COB YIELD, NUTRITIONAL QUALITY AND HERBAGE PRODUCTIVITY OF BABY CORN AS INFLUENCED BY IRRIGATION AND INTEGRATED NUTRIENT FERTILIZATION

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Abstract. The optimization of plant nutrients and irrigation regimes hold potential to boost maize growth, cob yield, herbage biomass and revenue generation of maize. A field study was conducted to optimize irrigation and fertilization management for dual-purpose maize. The experiment was comprised four irrigation regimes viz. no irrigation (I_0), one irrigation 20 days after sowing (DAS) (I_1), two irrigations 20 and 40 DAS (I_2), and three irrigations 20, 40 and 60 DAS (I_3). The fertilization regimes included a treatment with recommended dose of fertilizers (RDF) (275-125-80-125-8 kg ha^{-1} of nitrogen, phosphorous, potassium, gypsum and sulfur) (F_1), poultry manure (PM) (5 t ha^{-1}) (F_2), 75% RDF + PM (2.5 t ha^{-1}) (F_3), and 50% RDF + PM (5 t ha^{-1}) (F_4). Combination of I_3 and F_3 outperformed other treatment combinations in terms of most of the yield attributes such as plant height (177.72 cm), cob length with (8.36 cm) and without husk (1.62 cm), and cob (without husk) yield (3.86 t ha^{-1}). This treatment combination also produced maize with the highest protein content of leaves and cobs. However, the highest green herbage yield (29.99 t ha^{-1}) was recorded with $I_1 \times F_1$, which remained at par with $I_1 \times F_3$. It took 20 additional days for crop switching from fodder harvest to attain baby corn maturity. The economic analysis revealed that $I_3 \times F_3$ treatment combination generated the greatest economic revenue.

Keywords: *cob, fodder, fertilizer, manure, profitability, proximate component*

Introduction

Globally after wheat, maize (Zea mays L.) is ranked as the second most cultivated and produced crop (Maqsood et al., 2020; Ahmed et al., 2023). Among South Asian countries, maize is the third most important cereal food crop in Bangladesh after rice and wheat. It is a multi-purpose crop that is being grown for food, fodder and fuel as well as being a raw material for numerous industrial products (Pandey et al., 2002; Abbas et al., 2021; Wasaya et al., 2021). Its production has recently become critical for ensuring food security, because it is a high value crop with high nutritional value and it is demanded in great amount. Furthermore, it is a low-calorie vegetable with a high fiber content and no cholesterol (Ramachandrappa et al., 2004; Dass et al., 2012; Dar et al., 2017; Rani et al., 2017). Due to the growth of the food processing industry baby corn is gaining global importance (Bakshi et al., 2017; Iqbal et al., 2021). In Bangladesh, its cultivation is gaining popularity due to its export potential and huge employment generation.

Maize is considered an ideal fodder crop' due to its ease of cultivation, adaptability (Nawaz et al., 2016; Khaliq et al., 2019; Rajkumara et al., 2020) and nutritional value (Kumar et al., 2016; Saiyad and Kumar, 2017). In Bangladesh, the shortage of quality feed and fodder remains one of the major reasons for the low productivity of livestock (Sarker et al., 2020a). Most of the livestock farmers meet their fodder requirements by grazing animals on common land, fallow agricultural fields or harvested agricultural land. Thus, growing maize and other fodder crops can help meet the country's demand for livestock feed. The soil and climate of Bangladesh is suitable for maize production; however, arable land area is gradually decreasing due to residential settlements and industrial use (Timsina et al., 2018). Though cultivation of maize has become very popular lately, farmers are reluctant to allocate their arable land for producing fodder crops and grow maize for grain purposes only (Rahman et al., 2016; Kabir et al., 2017). In these circumstances, getting two harvests (green fodder and baby corn) from the same crop can multiply the profitability of the farmers. Baby corn can be grown all year round (Salahuddin and Ivy, 2003). Being a short duration crop (70-80 days), it can be cultivated 3-4 times a year and fits easily in an intensive cropping system. However, the yield of baby corn has remained only 0.99-1.1 t ha^{-1} while its potential yield is over 5 t ha^{-1} (BARI, 2004, 2008).

There are differences in agronomic practices for growing maize for baby corn and fodder purposes. Maize fodder is usually grown on marginal land with less inputs (irrigation, nutrients, etc.) and higher plant densities whereas nutrient management and irrigation and planting density are important determinants of baby corn yield (Ayub et al., 2003). Irrigation and fertilization serve as two major limiting growth factors for dual purpose maize production globally. Previous studies indicated significant declines in maize productivity due to drought, while noticeable increases in yield were recorded with proportional increases in fertilizer especially nitrogenous (N) manure (Li et al., 2020). Besides fertilization, maize yield reduction has long been attributed to irrigation water scarcity, but numerous studies have so far reported conflicting findings regarding the impact of drought on maize herbage production and grain yield. Some studies indicated that the highest grain yield of maize was attained with the maximum net irrigation (8 irrigations of 3.08 ha cm each), while other studies have confirmed that increasing the number of irrigations did not directly equate to higher grain yield (Ayub et al., 2003; BARI, 2004, 2008). Likewise, Li et al. (2020) inferred that grain yield of maize increased linearly with water input increments with total water inputs less than 314 mm resulting in

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the maximum yield and further increases in water input resulting in a net decline of 3% yield. It was also suggested that grain yield increases linearly with N input until 250 kg ha^{-1} of N and that further N input is ineffective and economically unviable. Along with herbage productivity and grain yield, suboptimal irrigation and nutrition regimes have negative effects on the nutritional quality of forage such as significant decreases in protein and ash contents, and noticeable increases in fiber contents. Excessive N application rates tend to impart negative effects on crops in terms of growth disruption and higher incidences of insect-pests along with greatly reducing N use efficiency (NUE) (Suri et al., 1997). Additionally, suboptimal N quantities also cause significant nitrate leaching and contamination of groundwater. The main source of nitrate contamination of ground water being crop production (Nanjundappa et al., 2000). The combined application of inorganic fertilizers with organic manures increased the yield and quality of baby corn and the fertility of soil (Ramamoorthy and Lourduraj, 2002). The application of NPK (150:75:40 kg ha^{-1} + 10 t FYM) was found to be optimal for obtaining high baby corn and fodder yields with good quality attributes (Ramachandrappa et al., 2004). Soil moisture stress reduced dry matter accumulation, kernel number and weight, and yield (Pandey et al., 2000; Karam et al., 2003; Biswas et al., 2015). Proper application of water significantly increased the protein percentage of cob (Roy et al., 2015). Since, the dual-purpose cultivation of maize is an emerging and new practice, there is a lack of information on its cultivation. In addition, considerable research gaps exist regarding nutrient and irrigation management for boosting the quality of dual-purpose maize. Moreover, climate change and increasing heat stress drawn attention to rationalizing irrigation and plant nutrition regimes for boosting maize herbage and cob yields. It was hypothesized that rationalization of irrigation and fertilization regimes might enhance maize productivity. This study was undertaken to identify the combination of irrigation scheduling and fertilization regimes that maximizes green forage productivity, young cob yield and quality attributes of dual-purpose maize.

Materials and methods

Experimental site

This experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University in Mymensingh, Bangladesh (24.75°N latitude and 90.50°E longitude at an altitude of 18 m from sea level) from November 2016 to May 2017. The site has non-calcareous dark grey floodplain soil under the Agro-ecological Zone of the Old Brahmaputra Floodplain (AEZ-9). The experimental soil was medium high land having sandy loam texture with pH of 6.8. In addition, its EC and organic carbon remained 1.23 ds/m and 1.29%, respectively. Moreover, soil was deficient in macro and micronutrients as evident from scant nitrogen (0.13%), phosphorous (13 ppm), potassium (0.24%), zinc (0.25 ppm) and sulfur (15 ppm).

Experimental details

The experiment consisted of four levels of irrigations *viz.* no irrigation (I_0), one irrigation at 20 days after sowing (DAS) (I_1), two irrigations at 20 and 40 DAS (I_2), three irrigations at 20, 40 and 60 DAS (I_3), and four different fertilizer treatments *viz.* Recommended dose of inorganic fertilizer (RDF) (275-125-80-125-8 kg ha^{-1} of Urea, TSP, MoP, Gypsum and Zinc Sulphate) (F_1), Poultry manure (5 t ha^{-1}) (F_2), 75% RDF +

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poultry manure (2.5 t ha^{-1}) (F_3), 50% RDF + poultry manure (5 t ha^{-1}) (F_4). The experiment was set up in a split plot design with three replicates where irrigation was assigned to the main plots and fertilization regimes were allocated to the sub-plots randomly.

Crop management

The soil for conducting the experiments was prepared thoroughly by tilling twice with a tractor mounted tiller followed by planking. The field layout was made according to the experimental specifications immediately following final land preparation. Poultry manure was applied in designated plots as per treatment and incorporated and mixed thoroughly with the soil before seed sowing. Chemical fertilizers viz. Urea, TSP, MoP, Gypsum and Zinc Sulphate were applied in each plot as per treatment. One- third of the urea was applied as a basal dose just before sowing and remaining 2/3 of urea was applied in two equal splits each at 20 and 40 days after sowing. Baby corn seeds "Baby Star" were sown in furrows on 3 December 2017 maintained with a spacing of 45 cm × 20 cm and two seeds hill^{-1}. Irrigation was applied in the experimental plot as per specification of the experimental treatments. Thinning and gap filling were done during the first weeding at 15 DAS. Other intercultural operations, earthing up and pest management were done when required. For higher yield and quality of baby corn the detasseling was done on daily basis till the tassels from all the plants were removed to protect pollination.

Data collection

Young cobs were harvested 2-3 days after silking when the length of the silk was 3-4 cm and the harvesting was completed by hand picking. At the time of harvesting (90 DAS) ten plants were randomly selected to record data regarding plant height, cob length, cob diameter, cob yield with and without husk were recorded. Finally, cob yield was converted to t ha^{-1}. After picking of the green cobs, plants were harvested immediately form each plot and the weight was recorded in kg and converted on hectare basis in t ha^{-1}.

Chemical analysis

Cobs collected from each experimental plot were dried and cleaned manually. Oven dried samples were ground by a grinding mill using 60 mesh sieves. The prepared samples were then put in polythene bags and kept in a desiccator for subsequent chemical analysis. The crude protein (Kjeldahl N × 6.25) was determined by the Kjeldahl method (AOAC, 1984). Total carbohydrates were estimated using the methods by Raghuramulu et al. (2003). The fat content of the samples was determined by continuous solvent extraction using a Soxhlet apparatus by the methods by Hughes (1969). The procedure of fiber and ash determination was described by Ranganna (1986). The moisture content of baby corn and fodder samples was determined by the method of Ezeagu et al. (1996).

Statistical analysis

A two-way Analysis of variance (ANOVA) was employed on the recorded data to determine the significance of the differences in the recorded parameters resulting from

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the experimental treatments. The mean differences were adjudged by Duncan's Multiple Range Test (DMRT) applied at 5% level of significance (Gomez and Gomez, 1984). Statistical analyses were performed using the software program Statistix 10.

Results

Crop characters and yield components

Yield components of baby corn were significantly affected by irrigation levels and fertilization regimes (*Table 1*). The tallest plants (177.72 cm) at harvest were recorded in $I_3 \times F_3$ which was at par with $I_0 \times F_1$, $I_1 \times F_1$ and $I_3 \times F_1$ while the shortest plants (143.00 cm) were recorded in $I_3 \times F_2$. The interaction effect of $I_1 \times F_1$ was found to produce the highest number of cobs plant^{-1} (1.86) which was as good as $I_3 \times F_1$ (1.70) and $I_3 \times F_3$ (1.53) while the lowest number of cobs plant^{-1} (0.96) was found in $I_0 \times F_2$ (*Table 1*). Numerically the highest cob length with husk (21.44 cm), cob length without husk (8.36 cm), cob diameter with husk (3.24 cm) and cob diameter without husk (1.62 cm) were recorded in $I_3 \times F_3$ whereas least performance was exhibited under $I_1 \times F_2$ treatment.

Table 1. *Interaction effect of irrigation and integrated nutrient management on yield components*

Interaction (irrigation × nutrient)	Plant height (cm)	Number of cobs plant^{-1}	Cob length with husk (cm)	Cob length w/o husk (cm)	Cob dia with husk (cm)	Cob dia w/o husk (cm)
$I_0 \times F_1$	168.22ab	1.36bcd	17.44ab	7.77ab	2.50abc	1.24abc
$I_0 \times F_2$	144.1ef	0.96d	18.33ab	7.53abc	2.42bc	1.21bc
$I_0 \times F_3$	159.89bcd	1.16cd	21.11ab	8.26a	2.53abc	1.26abc
$I_0 \times F_4$	146.47def	1.16cd	19.89ab	7.69abc	2.58abc	1.28abc
$I_1 \times F_1$	166.67abc	1.86a	19.13ab	7.95ab	3.13ab	1.56ab
$I_1 \times F_2$	151.94c-f	1.06d	17.22b	6.43c	2.30c	1.15c
$I_1 \times F_3$	158.56b-e	1.26bcd	21.11ab	7.07abc	2.82abc	1.43abc
$I_1 \times F_4$	156.33b-f	1.30bcd	20.11ab	6.87bc	2.82abc	1.41abc
$I_2 \times F_1$	146.05def	1.30bcd	19.43ab	7.59abc	2.83abc	1.41abc
$I_2 \times F_2$	145.67def	1.20cd	19.00ab	7.87ab	2.89abc	1.44abc
$I_2 \times F_3$	152.89c-f	1.20cd	18.92ab	7.51abc	3.00abc	1.50abc
$I_2 \times F_4$	155.55b-f	1.26bcd	19.00ab	7.37abc	3.05abc	1.52abc
$I_3 \times F_1$	165.78abc	1.70ab	19.55ab	7.41abc	2.82abc	1.41abc
$I_3 \times F_2$	143.00f	1.16cd	18.44ab	7.12abc	2.57abc	1.28abc
$I_3 \times F_3$	177.72a	1.53abc	21.44a	8.34a	3.24a	1.62a
$I_3 \times F_4$	148.67def	1.23cd	19.38ab	7.55abc	2.59abc	1.29abc
Sig. level	*	*	*	*	*	*
CV (%)	5.62	5.56	3.75	3.5	2.87	4

In a column, mean values with the same letter (s) or without letter do not differ significantly whereas mean values with dissimilar letter differ significantly (as per DMRT). * = Significant at 5% level of probability. I_0 = No irrigation, I_1 = One irrigation at 20 DAS, I_2 = Two irrigations at 20 and 40 DAS, I_3 = Three irrigations at 20, 40 and 60 DAS. F_1 = Recommended dose of inorganic fertilizer (RDF) (275-125-80-125-8 kg ha^{-1} of Urea, TSP, MOP, Gypsum and Zinc Sulphate), F_2 = Poultry manure @ 5 t ha^{-1}, F_3 = 75% RDF + poultry manure @ 2.5 t ha^{-1}, F_4 = 50%RDF + poultry manure @ 5 t ha^{-1}

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Cob yield

The highest cob yield with husk (14.54 t ha^{-1}) was obtained in $I_3 \times F_3$ which was statistically at par to $I_1 \times F_1$ and $I_3 \times F_1$ while the lowest cob yield with husk (3.74 t ha^{-1}) was obtained in $I_0 \times F_2$ (*Fig. 1*). The highest cob yield without husk (3.86 t ha^{-1}) was recorded in $I_3 \times F_3$ which was at par with $I_1 \times F_1$, $I_1 \times F_3$ and $I_1 \times F_4$, whereas the lowest cob yield without husk (1.51 t ha^{-1}) was recorded in $I_0 \times F_2$, which was statistically identical to $I_2 \times F_2$ and $I_1 \times F_2$ (*Fig. 1*).

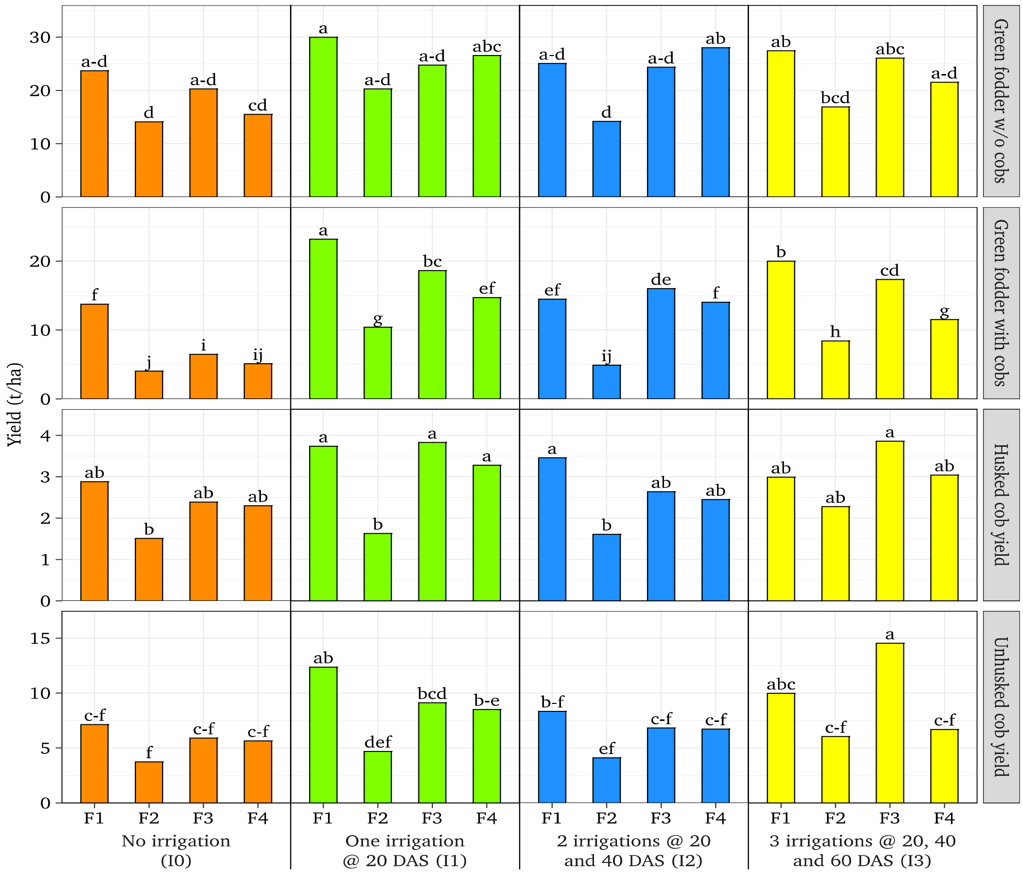

Figure 1. *Effects of fertilizer and irrigation managements on green fodder and baby corn yield. F_1 = Recommended dose of inorganic fertilizer (RDF) (275-125-80-125-8 kg ha^{-1} of Urea, TSP, MOP, Gypsum and Zinc Sulphate), F_2 = Poultry manure @ 5 t ha^{-1}, F_3 = 75% RDF + poultry manure @ 2.5 t ha^{-1}, F_4 = 50%RDF + poultry manure @ 5 t ha^{-1}; Fodder: Tk 3.00/kg and baby corn (without husk) Tk 60.00/kg*

Green fodder yield

Green fodder yield was significantly influenced by treatment combination (*Fig. 1*). At 70 DAS, the highest green fodder yield (23.8 t ha^{-1}) was recorded in $I_1 \times F_1$ followed by $I_3 \times F_1$ and the lowest one was found in $I_0 \times F_2$. At harvest, the highest green fodder yield without cobs (29.99 t ha^{-1}) and with cobs (42.35 t ha^{-1}) were found in treatment $I_1 \times F_1$ which remained statistically non-significant to $I_3 \times F_3$. However, fodder yield decreased with sole application of poultry manure irrespective of irrigation level and the lowest green fodder yield without cobs (14.11 t ha^{-1}) and with cobs (17.85 t ha^{-1}) were recorded by the treatment combination of $I_0 \times F_2$.

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Protein content

The interaction between irrigation and integrated nutrient management had a significant impact on protein content. Baby maize cobs contained the highest amount of protein irrespective of treatment combinations compared to leaves and stems. The highest cob protein content (20.33%) which was found in $I_3 \times F_3$, which was followed by $I_1 \times F_4$ (18.03%) and $I_2 \times F_3$ (18.00%). The minimum protein content (9.23%) was recorded for $I_0 \times F_2$ (*Table 2*). The highest protein content in leaves (18.43%) was found in one irrigation at 20 DAS and fertilization with 50% RDF + poultry manure (5 t ha^{-1}) ($I_1 \times F_4$) and lowest (7.53%) one in no irrigation and fertilization with poultry manure (5 t ha^{-1}) ($I_0 \times F_2$) treatment combination (*Table 3*). In case of stem, the highest protein content (4.86%) was obtained without irrigation along with 50% RDF + poultry manure (5 t ha^{-1}) ($I_0 \times F_4$) while the lowest protein content (2.10%) was recorded in three irrigations (20, 40 and 60 DAS) fertilized with poultry manure (2.5 t ha^{-1}) ($I_3 \times F_2$), which was at par with three irrigations (20, 40 and 60 DAS) fertilized with 50% RDF + poultry manure (5 t ha^{-1}) ($I_3 \times F_4$), no irrigation with poultry manure (5 t ha^{-1}) ($I_0 \times F_2$) and one irrigation (20 DAS) with RDF ($I_1 \times F_1$) treatment combinations, respectively (*Table 4*).

Table 2. *Effect of interaction between irrigation and nutrient management on the quality of baby corn*

Interaction (irrigation × nutrient)	Protein (%)	CHO (%)	Fat (%)	Fibre (%)	Ash (%)	Moisture (%)
$I_0 \times F_1$	9.40h	45.77ab	9.42a	9.74ab	5.78fgh	14.14bc
$I_0 \times F_2$	9.23h	43.62ab	10.05a	10.40ab	5.78fgh	13.75bc
$I_0 \times F_3$	16.10e	40.43ab	9.07a	10.08ab	6.08d	17.86a
$I_0 \times F_4$	15.46f	44.65ab	6.11b	10.57a	5.67gh	16.32ab
$I_1 \times F_1$	16.86d	40.88ab	8.88a	10.15ab	6.08d	16.18ab
$I_1 \times F_2$	16.23e	46.80a	3.28cd	8.66ab	5.81efgh	16.11ab
$I_1 \times F_3$	16.70d	45.78ab	5.35b	9.55ab	5.60h	17.90a
$I_1 \times F_4$	18.03b	43.36ab	6.01b	9.61ab	6.04de	14.70bc
$I_2 \times F_1$	18.00b	42.38ab	4.81bc	8.70ab	5.87defg	15.91abc
$I_2 \times F_2$	17.40c	42.69ab	6.03b	9.15ab	5.94def	15.80abc
$I_2 \times F_3$	16.63d	39.18b	5.31b	9.42ab	7.59a	17.65a
$I_2 \times F_4$	15.36f	47.17a	2.47d	10.23ab	6.53c	13.28c
$I_3 \times F_1$	16.63d	46.10ab	3.57cd	9.16ab	6.92b	14.80bc
$I_3 \times F_2$	11.30g	45.46ab	8.79a	8.72ab	5.25i	14.89bc
$I_3 \times F_3$	20.33a	46.27ab	2.36d	8.36b	6.33c	18.15a
$I_3 \times F_4$	15.46f	40.77ab	10.41a	8.48ab	5.67gh	13.96bc
Level of sig.	***	*	***	*	***	*
CV (%)	1.13	7.19	5.92	7.81	2.39	7.47

In a column, mean values with the same letter (s) or without letter do not differ significantly whereas mean values with different letters are significantly different (as per DMRT). * = Significant at 5% level of probability. I_0 = No irrigation, I_1 = One irrigation at 20 DAS (I_1), I_2 = Two irrigations at 20 and 40 DAS, I_3 = Three irrigations at 20, 40 and 60 DAS. F_1 = Recommended dose of inorganic fertilizer (RDF) (275-125-80-125-8 kg ha^{-1} of Urea, TSP, MOP, Gypsum and Zinc Sulphate), F_2 = Poultry manure @ 5 t ha^{-1}, F_3 = 75% RDF + poultry manure @ 2.5 t ha^{-1}, F_4 = 50%RDF + poultry manure @ 5 t ha^{-1}

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Table 3. *Effect of interaction between irrigation and nutrient management on the quality of leaves*

Interaction (irrigation × nutrient)	Protein (%)	CHO (%)	Fat (%)	Fibre (%)	Ash (%)	Moisture (%)
$I_0 \times F_1$	11.20d	34.21a-d	1.68kl	33.48f	8.61g	13.37a
$I_0 \times F_2$	7.53g	25.57f	2.32g	39.56a	8.62g	12.68bc
$I_0 \times F_3$	14.06bc	26.62ef	1.93i	37.57b	8.05k	12.35cd
$I_0 \times F_4$	13.43c	35.25abc	2.84e	31.34j	8.34j	10.61jk
$I_1 \times F_1$	11.40d	26.49ef	1.69k	37.58b	9.48c	13.16ab
$I_1 \times F_2$	10.86d	26.68ef	1.76j	35.23d	9.27d	11.11hi
$I_1 \times F_3$	14.43b	27.34ef	2.50h	33.68f	8.38i	12.23cde
$I_1 \times F_4$	18.43a	29.63c-f	2.40f	31.59j	9.28d	11.67fg
$I_2 \times F_1$	10.90d	32.54a-e	2.79e	32.36h	8.98e	11.53fgh
$I_2 \times F_2$	8.06fg	31.77b-f	3.63c	30.73k	10.09a	10.45k
$I_2 \times F_3$	10.63d	28.50def	3.07d	32.88g	8.43h	11.57fgh
$I_2 \times F_4$	14.56b	30.09c-f	3.87b	31.89i	8.74f	11.83efg
$I_3 \times F_1$	10.86d	31.96b-f	1.71jk	34.05e	8.75f	11.99def
$I_3 \times F_2$	9.76e	26.05f	4.12a	36.86c	7.32m	12.67bc
$I_3 \times F_3$	13.60c	39.01a	2.53h	20.94l	9.82b	11.43ghi
$I_3 \times F_4$	8.43f	37.30ab	1.61l	30.58k	7.86l	11.01ij
Level of sig.	0.78	**	***	***	***	***
CV (%)	***	6.75	6.68	6.46	0.22	6.5

In a column, mean values with the same letter (s) or without letter do not differ significantly whereas mean values with different letters are significantly different (as per DMRT). * = Significant at 5% level of probability, I_0 = No irrigation, I_1 = One irrigation at 20 DAS, I_2 = Two irrigations at 20 and 40 DAS, I_3 = Three irrigations at 20, 40 and 60 DAS. F_1 = Recommended dose of inorganic fertilizer (RDF) (275-125-80-125-8 kg ha^{-1} of Urea, TSP, MOP, Gypsum and Zinc Sulphate), F_2 = Poultry manure @ 5 t ha^{-1}, F_3 = 75% RDF + poultry manure @ 2.5 t ha^{-1}, F_4 = 50%RDF + poultry manure @ 5 t ha^{-1}

Carbohydrate content

The highest amount of carbohydrate was recorded in cobs followed by stems and leaves irrespective of treatment combinations. The highest carbohydrate (47.17%) was recorded in treatment $I_2 \times F_4$ which was at par with other treatment combinations except $I_2 \times F_3$ (39.18%), which was the lowest (*Table 2*). In stem, and leaves, the highest values of carbohydrates were recorded in $I_2 \times F_3$ by 40.53% and 39.01% in stems and leaves, respectively, while the lowest values in stems (31.24%) and leaves (26.05%) were recorded for treatment $I_2 \times F_4$ and $I_3 \times F_2$, respectively (*Table 3* and *Table 4*).

Fat content

Fat content in cobs differ from leaves and stems. The highest fat in cobs (10.41%) was recorded in $I_3 \times F_4$ which was statistically at par to the treatment $I_0 \times F_1$, $I_0 \times F_2$, $I_0 \times F_3$, $I_1 \times F_1$, and $I_3 \times F_2$, while the lowest one (2.47%) was found in $I_2 \times F_4$ (*Table 2*). In leaves, treatment combination of $I_3 \times F_2$ produced the highest fat content (4.12%), while the highest fat (12.62%) in stems was recorded in $I_0 \times F_4$, while the lowest fat (3.85%) was recorded in $I_1 \times F_4$ treatment combination (*Table 3*).

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Table 4. *Effect of interaction between irrigation and nutrient management on the quality of stem*

Interaction (irrigation × nutrient)	Protein (%)	CHO (%)	Fat (%)	Fibre (%)	Ash (%)	Moisture (%)
$I_0 \times F_1$	3.20d	34.67abc	9.76e	30.53c	5.47h	14.97c
$I_0 \times F_2$	2.16f	37.39abc	9.65e	25.26e	4.69l	11.49l
$I_0 \times F_3$	3.56c	35.83abc	9.76e	33.30b	5.30j	11.15m
$I_0 \times F_4$	4.86a	37.77ab	12.62a	19.42g	3.44m	11.67k
$I_1 \times F_1$	2.16f	33.81bc	11.71bc	26.41e	6.15e	16.18a
$I_1 \times F_2$	2.80e	35.85abc	8.91f	30.72c	6.38c	12.77h
$I_1 \times F_3$	4.30b	34.50abc	3.87j	33.17b	6.52b	13.03f
$I_1 \times F_4$	3.13d	37.98ab	3.85j	32.64b	6.29cd	14.26e
$I_2 \times F_1$	1.76g	37.80ab	4.68i	36.34a	6.32c	11.68k
$I_2 \times F_2$	3.50c	39.39ab	12.23ab	21.85f	6.23de	15.94b
$I_2 \times F_3$	3.56c	36.86abc	6.03h	32.72b	5.60g	12.42i
$I_2 \times F_4$	2.80e	31.24c	10.54d	30.61c	6.94a	12.19j
$I_3 \times F_1$	3.43c	35.94abc	5.06i	36.53a	5.90f	11.15m
$I_3 \times F_2$	2.10f	35.42abc	10.95d	33.36b	5.37ij	14.80d
$I_3 \times F_3$	4.16b	40.53a	7.74g	28.45d	5.14k	12.96g
$I_3 \times F_4$	2.10f	38.77ab	11.66c	25.37e	5.44hi	16.16a
Level of sig.	0.18	*	***	***	***	***
CV (%)	***	8.5	7.57	0.76	0.97	8.12

In a column, mean values with the same letter (s) or without letter do not differ significantly whereas mean values with different letters are significantly different (as per DMRT). * = Significant at 5% level of probability. I_0 = No irrigation, I_1 = One irrigation at 20 DAS, I_2 = Two irrigations at 20 and 40 DAS, I_3 = Three irrigations at 20, 40 and 60 DAS. F_1 = Recommended dose of inorganic fertilizer (RDF) (275-125-80-125-8 kg ha^{-1} of Urea, TSP, MOP, Gypsum and Zinc Sulphate), F_2 = Poultry manure @ 5 t ha^{-1}, F_3 = 75% RDF + poultry manure @ 2.5 t ha^{-1}, F_4 = 50%RDF + poultry manure @ 5 t ha^{-1}

Fiber and ash contents

Fiber content in cobs differ from leaves and stems. Cobs contain the lowest amount of fiber compare to leaves and stems irrespective of treatments. In cobs, the highest fiber (10.57%) was recorded in treatment $I_0 \times F_4$, which was at par with other treatment combinations except $I_3 \times F_3$ which was the lowest (8.36%) (*Table 2*). The highest (39.56%) and lowest (20.94%) fiber contents were recorded in leaves by the treatment combination of $I_0 \times F_2$ and $I_3 \times F_3$, respectively (*Table 3*). In stems, the highest (36.53%) fiber was recorded in $I_3 \times F_1$ which was at par with $I_2 \times F_1$ and the lowest value (21.85%) was found in $I_2 \times F_2$ (*Table 4*). Ash content differed significantly in cobs, leaves and stems of baby corn maize. The highest (7.59%) and lowest (5.25%) ash content in cobs were recorded in $I_2 \times F_3$ and $I_3 \times F_2$, respectively, while the highest ash in leaves (10.09%) and stems (6.94%) were recorded in $I_2 \times F_2$ and $I_2 \times F_4$, respectively (*Tables 2, 3* and *4*).

Moisture percentage

Moisture content also differed and relatively higher moisture content was found in cobs (*Table 2*). The highest moisture (17.86%) was recorded in $I_0 \times F_3$ which was statistically identical to $I_2 \times F_3$ and $I_2 \times F_3$ while the lowest moisture (13.28%) was found in $I_2 \times F_4$. In leaves the highest moisture in leaves (13.39%) in treatment $I_0 \times F_1$

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which was at par with $I_1 \times F_1$ (13.16%) while the lowest moisture (10.45%) was found in $I_2 \times F_2$ (*Table 3*). In stems, the highest moisture (16.18%) was found in $I_2 \times F_3$ which was at par with $I_3 \times F_4$ (*Table 4*).

Economic performance

The economic performance of baby maize in response to irrigation regimes and integrated fertilization has been presented in *Table 5*. The highest gross return from green fodder at 70 DAS was Tk. 12,120.00 to Tk. 69,540.00 while at 90 DAS (at harvest) gross return from green fodder and baby corn ranged from Tk. 1,32,930.00 to 3,14,370.00 ha^{-1} depending on treatment combinations. The highest gross return was obtained at 90 DAS Tk. 3,14,370.00 ha^{-1} in $I_1 \times F_1$ followed by $I_3 \times F_3$ (Tk. 3,09,180.00) and $I_2 \times F_3$ (Tk. 3,04,020.00). Result revealed a 20-day delay for cobs increased gross returns from Tk. 1,20,810.00 to 2,57,190.00 from 70 DAS to 90 DAS. The highest return increase was in $I_3 \times F_3$ (Tk. 2,57,190.00) followed by $I_1 \times F_3$ (2,48,130.00) and the lowest return increase was in $I_0 \times F_3$ (Tk. 1,20,810.00) (*Fig. 2*).

Table 5. *Returns (Tk ha^{-1}) from baby corn cultivation ha^{-1}*

Treatment (irrigation × nutrient)	Income from green fodder (Tk)	Income from green fodder (Tk)	Income from green cobs w/o husk (Tk)	Total income (Tk)	Income from additional 20 days (Tk)
	70 DAS	**90 DAS**	**90 DAS**	**90 DAS**	**90 DAS- 70 DAS**
$I_0 \times F_1$	41,250.00	71,100.00	1,72,800.00	2,43,900.00	2,02,650.00
$I_0 \times F_2$	12,120.00	42,330.00	90,600.00	1,32,930.00	1,20,810.00
$I_0 \times F_3$	19,410.00	60,840.00	1,43,000.00	2,03,840.00	1,84,430.00
$I_0 \times F_4$	15,000.00	46,500.00	1,38,000.00	1,84,500.00	1,69,500.00
$I_1 \times F_1$	69,540.00	89,970.00	2,24,400.00	3,14,370.00	2,44,830.00
$I_1 \times F_2$	31,260.00	60,840.00	97,800.00	1,58,640.00	1,27,380.00
$I_1 \times F_3$	55,890.00	74,220.00	2,29,800.00	3,04,020.00	2,48,130.00
$I_1 \times F_4$	44,130.00	79,620.00	1,96,800.00	2,76,420.00	2,32,290.00
$I_2 \times F_1$	43,410.00	75,150.00	2,07,600.00	2,82,750.00	2,39,340.00
$I_2 \times F_2$	14,730.00	42,540.00	96,600.00	1,39,140.00	1,24,410.00
$I_2 \times F_3$	48,030.00	73,050.00	1,58,400.00	2,31,450.00	1,83,420.00
$I_2 \times F_4$	42,060.00	84,090.00	1,47,000.00	2,31,090.00	1,89,030.00
$I_3 \times F_1$	60,000.00	82,290.00	1,79,400.00	2,61,690.00	2,01,690.00
$I_3 \times F_2$	25,260.00	50,700.00	1,36,800.00	1,87,500.00	1,62,240.00
$I_3 \times F_3$	51,990.00	78,180.00	2,31,000.00	3,09,180.00	2,57,190.00
$I_3 \times F_4$	34,560.00	64,530.00	1,82,400.00	2,46,930.00	2,12,370.00

I_0 = No irrigation, I_1 = One irrigation at 20 DAS, I_2 = Two irrigations at 20 and 40 DAS, I_3 = Three irrigations at 20, 40 and 60 DAS. F_1 = Recommended dose of inorganic fertilizer (RDF) (275-125-80-125-8 kg ha^{-1} of Urea, TSP, MOP, Gypsum and Zinc Sulphate), F_2 = Poultry manure @ 5 t ha^{-1}, F_3 = 75% RDF + poultry manure @ 2.5 t ha^{-1}, F_4 = 50%RDF + poultry manure @ 5 t ha^{-1}; Fodder: Tk 3.00/kg and baby corn (without husk) Tk 60.00/kg

Discussion

In accordance with the postulated hypothesis, irrigation scheduling and fertilization regimes had a significant influence on the yield attributes of dual-purpose maize crop. Plant height varied due to interactions between irrigation and nutrient management

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where the tallest plants were recorded with increasing levels of irrigation and conjunctive use of inorganic fertilizer and poultry manure or RDF, because irrigation and proper fertilization had a beneficial influence on plant growth (*Table 1*). It might be inferred that optimized growth factors (irrigation and fertilizer) triggered increased photosynthesis and ultimately rapid increases in plant height. In contrast, the highest number of cobs per plant was produced by one irrigation and RDF. Similar findings have been reported previously by Singh et al. (2016), who opined that increasing fertilizer dose resulted in an increase in the number of cobs per plant. The plants that were under well irrigated conditions with a supply of well-balanced fertilizer resulted in the highest number of cobs per plant and plants that were under no irrigation and supplied only poultry manure resulted in the lowest number of cobs per plant. Likewise, Dutta et al. (2015) reported that the highest number of cobs per plant and other yield components were obtained through maintenance of adequate moisture. Proper water supply has been reported to facilitate better growth and yield attributes in baby corn (Tenaw, 2000). The highest cob length with husk, cob diameter with husk, cob length without husk and cob diameter without husk were recorded in $I_3 \times F_3$, while the lowest values of the mentioned parameters were observed in the one irrigation and poultry manure (5 t ha^{-1}) treatment. This might be due to the fact that irrigation water increased the turgidity of cells, stomatal opening, increased net assimilation and ultimately resulted in better cob development. A similar observation was noticed by Roy et al. (2015), who inferred that irrigation regimes had significant influence on cob length and diameter. The highest cob yield without husk (3.86 t ha^{-1}) was recorded in 75% RDF + poultry manure @ (2.5 t ha^{-1}), which remained at par to $I_1 \times F_1$, $I_1 \times F_3$ and $I_1 \times F_4$. It might be interpreted that irrigation improved marketable fresh baby maize yield significantly due to the improvement in yield contributing characteristics. Patel et al. (2008) reported that optimal scheduling of irrigation led to increased cob yield of baby maize. Integrated use of both organic and inorganic manure has been reported to have a greater, positive effect on yield components and the total productivity of maize crop than the sole use of mineral fertilizer (Mahajan et al., 2007; Lone et al., 2013). Optimum irrigation along with fertilization (75% RDF + FYM) exhibited better yield of baby maize by Roy et al. (2015). Similar trends were reported by Jinjala et al. (2016) and Dadarwal et al. (2009), who opined that integrated manure management was an effective and biologically viable approach to boost maize yield under irrigated conditions, while the sole use of chemical fertilizers remained statistically suboptimal to integrated manure management. This might be due to better availability of required nutrients in the crop root zone by combined application of inorganic fertilizers and manure with proper soil moisture by irrigation, which probably enhances nutrient availability and uptake by baby corn roots. Thus, greater availability of photosynthates, metabolites and nutrients to develop reproductive structures seems to have resulted in increased productive plants, cob girth, cob length and cob weight with these integrated nutrient management treatments.

The highest green fodder yield (23.8 t ha^{-1}) at 70 DAS, fodder yield without green cob (29.99 t ha^{-1}), fodder yield with green cob at harvest (90 DAS) was found in treatment $I_1 \times F_1$ while the lowest green fodder yield (14.11 t ha^{-1}) was found under the treatment of $I_0 \times F_2$ (*Table 1*). Maximum green fodder yield was obtained from the application of high dose of inorganic fertilizer, which resulted in rapid vegetative growth of the plant. On the other hand, the plants that were planted in the rain fed condition with sole application of manure produced the lowest fodder yield. Water

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stress with only manure might have restricted root growth, which eventually hampered productivity of the green fodder of the baby corn plant. Irrigation has been reported to significant influence the green fodder yield of baby corn (Roy et al., 2015).

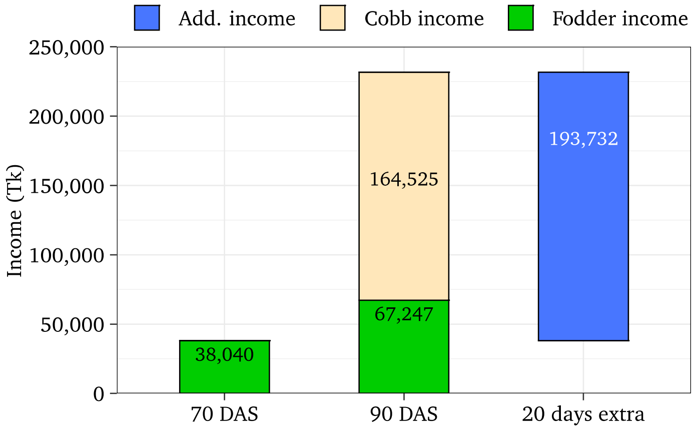

***Figure 2.** Additional income generated by growing green fodder and bay corn from the same crop. The values shown in the figures are pooled data from all treatment combinations*

Protein content in cobs remained significantly higher than the leaves and stems. The use of poultry manures combined with inorganic fertilizers yielded higher protein values in the cobs and leaves under irrigated conditions and in the stems under rain fed conditions. The crude protein content of baby corn increased significantly as total nitrogen uptake increased. Combined use of organic manure and chemical fertilizer improved protein content. Ravi et al. (2012) previously found that the use of 75% RDF along with other organic and bio-fertilizers significantly increased the protein content of maize. Irrigation scheduling with integrated fertilization regimes gave the highest protein content which might be due to available soil moisture, favorable soil conditions and synchronized release of plant nutrients throughout the crop growth period, which led to increased protein content of maize. This explanation agrees with the results of Roy et al. (2015), who inferred those integrated manures kept on supplying nutrients slowly over a longer period of time which boosted N supply and ultimately increased protein content.

In our study, CHO content differed significantly in the cobs, stems and leaves. Irrespective of treatments, CHO contents in cobs followed by stems and leaves. Yesmin et al. (2019) also reported that CHO content in baby maize was higher than other parts of plant. Sarker et al. (2020b) reported that application of 200 kg N ha^{-1} gave the highest carbohydrate and protein contents in baby maize as well as green fodder when collected from the same crop. Crude fat is one of the most important components of maize cobs while fat content increased in cobs, stems and leaves with higher irrigation and N supply. Similar results were reported by Ayub et al. (2003) and Yesmin et al. (2019), who inferred that optimized irrigation scheduling and N fertilization had positive influence on nutritional quality attributes.

Conclusions

The research findings support the postulated hypothesis as the irrigation scheduling and fertilization regimes had a significant influence on the yield attributes, herbage

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productivity, cob yield and profitability of maize. The results of this experiment suggest that adequate irrigation and optimum nutrient management might be vital for boosting baby corn yield (both green forage and young cob). Higher herbage yield from maize could be obtained by applying the recommended dose of fertilizers and one irrigation. However, for taking high quality forage (protein contents of cobs and stem), poultry manure (2.5 t ha^{-1}) should be supplemented with 75% of the recommended dose of fertilizers along with 3 irrigations. The economic analysis revealed that by growing maize as a dual purpose (baby corn and green fodder) crop and keeping the crop 20 more days than sole green fodder crop, that farmers can get a much higher gross income. Since growing maize as a dual-purpose crop is comparatively a new practice, more research should be conducted to determine the proper agronomic management practices.

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Data availability statement. The data presented in this study are available on request from the corresponding author. The data are not publicly available since these data are published for the first time. The authors have no problems providing them on request.

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