	344.37	28.49a	5.46a	8.89a
120	258.70b	28.91	19.12ab	4.69a	1.33a	336.34	27.89b	5.44a	8.99a
S_X	2.20	-	0.08	0.05	0.04	-	0.19	0.07	0.10
Level of significance	0.01	NS	0.01	0.01	0.01	NS	0.05	0.01	0.01

Figure in a column having common letter(s) do not differ significantly but dissimilar letter differ significantly, NS = Not significant.

found between control and 120 kg N/ha treatments. Root length did not vary statistically due to application of nitrogenous fertilizers. Ear length and breadth had marked variation due to change in nitrogenous fertilizers. Nitrogenous fertilizer significantly increased ears/plant while no variation was found in kernels/ear. Highest number of ears/plant (1.33) was produced by 100 kg N/ha and no significant variation was found among 70 to 120 kg N/ha while the lowest (1.17) was in control. Different nitrogen treatments had significant influence on 100 kernel weight. The highest weight of 100-kernel (28.49) was found with 100 kg N/ha and the lowest (27.89 g) with 120 kg N/ha. The grain yields were significantly influenced by different doses of nitrogen. The grain yield was the highest (5.61 t/ha) due to the application of 70 kg N/ha and was statistically similar up to 120 kg N/ha. The lowest grain yield (4.93 t/ha) was produced by control. The results are in agreement with the findings of Cox et al. (1993), Gupta and Gautam (1994). Straw yield followed the similar pattern as in grain yield. This might be due to the exuberant vegetative growth noted in the case of higher doses of nitrogen application.

Interaction effect of irrigation and nitrogen on the performance of maize yield and yield contributing parameters are presented in Table 3. The highest grain yield (7.26 t/ha) was obtained by the combination of IW/CPE ratio of 0.5 and 70 kg N/ha while the lowest (3.81 t/ha) was in control. It is significantly supported by the yield contributing characters. These results are in conformity with the findings of El-Noemami et al. (1990) and Gab-Alla et al. (1995). In combination, irrigation and nitrogen had no significant effect on root length, ears/plant and kernels/ear, respectively. The moisture status of the experimental plots during growing period of maize is shown in Figures 1 to 5. Percentage of soil moisture gradually decreased through the soil profile in control (Figure 1). Moisture status at 20 and 40 cm depths of soil decreased days after irrigation and then gradually increased at every time of irrigation applied (Figure 2). It might be due to elapsed time of percolation through the soil profile. In Figures 3, 4 and 5 soil moisture status at 40 and 60 cm depths of soil followed similar trend as in Figure 2. But moisture status at 20 cm depth of soil fluctuated prior to and post irrigation, respectively. It might be due to low infiltration, evaporation and water holding capacity of the soil. Percent nitrogen content of experimental plots in 70, 100 and 120 kg N / ha treatments increased gradually up to 60 days (Figure 6). It may be due to the fact that, one third of nitrogen was applied at sowing and the rest in two equal splits at 35 and 65 days after swelling (DAS). It can be seen that, the nitrogen content decreased rapidly from 90 to 120 DAS because nitrogen was not applied at that period and also nitrogen uptake by plants may be higher due to flowering and grain formation. Potassium content in all the treatments gradually increased up to 30 days after swelling because the whole quantity of potassium was applied at the final land preparation (Figure 7). Potassium content gradually decreased from 30 to 90 DAS and followed similar trend up to 120 DAS (at harvest) because at that time no potassium was applied and its uptake by the plants may be increased due to flowering and grain formation. Phosphorus content in all the treatments gradually increased up to 30 DAS (Figure 8). It may be due to the fact that, the whole quantity of phosphorus was applied at the time of final land preparation. Phosphorus content gradually decreased from 30 to 120 DAS because no phosphorus was applied at that time and its uptake by the plants may be increased due to flowering and grain formation. The physico-chemical properties of soil during

Table 3. Interaction effect of irrigation regimes on the yield and yield contributing characters of maize.

Interaction (Irrigation x Nitrogen)	Plant height (cm)	Root length (cm)	Ear length (cm)	Ear breadth (cm)	Ears/plant (no.)	Kernels/ear (no.)	100 Kernel weight (g)	Grain weight (t/ha)	Stover yield (t/ha)
I_0N_0	240.80j	25.87	18.22efg	4.03ef	1.13	307.17	24.67ij	3.18k	5.42j
I_0N_1	255.60ghij	25.30	18.42efg	3.85f	1.07	308.02	23.71ij	4.52ij	7.52ghi
I_0N_2	252.7hij	26.80	18.76def	4.07ef	1.20	318.26	24.28ij	4.22j	7.14i
I_0N_3	250.00ij	27.73	18.44efg	4.22cdef	1.07	307.85	24.93hij	3.50k	7.26hi
I_1N_0	247.50ij	29.00	19.29bcd	4.72abc	1.13	397.43	25.56ghi	5.28efgh	8.75ef
I_1N_1	269.50bcdefg	29.53	19.23cd	5.03ab	1.40	354.94	26.63fgh	5.80cdef	9.40de
I_1N_2	273.60bcde	30.40	20.00ab	4.67abcd	1.40	365.94	26.63fgh	5.61def	9.69cd
I_1N_3	273.00bcdef	29.07	20.37a	5.10a	1.47	371.70	27.96ef	6.41bc	10.27cd
I_2N_0	258.30efghi	29.27	19.89abc	4.62abcd	1.27	345.55	31.15bc	6.05cd	10.49bc
I_2N_1	274.80bcd	28.93	20.11a	4.93ab	1.47	367.25	31.05bc	7.26a	11.44a
I_2N_2	279.70ab	28.67	20.54a	4.63abcd	1.40	350.97	34.00a	6.79ab	11.19ab
I_2N_3	260.80defghi	28.60	20.31a	4.95ab	1.40	340.10	30.79bc	6.98ab	11.43a
I_3N_0	268.90bcdefgh	30.67	18.68def	3.97ef	1.27	306.59	31.94b	5.07fghi	8.46fg
I_3N_1	290.40a	29.47	18.30efg	4.13def	1.33	341.36	31.32bc	5.94cde	8.41fg
I_3N_2	277.90abc	29.87	17.97fg	4.33cdef	1.47	350.39	31.00bc	5.95cde	8.72ef
I_3N_3	257.00fghij	28.00	18.42efg	4.50bcde	1.47	334.22	29.94cd	5.47defg	7.82fghi
I_4N_0	255.20ghij	28.93	17.80g	4.03ef	1.07	306.87	28.90de	5.08fghi	7.91fghi
I_4N_1	256.40ghij	28.67	18.32efg	4.60abcd	1.27	337.34	26.80fg	4.55hij	7.62ghi
I_4N_2	262.80cdefghi	28.80	18.81de	3.90f	1.20	336.31	26.57fgh	4.71hij	7.74ghi
I_4N_3	252.70hij	31.13	18.07efg	4.67abcd	1.27	327.83	25.86ghi	4.86ghij	8.20fgh
S_x	4.91	-	0.18	0.12	-	-	0.42	0.17	0.22
Level of significance	0.05	NS	0.01	0.01	NS	NS	0.01	0.01	0.01

Figure in a column having common letter(s) do not differ significantly but dissimilar letter differ significantly, NS = Not significant.

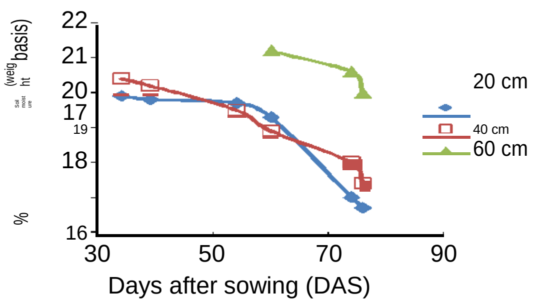

Figure 1. Soil moisture status at I_0 (IW/CPE = 0.0).

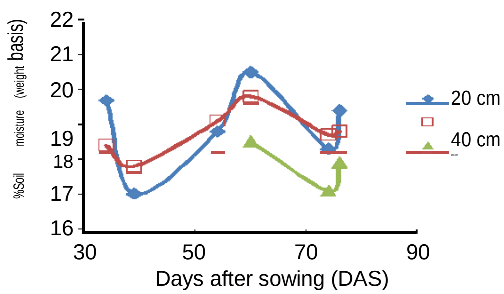

Figure 2. Soil moisture status at I_1 (IW/CPE = 0.2).

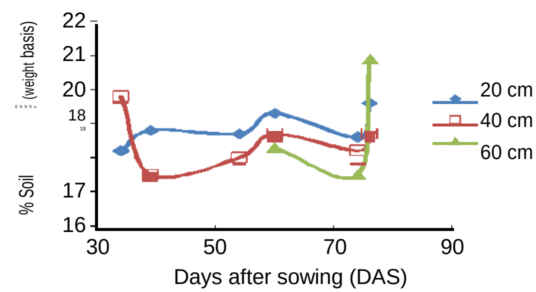

Figure 3. Soil moisture status at I_2 (IW/CPE = 0.5).

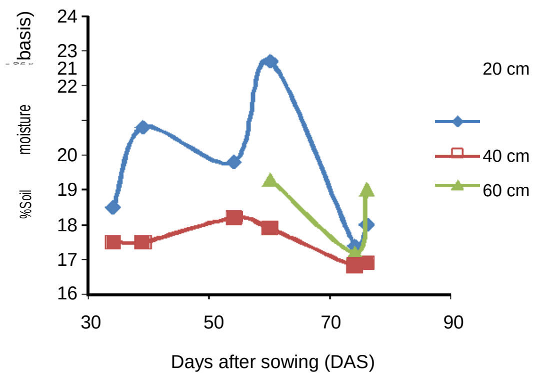

Figure 4. Soil moisture status at I_3 (IW/CPE = 0.8).

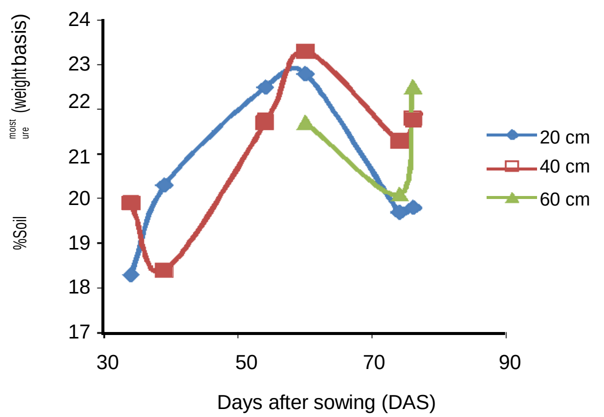

Figure 5. Soil moisture status at I_4 (IW/CPE = 1.0).

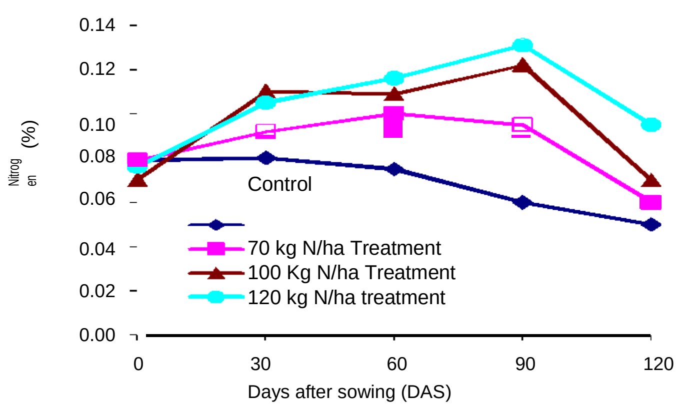

Figure 6. Nitrogen status in the soil during growing period of maize.

land preparation are presented in Table 4. Texturally, the soil of the study area was silt loam. pH, electrical conductivity (EC), NH_4-N, NH_3-N,sulphur (S) and organic carbon varied from 6.42 to 7.80, 340 to 488 µs/cm, 3.80 to 8.88 ppm, 4.80 to 14.00 ppm, 15 to 34 ppm and 0.48

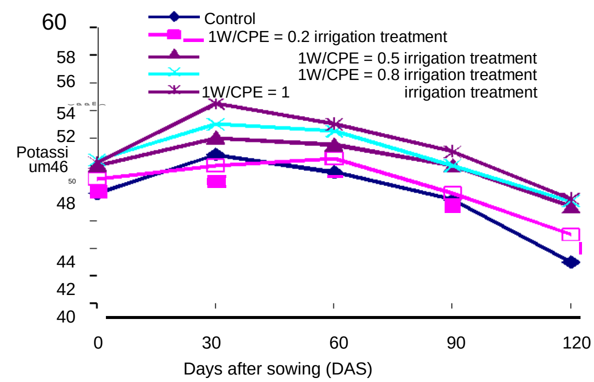

Figure 7. Potassium status in the soil during growing period of maize

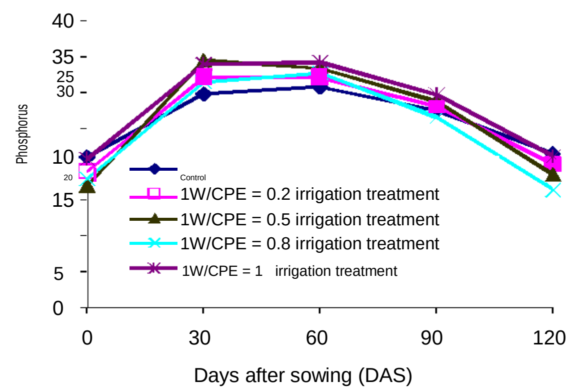

Figure 8. Phosphorus status in the soil during growing period of maize

to 1.61%, respectively. The physico-chemical properties of soil at harvest are presented in Table 5. It was found that pH, electrical conductivity (EC), NH_4-N, NH_3-N, sulphur (S) and organic carbon varied from 6.52 to 7.60, 312 to 479 µs/cm, 5.60 to 11.20 ppm, 4.2 to 19.60 ppm, 13 to 32 ppm and 0.67 to 1.28%, respectively. Tables 4 and 5 indicate that, the plant nutrients and percentage of organic carbon decreased slightly at harvest in comparison with land preparation. This might be due to the uptake of plant nutrients during the growing period of the crop.

CONCLUSIONS

Nitrogenous fertilizer and irrigation regimes are the important factors to yield and yield contributing characters of maize. Grain yield significantly influenced by the irrigation regimes. IW/CRE ratio of 0.5 irrigation treatment is the best treatment in respect of yield and yield contributing characters. Based on the interaction effect of irrigation and nitrogen for silt loam soil combination

Table 4. Physico-chemical properties of soil during land preparation.

Treatment	pH	EC (μs/cm)	NH_4-N (ppm)	NO_3-N (ppm)	S (ppm)	Organic carbon (%)	Soil texture
I_0N_0	6.48	420.00	4.20	11.20	20	0.95	Silt loam
I_0N_1	6.43	406.00	8.40	14.00	15	1.00	"
I_0N_2	7.42	440.00	7.00	12.60	15	1.00	"
I_0N_3	6.60	464.00	7.00	9.80	34	0.48	"
I_1N_0	7.72	478.00	5.60	4.20	20	1.48	"
I_1N_1	6.76	430.00	3.80	7.00	25	0.84	"
I_1N_2	6.78	340.00	4.20	4.80	15	1.48	"
I_1N_3	7.80	368.00	5.80	4.80	20	1.26	"
I_2N_0	6.74	488.00	4.20	7.00	20	0.79	"
I_2N_1	6.86	354.00	4.20	4.20	28	1.44	"
I_2N_2	6.87	468.00	4.20	8.40	28	0.61	"
I_2N_3	7.60	401.00	3.80	8.40	18	0.79	"
I_3N_0	6.67	440.00	5.60	8.40	20	0.53	"
I_3N_1	7.48	356.00	5.60	12.60	30	0.70	"
I_3N_2	6.76	483.00	4.20	8.40	30	1.61	"
I_3N_3	7.23	340.00	8.00	8.67	28	0.88	"
I_4N_0	7.80	402.00	7.68	10.11	28	0.79	"
I_4N_1	7.68	411.00	8.10	6.67	30	0.90	"
I_4N_2	7.70	414.35	9.20	10.45	35	0.69	"
I_4N_3	7.52	378.00	8.88	8.85	27	1.00	"
Mean	7.14	414.35	5.98	8.68	24	0.96	
Range	6.42 -7.8	340-488	3.80 - 8.88	4.80 - 14	15-34	0.48-1.61	

Table 5. Physico-chemical properties of soil at harvest.

Treatment	pH	EC (μs/cm)	NH_4-N (ppm)	NO_3-N (ppm)	S (ppm)	Organic carbon (%)
I_0N_0	6.52	411.00	8.40	10.00	17	0.88
I_0N_1	6.88	434.00	8.40	12.60	13	1.02
I_0N_2	6.90	419.00	8.40	19.60	14	0.93
I_0N_3	7.03	439.00	9.80	4.20	32	0.83
I_1N_0	7.12	448.00	7.00	8.40	13	0.85
I_1N_1	7.04	402.00	11.20	4.80	14	0.95
I_1N_2	7.16	376.00	8.40	7.00	19	0.95
I_1N_3	6.99	407.00	7.00	8.40	15	0.74
I_2N_0	6.73	337.00	5.60	4.80	16	1.14
I_2N_1	7.12	381.00	7.00	5.60	30	1.28
I_2N_2	6.57	382.00	7.00	19.00	27	0.72
I_2N_3	6.58	479.00	7.00	14.00	17	0.79
I_3N_0	6.98	394.00	7.00	7.00	15	0.67
I_3N_1	6.61	327.00	5.60	11.20	24	0.85
I_3N_2	6.89	470.00	11.20	5.60	22	0.93
I_3N_3	7.30	312.00	8.30	10.50	22	0.78
I_4N_0	7.22	372.00	8.88	11.60	28	0.89
I_4N_1	7.60	410.00	7.60	8.67	27	0.67
I_4N_2	7.13	375.00	7.89	7.89	33	0.88
I_4N_3	7.33	340.00	7.00	6.78	22	0.85
Mean	6.99	395.75	7.93	9.38	21	0.88
Range	6.52-7.6	312-479	5.60-11.20	4.20-19.60	13-32	0.67-1.28

of IW/CPE ratio of 0.5 and 70 kg N/ha is the best one for yield and yield contribution of maize.

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