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Effect of irrigation and nutrient management on growth, yield, quality and water use of summer baby corn (*Zea mays* L.) in new alluvial zone of West Bengal

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ABSTRACT

A field experiment was conducted in sandy-loam soil in the Instructional Farm of Bidhan Chandra Krishi Viswavidyalaya to study the effect of irrigation and nutrient management on growth, yield attributes, yield, quality and WUE of baby corn (cv. Super 36) during summer of 2011 and 2012. The experiment was laid out in split-plot design having 4 irrigation treatments, viz. I_1 - rainfed and I_2 to I_4 irrigation at 0.5, 0.75 and 1.0 ratio of IW/CPE as main-plot and 3 different nutrient managements, N_1 - 75% RDF (120:60:60 kg ha^{-1}), N_2 - 100% RDF and N_3 - 75% RDF along with FYM (Farmyard manure) (6.0 t ha^{-1}), as sub-plot treatments, replicated thrice. Application of irrigation and nutrient management markedly influenced growth, yield components and yield and these were (both corn as well as fodder) produced maximum with the application of irrigation at I_4 treatment + balance supply of organic as well as inorganic sources of plant nutrients. Among the treatment variables, least performance exhibited under rain-fed situation, which received 75% RDF alone. Irrigation and nutrient management significantly influenced protein content of baby corn and highest value was with N_3 treatment. Consumptive use of water increased with increasing levels of irrigation and highest was observed under irrigation at 1.0 ratio of IW/CPE with 75% RDF and FYM. However, the maximum water use efficiency was recorded under 0.5 ratio of IW/CPE in combination with integrated nutrient management. Thus, it may be concluded that maintenance of optimum moisture as well as integrated nutrient management is ideal for growing summer baby corn in this region.

Keywords **:** Baby corn, growth, irrigation & nutrient management, water use efficiency, yield

Maize (*Zea mays* L.) is the third most important crop next to rice and wheat in the world agricultural economy both as food and feed. It shows great adaptability to wide range of agro-climatic regions and can be grown in all the three seasons *viz., pre-kharif, kharif* and *rabi*. For diversification and value addition of maize as well as growth of food processing industries, an interesting development is of growing maize for vegetable purpose, which is known as 'baby corn'. The cultivation of baby corn in countries like Thailand and Taiwan has proven to be a successful venture. India has to use its great potentials of availability of cheap labour to invest more in its cultivation since its value and market is becoming popular and increasing respectively, both within and outside the country (Ranjan *et al.,* 2013). Baby corn is a dehusked maize ear harvested within 2 - 3 days of silk emergence, but prior to fertilization (Pandey *et al*., 2002). Baby corn ears are light yellow colour with regular row arrangement, 10 - 12 cm long and a diameter of 1.0 -1.5 cm are preferred in the market. A crop of baby corn gets ready within 45 - 60 days. Being a very short duration crop farmer can grow it 3 to 4 times in a year depending upon the agro-climatic conditions and can also be a good substitute at times when other crop fails. Baby corn is not only a 'cash crop' but also a very good 'catch crop'. Thus, it is one such new crop, which can improve the economic status of poor farmer.

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Soil moisture is the primary factor that limits the crop production, particularly in case of maize grown during *rabi* and pre-*kharif* season. Moreover, water management like improper scheduling, lack of proper drainage, *etc.* often leads to reduction in yields. For efficient water management, scheduling of irrigation to the crop should be done on the basis of IW/CPE ratio. Baby corn, being an exhaustive feeder, requires substantial amount nutrients for sustaining higher productivity. While maintaining the soil fertility as well as sustainability of crop production, the use of organic manure has assured great significance in conjunction with chemical fertilizers (Singh and Biswas, 2000). Nitrogen, a key element, is considered to be the most limiting factor for realizing higher yields. Adequate supply of N to baby corn is associated with efficient source to sink relationship leading to higher productivity (Pandey *et al*., 2000). Hence, to sustain higher productivity, increase fertilizer use efficiency and restored soil fertility, balanced and integrated nutrient management approaches involving organic green manures like

FYM and inorganic N need to be standardized for baby corn.

MATERIALS AND METHODS

The field experiment with baby corn (cv. Super 36) was conducted during the summer season (February - May) during 2011-2012 at the Jaguli Instruction Farm of Bidhan Chandra Krishi Viswavidyalaya, Jaguli, Nadia, West Bengal, India, located at 22º 93ì N latitude, 88º 53ì E longitude and at an altitude of 9.75 m above mean sea level. The experiment was conducted in split plot design with 3 replications considering irrigation (depth of irrigation was 5cm) treatments in main plot and nutrient management in the sub-plots. The main plot treatments were rainfed (I_1), irrigation at 0.5 IW/CPE (I_2) (corresponding one irrigation was provided), irrigation at 0.75 IW/CPE (I_3) (corresponding two irrigations were given that coincided knee high and silking stage) and irrigation at 1.0 IW/CPE (I_4) (three irrigations was applied that coincided knee high, silking and tasseling stage). The sub-plot treatments were 75% recommended dose (RDF) of NPK (N_1), 100% RDF (N_2) and 75% RDF + FYM at 6 t ha^{-1} (N_3). The 100% RDF was applied @ 120:60:60 kg ha^{-1} and FYM was applied @ 6 t ha^{-1}. The full dose of P_2O_5 and K_2O were applied as basal and N was applied in 3 equal split doses (as basal, at 25 days after sowing and at 60 days after sowing). FYM was applied during the time of final land preparation. Biometrical data were recorded at 30, 45, 60 days after sowing and at harvest. Initial soil water status was estimated from the bulk density measurement using the Field method (Dastane, 1972). The bulk density at top layer (0-15 cm) of soil was recorded 1.46, 1.47, 1.49 and 1.51 g cc^{-1}, respectively at respective 15 cm interval soil depth up to 60 cm. The initial field soil characteristics were, *viz.* pH (6.85), organic carbon (0.58%), total nitrogen (0.07%) and available P_2O_5 and K_2O (25.45 and 178.95 kg ha^{-1}) following the analytical procedure of Jackson (1973).

The data relating to growth, yield parameters, yield and quality as well as water balance components and soil moisture status during the period of experimentation were statistically analyzed following analysis of variance method (Gomez and Gomez, 1984). Significance of difference for sources of variance was tested by error mean square by Fisher Snedecor's 'F' test at probability level of 0.05. For comparison of 'F' values and computation of critical difference at 5% level of significance, Fisher and Yates' tables were consulted.

RESULTS AND DISCUSSION

Growth attributes

At harvest, significantly maximum plant height (207.64 cm) in baby corn was recorded with treatment I_4, where all the four irrigation at different growth stages of the crop was received, while lowest value was with the treatment I_1 (168.82 cm). Plant height increased with the increasing levels of irrigation due to the fact that the irrigation had beneficial influence on growth of plants. This might be attributed to rapid meristematic cell division and cell elongation as because irrigation water acts as a medium for dissolving nutrients in soil due to presence of adequate moisture as compared to relatively stressed plants (Table 1). The different levels of irrigation exhibited significant impact on LAI of the crop at various stages. The highest values of leaf area index was recorded by treatment I_4 (3.91) at 45 days after sowing while minimum was measured in treatment I_1 at all stages of the crop (Table 1). Crop growth rate between 30 to 45 days after sowing was recorded to be highest in treatment I_3 (13.71) which were significantly *at par* with treatment I_4 (13.70). Increasing levels of irrigation contributed to the increase in dry matter production which in turn contributed to the values of crop growth rate.

At harvest, plant height was significantly influenced by nutrient management. The highest plant height was obtained from N_3 (198.99 cm) which was *on par* with that of N_2. Similarly, a field trial conducted at University of Agriculture Faisalabad Pakistan reported that, the combining ability of poultry manure with single super phosphate result in positive increase in growth parameter of maize such as leaf area index and crop growth rate (Ali *et al.*, 2012). Treatment N_3 (3.72) gave the highest LAI at 45 days after sowing. Crop growth rate significantly increased with nutrient management. The greatest value was given by treatment N_3 (14.08) at the interval 35 to 45 days after sowing, which was statistically *at par* with N_2 (13.72) but significantly differed from N_1 (12.91). Also, Haq (2006) conducted a field trial at Shalimar Campus Kashmir and reported that, the combination of FYM and inorganic fertilizer significantly increases the growth parameters of maize like plant height, leaf number and LAI.

Yield attributes and yield

Application of irrigation at I_4 produced the highest no. of cobs plant^{-1} (2.45) and it was *at par* with irrigation given at I_3 whereas the lowest no. of cobs plant^{-1} (1.92) was obtained in rain-fed condition. Application of irrigation had favorable influence on LAI and dry matter production, resulting in greater no. of cobs per plant (Table 2). In case of single cob weight with both husk and without husk, the highest and the lowest cob weight were obtained from the plots receiving irrigation at I_4 and rain-fed, respectively. This might be due to the fact that irrigation water increased the turgidity of cells, opening of stomata, LAI and net assimilation, ultimately better development of cob (Table 2). In case of cob length (cm) with both husk and without husk, highest length under irrigation at I_4 which was significantly superior over irrigation applied at I_3. In

Table 1 : Effect of levels of irrigation and nutrient management on growth attributes of baby corn

Treatment	Plant height (cm)				Leaf area index				Crop growth rate (g m^{-2} day^{-1})			
	30 DAS	45 DAS	60 DAS	At harvest	30 DAS	45 DAS	60 DAS	At harvest	0-30 DAS	30-45 DAS	45-60 DAS	60 DAS-at harvest
Irrigation level (I)												
I_1	53.61	120.19	159.78	168.82	1.28	3.32	2.87	2.67	5.83	13.40	3.48	0.87
I_2	56.62	126.38	172.09	190.14	1.31	3.51	3.12	2.79	6.08	13.47	6.91	0.39
I_3	63.42	135.70	185.91	198.86	1.37	3.72	3.58	3.12	6.34	13.71	7.51	0.89
I_4	65.57	143.92	192.65	207.64	1.40	3.91	3.72	3.26	6.81	13.70	8.00	1.03
SEm(±)	**1.670**	**2.628**	**2.097**	**1.883**	**0.003**	**0.024**	**0.016**	**0.014**	**0.040**	**0.068**	**0.222**	**0.115**
LSD(0.05)	**5.780**	**9.094**	**7.256**	**6.517**	**0.011**	**0.085**	**0.056**	**0.048**	**0.138**	**0.235**	**0.767**	**0.399**
Nutrient level (N)												
N_1	57.05	121.06	169.49	183.73	1.30	3.50	3.26	2.91	6.08	12.91	6.62	0.77
N_2	59.62	130.51	177.72	191.38	1.35	3.63	3.31	2.95	6.27	13.72	6.35	0.87
N_3	62.75	143.08	185.62	198.99	1.37	3.72	3.41	3.02	6.45	14.08	6.47	0.75
SEm(±)	**1.507**	**5.317**	**3.837**	**3.551**	**0.009**	**0.031**	**0.033**	**0.022**	**0.061**	**0.134**	**0.376**	**0.117**
LSD (0.05)	**N.S.**	**15.939**	**11.503**	**10.645**	**0.026**	**0.094**	**0.100**	**0.065**	**0.183**	**0.402**	**N.S.**	**N.S.**

Note: I_1 = Rainfed, I_2 = Irrigation at 0.5 ratio of IW/CPE, I_3 = Irrigation at 0.75 ratio of IW/CPE, I_4 = Irrigation at 1.0 ratio of IW/CPE; N_1 = 75% recommended dose of NPK, N_2 = 100% recommended dose of NPK, N_3 = 75% recommended dose of NPK + 25% N through FYM.

Table 2 : Effects of irrigation and nutrient management on yield attributes and yield of baby corn

Treatment	No. of cobs plant^{-1}	Single cob weight (g)		Cob length (cm)		Cob diameter (mm)		Yield (ha^{-1})		Protein (%)
		with husk	without husk	with husk	without husk	with husk	without husk	Fresh corn (kg)	Green fodder (t)	
Irrigation level (I)										
I_1	1.92	27.03	6.27	18.34	7.96	18.82	12.68	801.89	22.01	12.89
I_2	2.24	27.91	6.31	18.97	8.09	19.35	12.92	939.84	23.15	13.12
I_3	2.39	30.42	6.42	19.56	8.23	20.76	13.87	1019.26	25.27	13.80
I_4	2.54	32.86	6.53	20.82	8.74	21.48	14.26	1103.89	26.14	14.06
SEm(±)	**0.045**	**0.305**	**0.048**	**0.241**	**0.030**	**0.035**	**0.039**	**13.178**	**0.604**	**0.035**
LSD (0.05)	**0.156**	**1.054**	**0.168**	**0.834**	**0.103**	**0.119**	**0.135**	**45.603**	**2.091**	**0.120**
Nutrient level (N)										
N_1	2.06	26.98	6.18	18.63	8.03	19.73	13.18	881.40	22.39	13.07
N_2	2.29	30.20	6.41	19.44	8.24	20.13	13.46	965.45	24.02	13.49
N_3	2.47	31.48	6.56	20.21	8.50	20.44	13.66	1051.82	26.03	13.85
SEm(±)	**0.056**	**0.727**	**0.054**	**0.284**	**0.064**	**0.070**	**0.063**	**17.776**	**0.845**	**0.062**
LSD (0.05)	**0.167**	**2.180**	**0.161**	**0.851**	**0.192**	**0.211**	**0.189**	**53.293**	**2.533**	**0.186**

case of crop diameter with husk and without husk, the application of I_4 treatment gave highest diameter which was differed significantly at I_3. The lowest value was recorded in rainfed condition (Table 2). Irrigation improved marketable fresh corn yield significantly due to the improvement in yield attributing characteristics with application of irrigation water. The highest yield (1104 kg ha^{-1}) was recorded in I_4 treatment which was followed by irrigation at I_3 and they are superior over other treatment. Irrigation had significant influence on green fodder yield of baby corn. The application of irrigation at I_4 gave the highest green fodder yield (26.14 t ha^{-1}) which was statistically *at par* with I_3 but differed significantly with I_2. However, the lowest fodder yield was obtained in rain-fed condition (Table 2).

Number of cobs per plant was significantly influenced by nutrient management. N_3 gave the highest number of cobs per plant (2.47) which differed significantly with N_2 (2.29). Single cob weight, cob length and cob diameter in case of both with husk and without husk was highest at N_3 treatment and the lowest was in N_1. Kannan *et al.* (2013) in their research trial conducted at Vanavavarayar Institute of Agriculture reported that integrated nutrient management showed the superior result on yield parameters of maize It was possible due to slow and continuously nutrient supply by NPK and organic matter *i.e.* FYM throughout the period of crop growth. We find maximum corn yield (1051.82 kg ha^{-1}) was obtained at N_3. Similar results were reported by Ravi *et al.* (2012) in their research trial conducted at agricultural research station Arabhavi of Karnataka. This indicates that baby corn responses well to integrated nutrient management, which might be owing to favourable soil condition and synchronize release of plant nutrients throughout the crop growth period. However, the lowest yield was recorded at N_1 might be due to insufficient supply of plant nutrients to the crop which resulted lower yield of the crop. Nutrient management also significantly influenced the green fodder yield. The highest fodder yield (26.03 t ha^{-1}) was recorded under N_3 treatment which was statistically *at par* with N_2 but differed significantly with N_1. This result was in support in support of a field trial conducted at Konkan region of India which suggested that substitution of 25 per cent recommended doses of fertilizer with FYM will positively result in better green fodder yield production of maize (Bhagade *et al*., 2008). NPK along with reasonable quantity of organic manures like FYM had a significantly positive role on the unhusked cob yield of baby corn (Lone *et al.*, 2013).

Quality parameters

Levels of irrigation significantly influenced the protein content of baby corn. The highest protein content (14.06%) was noted under irrigation at I_4 which was significantly superior over irrigation applied at I_3. The lowest value of protein percentage (12.89%) was recorded under rainfed condition.

The protein content was also significantly influenced by nutrient management, in which N_3 gave highest protein (13.85%) which was significantly superior over with N_2 (13.49%). Integrated nutrient management treatment gave the highest protein content might be due to suitable soil condition and synchronized release of plant nutrients throughout the crop growth period (Table 2).

Consumptive use (cu) and water use efficiency (WUE)

Soil moisture at the time of sowing ranges from 20.24 to 22.68% (Table 3) reveals that sufficient soil water reserve was there for proper germination. Surface layer (0-15 cm) had less initial soil moisture content due to soil evaporation. At harvest, soil water status varied depending upon the water mining pattern by the plant influenced by different irrigation and nutrient management practices. Soil water status was higher in I_4 treatment followed by I_3 treatment due to maximum no. of irrigation whereas low water content was recorded under rainfed condition. Irrespective of irrigation integrated nutrient management practices treatments showed lower moisture content at harvest due to higher extraction.

Field water balance components of baby corn revealed that profile contribution varied widely from 39.95mm to 85.66 mm in different irrigation treatments (Table 4). CU was the maximum (360.57 mm) under irrigation at I_4N_3 during the experiment due to higher number of irrigation. However, the maximum water use efficiency (3.40 kg ha^{-1} mm^{-1}) was recorded under I_2N_3.

From the present study, it may be concluded that irrigation at 1.0 IW/CPE (I_4) along with nutrient management of 75% RDF + 25% N through FYM (N_3) exhibited better growth, yield attributes and yield of baby corn. Moreover, maximum water use efficiency was recorded where irrigation was provided at 0.5 IW/CPE ratio in combination with integrated nutrient management of the experiment.

Table 3: Soil moisture status at the time of sowing and harvesting of baby corn field

Treatment	Soil moisture content (%) at different depths			
	0 – 15 cm	15 – 30 cm	30 – 45 cm	45 – 60 cm
	Initial			
	20.24	20.83	21.95	22.68
	Harvesting			
I_1N_1	12.35	12.98	14.12	15.02
I_1N_2	11.55	12.16	12.52	13.44
I_1N_3	10.64	11.00	12.24	13.29
I_2N_1	14.02	15.07	16.81	18.16
I_2N_2	12.56	13.74	16.35	16.96
I_2N_3	11.85	13.97	15.36	17.10
I_3N_1	13.08	15.63	17.63	20.08
I_3N_2	11.93	14.36	17.19	19.32
I_3N_3	11.05	14.34	16.65	19.12
I_4N_1	13.32	15.99	17.66	20.68
I_4N_2	11.57	15.23	16.74	19.74
I_4N_3	10.68	15.20	16.79	19.24

Table 4: Water balance components in the baby corn field

Treatments	Pc (mm)	P (mm)	I (mm)	CU (mm)	Corn yield (kg ha^{-1})	WUE (kg ha^{-1} mm^{-1})
I_1N_1	69.43	201.10	0	270.53	718.34	2.66
I_1N_2	80.16	201.10	0	281.26	806.57	2.87
I_1N_3	85.66	201.10	0	286.76	882.76	3.07
Mean	**78.42**	**201.10**	**0**	**279.52**	**801.89**	**2.87**
I_2N_1	48.06	194.80	50	292.86	868.71	2.97
I_2N_2	57.50	194.80	50	302.30	912.12	3.02
I_2N_3	60.84	194.80	50	305.64	1038.69	3.40
Mean	**55.47**	**194.80**	**50**	**300.27**	**939.84**	**3.13**
I_3N_1	42.68	173.60	100	316.28	928.86	2.94
I_3N_2	50.71	173.60	100	324.31	1016.57	3.13
I_3N_3	54.34	173.60	100	327.94	1112.35	3.39
Mean	**49.24**	**173.60**	**100**	**322.84**	**1019.26**	**3.16**
I_4N_1	39.95	157.90	150	347.85	1009.68	2.90
I_4N_2	49.61	157.90	150	357.51	1126.53	3.15
I_4N_3	52.67	157.90	150	360.57	1175.46	3.26
Mean	**47.41**	**157.90**	**150**	**355.31**	**1103.89**	**3.11**

Note: Pc = Profile contribution, P = Effective rainfall, I = Irrigation, CU = Consumptive use, WUE = Water use efficiency

So, the final outcome of this experiment may be suggested that the new alluvial zone of West Bengal is suited enough for cultivation of summer baby corn, if adequate irrigation and optimum nutrient management is followed.

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