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# Effect of irrigation levels and planting geometry on growth, cob yield and water use efficiency of baby corn (*Zea mays* L.)

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## ABSTRACT

*A field experiment was conducted during 2010 to 2012 (three years) at Gayeshpur, Nadia, West Bengal to investigate the effect of irrigation schedules and planting geometry on growth, yield and water-use efficiency (WUE) of summer baby corn (Zea mays L.). The experiment was laid out in split-plot design with four irrigation levels viz. conventional method (Farmers' practice), IW/CPE ratios of 0.6, 0.8 and 1.0 in main plots and three levels of planting geometry viz. 30 × 30 cm, 45 × 20 cm and 60 × 15 cm in sub-plots. Pooled results of three years showed that significantly higher growth, yield attributes and cob yield of baby corn (1310 kg ha$^{-1}$) were obtained with irrigation at IW/CPE 1.0, which was statistically at par with conventional irrigation. However, the maximum WUE of 3.91 kg ha-mm$^{-1}$ was recorded with IW/CPE 0.6. While the planting geometry of 45 × 20 cm exhibited significantly higher baby corn yield, but on a par with 60 × 15 cm geometry. The highest gross return, net return and benefit-cost ratio were recorded with IW/CPE 1.0 and 45 × 20 cm planting geometry.*

***Keywords***: Baby corn, IW/CPE ratio, planting geometry, water use efficiency

Baby corn is a dehusked maize ear harvested within 2-3 days of silk emergence, but prior to fertilization (Pandey *et al*., 2002). Due to its short duration, the crop can easily be fitted in an intensive cropping system (Dass *et al*., 2008). Baby corn provides a viable option for crop diversification due to its multi-uses such as vegetable for delicious human food, green fodder for quality livestock feed, raw material for canning and pickling food processing industries, and enhancing profitability particularly in peri-urban areas. It also offers huge export potential and revenue generation. Baby corn, being $C_4$ plant and exhaustive feeder, is generally fertilized heavily and spaced widely. Though baby corn is becoming popular in India, systemic development of agro-techniques particularly proper plant population through appropriate planting geometry and water management strategies are equally important to achieve higher production in a specific agro-climatic situation. There is ample scope for increasing the crop productivity through better management practices including timely sowing, proper plant density, balanced fertilization, optimum irrigation and need based plant protection measures. The supply of irrigation water along with optimum nutrients to baby corn may achieve breakthrough in productivity of the crop.

In irrigation scheduling, the climatological approach based on IW/CPE ratio (IW-irrigation water, CPE- cumulative pan evaporation) has been found most appropriate. This approach integrates all weather parameters that determine water use by the crop and is likely to increase production by at least 15-20% (Dastane, 1972). Optimum scheduling of irrigation leads to increased cob yield and water use efficiency (WUE) of baby corn (Patel *et al*., 2008).

Optimum crop geometry is one of the important factors for higher production, by efficient utilization of underground resources and also harvesting as much as solar radiation and in turn better photosynthates formation. The planting patterns of baby corn also significantly influence growth and yield parameters (Saif *et al*., 2003).

Considering the above view, the work done on the influence of irrigation and planting geometry in baby corn productivity is scanty. Therefore, the present experiment was planned to study the effect of different irrigation levels and planting geometry on growth and cob yield of baby corn.

## MATERIALS AND METHODS

A field experiment was conducted during summer season from 2010 to 2012 (3 years) at the Regional Research Station (New alluvial zone) of BCKV, Gayeshpur, Nadia, West Bengal (22.1° N latitude, 89.2° E longitude and 9.75 m above mean sea level) to investigate the effect of irrigation schedules and planting geometry on growth, yield and water use efficiency of summer baby corn. The alluvial soil (Inceptisol) of the experimental field was sandy loam in texture with bulk density 1.47 g cm$^{-3}$, pH 6.7, organic carbon (0.54%) and available N, P and K contents were 173.3, 14.6 and 157.3 kg ha$^{-1}$

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respectively. The moisture content at field capacity and permanent wilting point was 20.1 and 9.8% respectively.

The experiment was laid out in split-plot design and replicated thrice. Main plots treatments consisted of 4 irrigation schedules, *viz.* conventional method (Farmers' practice), IW/CPE ratios of 0.6, 0.8 and 1.0 and the sub-plots with 3 levels of planting geometry *viz.* 30 × 30 cm, 45 × 20 cm and 60 × 15 cm. Recommended doses of N, $P_2O_5$ and $K_2O$ @ 120: 60:60 kg $ha^{-1}$ were applied in the form of urea, single super phosphate and muriate of potash, respectively. Full dose of $P_2O_5$ and $K_2O$ were applied as basal. The half dose of N was applied as basal and remaining half dose was applied at 25-30 days after sowing, depending on the availability of the soil moisture. N fertilizer (urea) was properly mixed with the soil by earthing up. The climatic condition with reference to evaporation and rainfall during the crop period is presented in Fig. 1. The average of maximum and minimum temperatures were 38.3 and 23.0ºC in 2010, 35.7 and 20.8ºC in 2011 and 38.0 and 22.7ºC in 2012 respectively in crop growing seasons.

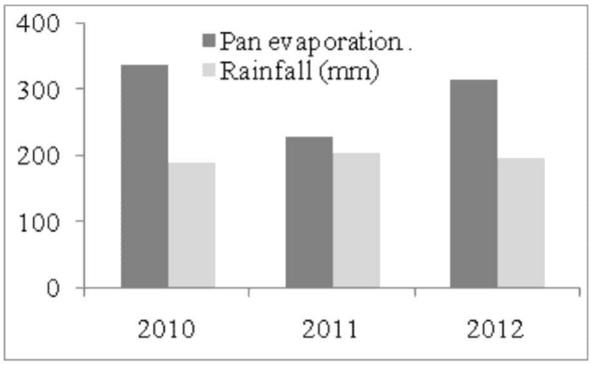


**Fig. 1: Evaporation and rainfall during the crop period**

Baby corn variety 'Golden Baby' was sown on 3rd week of March in all the three years with 6 × 3 m plot size. Plant-protection measures were taken as and when required. Other cultural operations were carried out as per recommendations. The harvesting of baby corn was started from 3rd week of May onwards by two pickings in 7 days interval in all the years. The growth like plant height, leaf area index, dry matter accumulation and crop growth rate *etc.* parameters were recorded periodically. Observations on yield and yield-attributing parameters were recorded at harvest. A pre-sowing irrigation was given for proper germination and establishment of the plants. Remaining irrigations were scheduled as per treatments when CPE reached at respective levels. 50 mm depth of irrigation water was maintained with the help of par-shall flume. The number of irrigation for conventional method was 5 and that of for IW/CPE ratios of 0.6, 0.8 and 1.0 were 2, 3 and 4 respectively. The total rainfall during the crop growth period was 186.9, 201.7 and 195.5 mm in 2010, 2011 and 2012 respectively. The profile soil moisture contribution was measured with thermo-gravimetric method by taking soil samples from 0-90 cm depth before sowing and after harvest of the crop. At harvest, N and P contents of baby corn plant were determined by indophenol-blue and molybdenum-blue colorimetry methods and K was determined by flame atomic absorption spectrometry. Total uptake of N, P and K was estimated by multiplying the dry matter accumulation at maturity in cob and green plants of baby corn by their respective percentage.

The water use efficiency (WUE) was calculated based on the cob yield (Y) of the crop per unit of water use. From the mean data, economics was worked out on the basis of prevailing market price of the produce and inputs used in the experiment. The data were statistically analyzed by standard tools for interpretation of the results.

## RESULTS AND DISCUSSION

### Growth and yield attributes

Irrigation levels influenced significantly the growth parameters and yield attributes of baby corn (Table 1). Higher plant height (168.43 cm) was recorded with conventional irrigation which was statistically *at par* with irrigation level of IW/CPE 1.0 (161.44 cm). Other growth parameters such as LAI, dry matter accumulation and CGR were significantly higher (3.53, 478.83 g $m^{-2}$ and 9.70 g $m^{-2}$ $day^{-1}$ respectively) in irrigation scheduled at IW/CPE 1.0. Maintenance of adequate moisture by irrigation at IW/CPE 1.0 might be the reason for establishment of significantly higher growth parameters. The higher total dry matter accumulation and CGR at IW/CPE 1.0 were favourably influenced by higher plant height and LAI. Sundarsingh (2001) reported higher plant height and dry matter accumulation at irrigation at IW/CPE 1.0 over 0.5 and 0.75 ratios. Similar results were also registered by Hussain *et al*. (2001).

Similarly, the significantly higher number of cob $plant^{-1}$ (2.16), cob weight (6.25 g), cob length (6.36 cm) and cob girth (1.25 cm) were recorded with IW/CPE 1.0, but on a par with conventional irrigation. This was mainly due to the beneficial effects on yield contributing factors through maintenance of adequate moisture regime by irrigation at IW/CPE 1.0. Shivakumar *et al*. (2011) reported similar effects of irrigation on yield attributing characters of baby corn.

The planting geometry had significant influence on growth and yield attributes of baby corn (Table 1). Baby corn raised at 60 × 15 cm spacing produced taller plants (166.94 cm), higher LAI (3.59), maximum dry matter accumulation (488.37 g $m^{-2}$) and higher CGR (9.89 g $m^{-2}$ $day^{-1}$). This treatment was statistically at par with the spacing of 45 × 20 cm. Taller plants might be due to competition of light under 60 × 15 cm spacing with closer plant-to-plant space for requirement of light. Wider row spacing had taller plants due to better availability of resources (Paulpandi *et al*., 1998). Wider space availability between the rows and closer intra-rows might have increased the root spread which eventually utilized the resources such as water, nutrients, $CO_2$ and light very effectively. Better utilization of available resources might have increased the functional leaves and in turn enhanced the LAI. Increased LAI due to closer intra row spacing was also observed by Abo-Shetaia *et al*. (2002). Higher dry matter accumulation was due combined effect of higher plant height and LAI. Similar results are also reported by Jiotode *et al*. (2002).

**Table 1: Growth and yield attributes of baby corn as influenced by different irrigation levels and planting geometry (Mean of 3 years)**

| Treatment | Plant height at harvest (cm) | LAI at 60 DAS | Dry matter accumulation at harvest (g $m^{-2}$) | CGR at 40-60 DAS (g $m^{-2}day^{-1}$) | Baby corn Cob | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | No $plant^{-1}$ | Weight (g) | Length (cm) | Girth (cm) |
| ***Irrigation levels*** | | | | | | | | |
| Conventional | 168.43 | 3.66 | 494.25 | 10.10 | 2.29 | 6.38 | 6.42 | 1.32 |
| IW/CPE 0.6 | 145.31 | 3.21 | 421.75 | 8.18 | 1.51 | 5.87 | 5.80 | 1.10 |
| IW/CPE 0.8 | 153.62 | 3.39 | 435.69 | 8.45 | 1.62 | 5.91 | 5.85 | 1.16 |
| IW/CPE 1.0 | 161.44 | 3.53 | 478.83 | 9.70 | 2.16 | 6.25 | 6.36 | 1.25 |
| **SEm(±)** | **3.62** | **0.07** | **8.37** | **0.21** | **0.08** | **0.10** | **0.06** | **0.03** |
| **LSD(0.05)** | **9.82** | **0.21** | **23.69** | **0.58** | **0.23** | **0.28** | **0.16** | **0.08** |
| ***Planting geometry*** | | | | | | | | |
| 30 cm × 30 cm | 140.91 | 3.16 | 411.92 | 7.89 | 1.52 | 5.89 | 5.76 | 1.08 |
| 45 cm × 20 cm | 163.75 | 3.57 | 472.60 | 9.52 | 2.02 | 6.12 | 6.18 | 1.23 |
| 60 cm × 15 cm | 166.94 | 3.59 | 488.37 | 9.89 | 2.13 | 6.28 | 6.38 | 1.29 |
| **SEm(±)** | **2.70** | **0.03** | **7.77** | **0.23** | **0.06** | **0.07** | **0.10** | **0.04** |
| **LSD(0.05)** | **7.35** | **0.10** | **21.97** | **0.63** | **0.16** | **0.19** | **0.28** | **0.10** |

On the other hand, wider row planting (60 × 15 cm) had stimulatory effect on the yield attributes of baby corn over narrow row (45 × 20 cm and 30 × 30 cm) spacing. At harvest heavier cobs (6.28 g), longer cobs (6.38 cm) and thicker cobs (1.29 cm) were recorded with 60 cm × 15 cm spacing and these results were statistically at par with 45 × 20 cm spacing. The enhanced yield component may be due to increased LAI, leading to higher photosynthetic rate and accumulation of more assimilates which in turn increased the sink size. The finding was corroborated by Thavaprakaash *et al*. (2005).

**Nutrient uptake**

The N, P and K uptake by baby corn plant was significantly influenced by different irrigation levels (Table 2). Maximum uptake of N, P and K by the crop was found with conventional irrigation (74.89, 22.43 and 56.91 kg $ha^{-1}$ respectively) which was statistically *at par* with irrigation level of IW/CPE 1.0 (73.91, 21.92 and 55.02 kg $ha^{-1}$ respectively). It might be due to the adequacy of available water which had synergistic effect on uptake of nutrients by plants. Higher growth and yield attributes of baby corn due to better availability of resources was reported by Turget (2000).

Crop geometry had also significant influence on N, P and K uptake of baby corn (Table 2). Nutrient removal was highest by the crop raised at 60 × 15 cm spacing (73.38, 21.25 and 55.92 kg $ha^{-1}$) and it was statistically *at par* with 45 × 20 cm spacing (71.97, 20.92 and 54.73 kg $ha^{-1}$). More nutrient uptake by plant with wider row spacing was due to better root growth ultimately producing higher growth and yield attributes. Higher yield attributes of baby corn under wider row spacing due to better availability of resources also noted by Paulpandi *et al*. (1998).

**Table 2: Nutrient uptake, yield and economics of baby corn as influenced by different irrigation levels and planting geometry (Mean of 3 years)**

| Treatment | Nutrient uptake (kg ha$^{-1}$) N | P | K | Baby corn yield (kg ha$^{-1}$) | Fodder yield (t ha$^{-1}$) | Cost of cultivation (×10$^3$ Rs. ha$^{-1}$) | Gross return (×10$^3$ Rs. ha$^{-1}$) | Net return (×10$^3$ Rs. ha$^{-1}$) | Benefit cost |
|---|---|---|---|---|---|---|---|---|---|
| ***Irrigation levels*** | | | | | | | | | |
| Conventional | 74.89 | 22.43 | 56.91 | 1336 | 23.34 | 24.3 | 60.4 | 36.1 | 2.48 |
| IW/CPE 0.6 | 67.82 | 19.83 | 51.63 | 1211 | 21.95 | 22.1 | 55.0 | 32.9 | 2.48 |
| IW/CPE 0.8 | 69.77 | 18.62 | 52.32 | 1243 | 22.79 | 22.5 | 56.5 | 34.0 | 2.51 |
| IW/CPE 1.0 | 73.91 | 21.92 | 55.02 | 1310 | 23.12 | 22.9 | 59.3 | 36.4 | 2.58 |
| **SEm(±)** | **1.10** | **0.63** | **0.76** | **10.72** | **0.17** | | | | |
| **LSD(0.05)** | **3.22** | **1.81** | **2.24** | **31.10** | **0.49** | | | | |
| ***Planting geometry*** | | | | | | | | | |
| 30 cm × 30 cm | 69.42 | 19.93 | 51.26 | 1208 | 20.62 | 22.3 | 54.5 | 32.2 | 2.44 |
| 45 cm × 20 cm | 71.97 | 20.92 | 54.73 | 1302 | 24.62 | 23.2 | 59.5 | 36.3 | 2.56 |
| 60 cm × 15 cm | 73.38 | 21.25 | 55.92 | 1316 | 23.22 | 23.4 | 59.6 | 36.2 | 2.54 |
| **SEm(±)** | **1.24** | **0.46** | **0.74** | **9.72** | **0.31** | | | | |
| **LSD(0.05)** | **3.63** | **1.33** | **2.19** | **28.20** | **0.89** | | | | |

*Note: *Selling price of baby corn cob is* Rs. *40 kg$^{-1}$ and stover is* Rs. *300 t$^{-1}$*

**Yield**

Cob and fodder yields of baby corn were significantly influenced by the irrigation schedules (Table 2). Mean data of three years showed that irrigation at IW/CPE 1.0 excelled the other IW/CPE ratios in producing cob and fodder yields (1310 kg and 23.12 t ha$^{-1}$ respectively). However, it was *at par* with conventional irrigation which registered maximum cob and fodder yields (1336 kg and 23.34 t ha$^{-1}$). The increased cob and fodder yields of baby corn was mainly due to the adequate moisture availability and increased uptake of nutrients throughout the crop growth stages, having beneficial effect on yield components. This clearly indicated the negative effects on yields under both the extremes of moisture levels and need of optimum moisture for better crop growth. Singh *et al*. (2015) observed significantly higher grain yield of maize under IW/CPE 1.2 over IW/CPE 0.6 irrigation treatment.

Plant geometry led to substantial variation in cob and fodder yield of baby corn (Table 2). Crop spacing of 45 × 20 cm significantly produced higher cob and fodder yields (1302 kg and 22.62 t ha$^{-1}$ respectively) over 30 × 30 cm spacing, however, it was at par with 60 × 15 cm spacing. This higher cob and fodder yields were due to effective utilization of applied nutrients which increased sink capacity and higher nutrients uptake of the crop. The yield potential of baby corn was decided by the growth and yield components. This was reflected in the present study. Higher yields of maize under wider spacing were also reported by Mathukia *et al*. (2014).

The mean interaction effect between irrigation levels and planting geometry was statistically analyzed (Table 3). The interaction effect showed significantly higher cob yield with application of irrigation at IW/CPE 1.0 along with 45 × 20 cm spacing.

**Table 3: Interaction between irrigation levels and planting geometry on cob yield of baby corn (kg ha$^{-1}$) (Mean of 3 years)**

| Planting geometry (P) | Irrigation levels (I) Conventional | IW/CPE 0.6 | IW/CPE 0.8 | IW/CPE 1.0 | Mean |
|---|---|---|---|---|---|
| 30cm × 30cm | 1301 | 1129 | 1161 | 1241 | **1208** |
| 45cm × 20cm | 1349 | 1241 | 1275 | 1343 | **1302** |
| 60cm × 15cm | 1358 | 1263 | 1294 | 1346 | **1316** |
| **Mean** | **1336** | **1211** | **1243** | **1310** | |
| | **I** | **P** | **I×P** | **P×I** | |
| **SEm(±)** | **11.54** | **11.01** | **13.86** | **12.67** | |
| **LSD(0.05)** | **30.49** | **28.07** | **38.46** | **34.69** | |

**Economics**

The highest gross return was recorded with conventional irrigation (Rs. 60.4×$10^3$ ha$^{-1}$) followed by irrigation scheduled at IW/CPE 1.0, whereas maximum net return (Rs. 36.4 ×$10^3$ ha$^{-1}$ ) and benefit-cost ratio (2.58) were at IW/CPE 1.0 (Table 2). Among the planting geometry, the highest gross return, net return and benefit-cost ratio were found with baby corn raised at 45 × 20 cm spacing, whereas the lowest values were obtained for 30 cm × 30 cm spacing.

**Water use and WUE**

The total water use ranged from 309.69 to 457.86 mm respectively, where lowest water use under irrigation at 0.6 IW/CPE ratio and highest under regular irrigation with conventional method (Table 4). The water use efficiency (WUE) was increased with decrease in irrigation interval. WUE was highest (3.91 kg ha-mm$^{-1}$) with irrigation at IW/CPE 0.6, followed by IW/CPE 0.8 and the lowest value (2.91 kg ha-mm$^{-1}$) with conventional method. This was due to the fact that with increased water supply, the rate of evapotranspiration was proportionally higher than the increase in yield up to certain limit. Similar result was reported by Mahajan *et al*. (2007).

Similarly, water use efficiency was almost equal between 60 × 15 cm and 45 × 20 cm spacing.

**Table 4: Components of soil water balance, water use and WUE of baby corn under different irrigation levels and planting geometry (Mean of 3 years)**

| Treatments | Profile contribution (mm) | Irrigation (mm) | Effective rainfall (mm) | Total water use (mm) | Cob yield (kg ha$^{-1}$) | WUE (kg ha-mm$^{-1}$) |
|---|---|---|---|---|---|---|
| ***Irrigation levels*** | | | | | | |
| Conventional | 13.16 | 250 | 194.70 | 457.86 | 1336 | 2.91 |
| IW/CPE 0.6 | 14.99 | 100 | 194.70 | 309.69 | 1211 | 3.91 |
| IW/CPE 0.8 | 14.41 | 150 | 194.70 | 359.11 | 1243 | 3.46 |
| IW/CPE 1.0 | 14.11 | 200 | 194.70 | 408.81 | 1310 | 3.20 |
| ***Planting geometry*** | | | | | | |
| 30 cm × 30 cm | 13.69 | 175 | 194.70 | 383.39 | 1208 | 3.15 |
| 45 cm × 20 cm | 13.24 | 175 | 194.70 | 382.94 | 1302 | 3.40 |
| 60 cm × 15 cm | 15.57 | 175 | 194.70 | 385.27 | 1316 | 3.41 |

It can be concluded from the study that irrigation scheduling at IW/CPE 1.0 along with 45 × 20 cm crop spacing is found beneficial to improve cob yield, WUE and economic returns of baby corn in Gangetic alluvial soil of West Bengal.

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