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Differences of Maize Fodder Yield and Crop Attributes under Different Irrigation and Nutrient Management

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Abstract: Irrigation and nutrient management are two vital components of modern agriculture playing crucial roles in ensuring optimal plant growth, maximizing crop yields and sustaining agricultural productivity. A field trial was conducted to evaluate how irrigation and nutrient management affect the growth characteristics and dry fodder yield of maize. The experiment involved four irrigation levels *viz.* no irrigation (I_0), one irrigation at 20 days after sowing (DAS) (I_1), two irrigations at 20 and 40 DAS (I_2) and three irrigations at 20, 40 and 60 DAS (I_3) and four fertilizer levels *viz.* recommended dose of fertilizers (RDF) (275-125-80-125-8 kg ha^{-1} of nitrogen, phosphorus, potassium, gypsum and sulphur) (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). The study was conducted with a split-plot layout and included three replications. Research results demonstrated significant impacts of both irrigation and nutrient management on growth metrics and the production of dry forage. At harvest, the highest plant height (177.72 cm), number of leaves plant^{-1} (12.16) and chlorophyll content (47.15) were recorded with three irrigations at 20, 40 and 60 DAS fertilized with 75% RDF + PM @ 2.5 t ha^{-1} whereas the highest total dry matter (40.60 g) and dry fodder yield (4.51 t ha^{-1}) was recorded with two irrigations at 20 and 40 DAS along with RDF. These results emphasize that maize can produce maximum dry fodder yield with two irrigations at 20 and 40 DAS along with RDF whereas three irrigations at 20, 40 and 60 DAS fertilized with 75% RDF + PM @ 2.5 t ha^{-1} obtained the superior growth traits of maize.

Keywords: Maize; Growth trait; Fertilization; Irrigation; Yield.

INTRODUCTION

Maize (*Zea mays* L.) holds a prominent status among global cereal crops, serving as a primary food source more extensively than any other cereal. Derived from the Americas approximately 7000 years ago, maize offers essential nutrients for humans and animals alike. Additionally, it acts as a versatile commodity, employed in producing oil, protein, starch, sweeteners, alcoholic beverage and even fuel. Its cultivation spans diverse climatic conditions worldwide, owing to its remarkable adaptability (Amanullah *et al.*, 2007; Chennankrishnan *et al.*, 2012). Renowned as the ‘queen of cereals’ maize boasts higher genetic yield potential compared to its cereal counterparts (Kannan *et al.*, 2013). Maize ranks as the third most significant cereal crop in Bangladesh, following rice and wheat, among South Asian nations. This flexible crop has various uses such as food, fodder, fuel and as a source material for different industrial products (Abbas *et al.*, 2021; Wasaya *et al.*, 2021; Hasan *et al.*, 2018). Maize cultivation for animal feed in Bangladesh is becoming more popular because of its potential for export and its significant role in creating job opportunities (Paul *et al.*, 2019; Sarker *et al.*, 2020).

To enhance water conservation and optimize water usage, it's crucial to adopt suitable irrigation techniques. Various strategies, especially in cultivating fodder have been experimented with to manage soil moisture levels and improve input efficiency. Changes in irrigation methods have a considerable effect on crop growth, including its various stages of development and ultimately, the amount of fodder produced (Sah *et al.*, 2020). However, it's evident that groundwater levels have been steadily declining over the past decade. To address this issue, a proper irrigation practices becomes imperative to make the most of available water resources. Fertilizers are crucial for boosting productivity in growing fodder (Abebe and Feyisa 2017). Utilizing chemical fertilizers can increase fodder production, but it's vital to consider their environmental effects and the extra costs they bring. Hence, employing fertilizers from various sources in moderation on crops or fodder can uphold environmental sustainability for future generations without causing harm to the environment (Dadarwal *et al.*, 2009). This strategy ensures that fertilizers are applied promptly at the right doses to address the gap between the nutrient needs of high-yield crops and the available nutrient levels. The simultaneous use of natural fertilizers and synthetic fertilizers promotes beneficial soil conditions, including improved microbial activity and nutrient accessibility (Roy *et al.*, 2018; Mushtaree *et al.*, 2022; Rahman *et al.*, 2023).

Irrigation and fertilization are critical factors that restrict the growth of maize and fodder on a global scale (Paul *et al.*, 2023). Previous studies have indicated that drought can greatly reduce fodder productivity but there have been noticeable increases in yield when using more nitrogen-based fertilizers. Besides fertilizer usage, the decrease in fodder yield has also been associated with water scarcity for irrigation. There are substantial research gaps regarding effective management of nutrients and irrigation to improve maize quality. This study sought to identify the optimal combination of irrigation timing and fertilizer methods to maximize both maize cob yield and growth characteristics.

MATERIALS AND METHODS

Experiment Site

The trial took place at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh. The experimental field was located at $24^{0}75^{'}$N latitude and $90^{0}50^{'}$E longitude at an average altitude of 18 m. The experimental field was medium to high land topography. It featured non-calcareous dark grey floodplain soil, specifically of the Sonatala series within the Old Brahmaputra Floodplain region (AEZ-9) (UNDP and FAO, 1988). The weather patterns throughout the experiment are detailed in (Figure 1) (Source: Weather Yard, Department of Irrigation and Water Management, Bangladesh Agricultural University, Mymensingh).

Experimental Details

The trial included four distinct irrigation levels: no irrigation (I_0), one irrigation at 20 days after sowing (DAS) (I_1), two irrigations at 20 and 40 DAS (I_2), and three irrigations at 20, 40 and 60 DAS (I_3). Additionally, there were four fertilizer levels: recommended dose of fertilizers (RDF) (275-125-80-125-8 kg ha^{-1} of nitrogen, phosphorus, potassium, gypsum and sulphur) (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). The study employed a split plot design with three repetitions wherein irrigation levels were designated to the main plots and fertilization treatments were randomly assigned to the sub-plots. This resulted in a total of 48 unit plots each measuring 2.25 m × 2.0 m. The distances between blocks and plots were 1 m and 0.5 m, respectively.

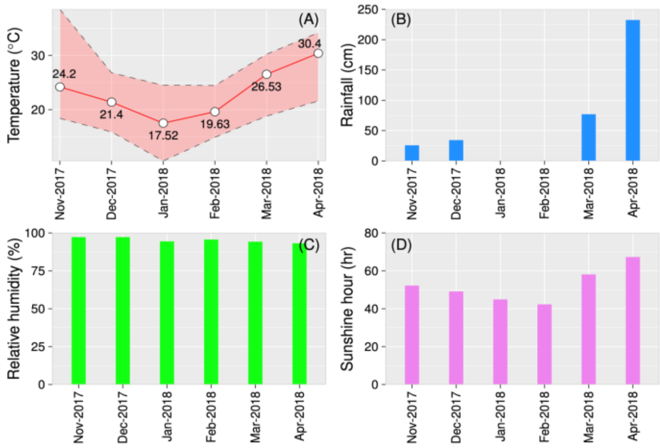

Figure 1. Distribution of monthly temperature, relative humidity, sunshine hour and rainfall of the experimental site during the crop growth period

Crop Management

The 'Baby Star' variety of maize, known for its high yield was chosen for cultivation. The land was meticulously prepared, first cultivated twice with a power tiller and then plowed three times with a traditional plow before being leveled with a harrow. After the land was prepared, it was laid out according to experimental specifications. Careful bunds were constructed around the experimental plot to facilitate irrigation based on treatment requirements. Poultry manure was spread onto the designated areas as prescribed and carefully incorporated into the soil before planting the seeds. Chemical fertilizers such as Urea, TSP, MOP, Gypsum and Zinc Sulphate were administered to each area according to the specific treatment regimen. One-third of the urea was applied as an initial dose just before planting, while the remaining two-thirds were divided equally and administered 20 and 40 days after planting. Furrows were opened using a marker to ensure proper spacing. Two to three seeds were placed in these furrows at a depth of 4-5 cm, maintaining appropriate distances of 20 cm between seeds and 45 cm between rows.

Data Collection

To collect data, five plants were chosen randomly and marked in each plot. Observations were made at different stages (30, 50 and 70 days after sowing and at harvest) to assess the impact of various treatments on plant growth and yield. Leaf chlorophyll levels were monitored as an indirect measure of nitrogen status using a portable SPAD meter (SPAD-502, Minolta crop, Ramsey, NJ). Measurements were taken from the selected plants at specified intervals

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and at different growth stages. To calculate total dry matter, samples were washed and then dried in an oven at a consistent temperature. The weight of each dried sample was noted and the total amount of dry matter produced per plant was expressed in grams.

Statistical Analysis

The average for each treatment was computed, and a statistical analysis was performed for each characteristic studied using the Statistix 10 software. Variations among treatments were assessed using Duncan's Multiple Range Test as outlined by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Plant Height

The impact of irrigation, nutrient management and their combined effects strongly impacted the height of maize plants. The maximum plant height (158.79 cm) was recorded from three irrigations at 20, 40 and 60 DAS (I_3) at harvest, which was at par with one irrigation at 20 DAS (I_1) and the lowest plant height (150.04 cm) was found with two irrigations at 20 and 40 DAS (I_2) (Table 1). In different fertilizers level, the maximum plant height (162.26 cm) was recorded in the plants application of 75% RDF + PM at 5 t ha^{-1} (F_3) which was at par with RDF (F_1) and the lower plant height (146.18 cm) recorded in application of PM at 5 t ha^{-1} (F_2) at harvesting stage (Table 1). While interacts, the highest plant height (177.72 cm) was recorded at harvest in the interaction of three irrigations at 20, 40 and 60 DAS fertilized with 75% RDF + PM at 2.5 t ha^{-1} ($I_3 \times F_3$) and the lowest one (143cm) was found in the plants of three irrigations at 20, 40 and 60 DAS fertilized with PM at 5 t ha^{-1} ($I_3 \times F_2$) (Table 2). The heightened growth of plants primarily results from effective irrigation and nutrient management techniques. Consistent access to water and nutrients, provided at the appropriate time, location and quantity near the roots throughout the cropping cycle, promotes greater leaf area leading to increased plant height. In general, nitrogen fertilization enhances the growth of crops by stimulating the production of protein and chlorophyll, which leads to taller plants and enhances their overall growth attributes. Haq (2006) found that combining organic and inorganic fertilizers led to a notable increase in the height of maize plants. Similarly, Kannan *et al.* (2013) discovered that employing integrated nutrient management methods had beneficial impacts on various growth aspects of maize, particularly enhancing plant height.

Number of Leaves Plant^{-1}

The number of leaves plant^{-1} was notably affected by irrigation, nutrient management and how these factors interacted with each other. At harvest the maximum number of leaves plant^{-1} (11.26) was found from three irrigation at 20, 40 and 60 DAS (I_3) which was at par with one irrigations at 20 DAS (I_1) and two irrigations at 20 and 40 DAS (I_2). The minimum number of leaves plant^{-1} (10.60) was found in no irrigation (I_0) (Table 1). At harvest with different levels of nutrients, the maximum number of leaves plant^{-1} (11.44) was found in the application of RDF (F_1) which was at par with 75% RDF + PM at 5 t ha^{-1} (F_3) and minimum (10.47) was found in PM at 5 t ha^{-1} (F_2) which was similar to 50% RDF + PM at 5 t ha^{-1} (F_4) (Table 1). While interacts, at harvest the highest (12.16) and the lowest (9.88) number of leaves plant^{-1} were recorded in three irrigation at 20, 40 and 60 DAS fertilized with 75% RDF + PM at 2.5 t ha^{-1} ($I_3 \times F_3$) and no irrigation fertilized with 50% RDF + PM at 5 t ha^{-1} ($I_0 \times F_4$) treatment combinations (Table 2). A balanced nutrient application across all growth stages, coupled with sufficient moisture, facilitated the attainment of greater leaf count and leaf area in maize crops. The increased leaf area was a result of taller plant growth, leading to more nodes per plant and consequently more leaves. Throughout the growth period, the presence of adequate soil moisture and nutrients supported crop development by matching the demand for water and nutrients. This ensured sustained photosynthetic activity over a longer period, contributing to overall plant growth. These discoveries align with the outcomes reported by Prajwalkumar (2018) and Chaithra (2021). This could be explained by the fast multiplication of meristematic cells and their elongation, facilitated by irrigation water. Irrigation water serves as a conduit for nutrient dissolution in soil, particularly benefiting plants experiencing less stress compared to those under relatively dry conditions (Desai *et al.*, 2022).

Leaf Chlorophyll Content

The amount of chlorophyll present was significantly influenced by various irrigation levels. At harvest the plant attained highest chlorophyll content (38.99) was found in three irrigations at 20, 40 and 60 DAS (I_3) which was at par with two irrigations at 20 and 40 DAS (I_2) and minimum (35.32) was found in one irrigation at 20 DAS (I_1) (Table 3). The integrated nutrient management greatly impacted the chlorophyll levels in maize. At harvest, the maximum chlorophyll content (40.84) was recorded in RDF (F_1) which was at par with 75 % RDF + PM at 2.5 t ha^{-1} (F_3) and minimum chlorophyll content (36.77) was found from the PM at 5 t ha^{-1} (F_2) (Table 3). The combined use of irrigation and integrated nutrient management substantially impacts the chlorophyll levels. At harvest, the highest (47.15) and the lowest (31.88) chlorophyll content was recorded from three irrigations at 20, 40 and 60 DAS along with 75% RDF + PM at 2.5 t ha^{-1} ($I_3 \times F_3$) and one irrigation at 20 DAS fertilized with PM at 5 t ha^{-1} ($I_1 \times F_2$) treatment combinations (Table 4). Generally, the enhanced growth of crops at an optimal moisture and nutrient appears to stem from its ability to positively influence both the soil and plant environment, thus facilitating the development of key morphological and biochemical components crucial for plant growth. Nitrogen is vital for chlorophyll synthesis, a process of significant importance in plant physiology.

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Table 1. Effect of irrigation and nutrient management on plant height and number of leaves plant^{-1} at different days after sowing

Treatments	Plant height (cm)				Number of leaves plant^{-1}			
	Days after sowing (DAS)				Days after sowing (DAS)			
	30	50	70	at harvest	30	50	70	at harvest
Irrigation level								
I_0	25.31a	46.29a	87.74b	154.67ab	4.80a	7.04a	9.45b	10.60b
I_1	26.98a	51.02a	103.30a	158.38a	5.08a	7.51a	10.82a	11.07ab
I_2	26.82a	49.02a	90.69b	150.04b	5.03a	7.64a	10.04ab	10.73ab
I_3	26.34a	48.83a	97.67ab	158.79a	4.75a	7.63a	10.62 a	11.26a
Sig. level	NS	NS	*	*	NS	NS	*	*
CV (%)	9.75	4.17	2.26	6.01	6.34	18.96	11.99	6.35
Fertilizer level								
F_1	28.74a	52.43a	111.16a	161.68a	5.14a	8.083a	10.88a	11.44a
F_2	23.94b	44.06b	78.08c	146.18b	4.35b	6.61b	9.56b	10.47b
F_3	25.56ab	49.37ab	96.08b	162.26a	5.09a	7.54a	9.99ab	11.23a
F_4	27.22ab	49.29ab	94.08b	151.76b	5.09a	7.59a	10.51a	10.52b
Sig. level	*	*	***	***	**	***	*	***
CV (%)	3.74	8.15	10.30	5.62	12.36	10.92	10.46	5.65

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, *** = Significant at 0.1% level of probability. Here, 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 (I_3). F_1 = Recommended dose of inorganic fertilizer (RDF) (275-125-80-125-8 kg ha^{-1} of Urea, TSP, MOP, Gypsum and sulphur), 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}.

Total Dry Matter

Total dry matter plant^{-1} was notably affected by different irrigation level (Table 3). At harvest, the maximum total dry matter plant^{-1} (32.05 g) was found in three irrigations at 20, 40 and 60 days after sowing (I_3) which was at par with two irrigations at 20 and 40 days after sowing (I_2) and minimum total dry matter plant^{-1} (24.45 g) was found in no irrigation (I_0). Total dry matter plant^{-1} had significant effect on number of leaves of maize at harvest (Table 3). At harvest the highest total dry matter plant^{-1} (32.10 g) was found from 50 % RDF + PM at 5 t ha^{-1} (F_4) which was at par with RDF (F_1) and minimum (25.31 g) was found in PM at 5 t ha^{-1} (F_2) which was at par with 75% RDF + PM at 2.5 t ha^{-1} (F_3). The combined influence of irrigation and integrated nutrient management greatly impacted the total amount on total dry matter plant^{-1} (Table 4). At harvest, the highest (40.60 g) total dry matter plant^{-1} was recorded in two irrigations at 20 and 40 days after sowing along with RDF ($I_2 \times F_1$) which was at par with one irrigation 20 days after sowing with 50% RDF + PM at 5 t ha^{-1} ($I_1 \times F_4$) and lowest (21.13 g) total dry matter plant^{-1} was recorded in one irrigation 20 days after sowing along with PM at 5 t ha^{-1} ($I_1 \times F_2$) combinations. Increasing irrigation levels and ensuring efficient nutrient distribution resulted in an increase in dry matter output, thereby improving crop growth rates. In a field experiment, it was found that the combined application of poultry manure and single super phosphate had a positive effect on maize growth indicators such as leaf area index and crop growth rate. This aligns with findings from Hussain (2014), which also showed that using a combination of organic and inorganic fertilizers enhanced total dry matter production in maize. Essentially, these results highlight the importance of not only providing adequate water but also ensuring that nutrients are supplied in a balanced manner to optimize the plant growth and maximize the productivity of maize and dry fodder.

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Table 2. Interaction effect of irrigation and nutrient management on plant height and number of leaves plant^{-1} at different days after sowing

Interactions	Plant height (cm)				Number of leaves plant^{-1}			
	Days after sowing (DAS)				Days after sowing (DAS)			
	30	50	70	at harvest	30	50	70	at harvest
$I_0 \times F_1$	26.30abc	52.47a	110.8ab	168.22ab	4.91ab	7.77abc	10.39a-d	11.11a-d
$I_0 \times F_2$	23.64bc	39.94b	77.00e	144.1ef	4.44ab	5.83d	8.55d	10.44de
$I_0 \times F_3$	23.75bc	45.97ab	77.78e	159.89bcd	5.00ab	7.22a-d	9.33cd	10.99bcd
$I_0 \times F_4$	27.55abc	46.78ab	85.33cde	146.47def	4.86ab	7.33a-d	9.55bcd	9.88e
$I_1 \times F_1$	29.72ab	54.53a	118.17a	166.67abc	5.43a	8.08ab	11.72a	11.66abc
$I_1 \times F_2$	22.19c	44.33ab	83.44de	151.94c-f	4.11b	6.77bcd	9.77bcd	10.72cde
$I_1 \times F_3$	26.61abc	52.72a	106.54abc	158.56b-e	5.27ab	7.55abc	10.66abc	11.11a-d
$I_1 \times F_4$	29.41ab	52.50a	105.06a-d	156.33b-f	5.50a	7.63abc	11.14abc	10.77cde
$I_2 \times F_1$	32.41a	53.16a	107.86ab	146.05def	4.86ab	8.05ab	10.19a-d	11.11bcd
$I_2 \times F_2$	23.73bc	48.72ab	74.42e	145.67def	4.63ab	7.41a-d	10.16a-d	10.27de
$I_2 \times F_3$	24.83bc	44.33ab	89.33b-e	152.89c-f	5.36ab	7.16a-d	9.47bcd	10.67cde
$I_2 \times F_4$	26.33abc	49.87ab	91.1bcde	155.55b-f	5.28ab	7.94abc	10.36a-d	10.88b-e
$I_3 \times F_1$	26.52abc	49.58ab	107.78ab	165.78abc	5.36ab	8.41a	11.22ab	11.89ab
$I_3 \times F_2$	26.19abc	43.27ab	77.4e	143.00f	4.22ab	6.44cd	9.77bcd	10.44de
$I_3 \times F_3$	27.08abc	54.48a	110.67ab	177.72a	4.72ab	8.25ab	10.50abc	12.16a
$I_3 \times F_4$	25.58bc	48.00ab	94.78b-e	148.67def	4.72ab	7.44abc	11.00abc	10.55de
Sig. level	*	*	*	*	*	*	*	*
CV (%)	3.74	8.15	10.30	5.62	12.36	10.92	10.46	5.65

In a column, mean values with the same letter (s) or without do not differ significantly whereas mean values with dissimilar letter differ significantly (as per DMRT). * = Significant at 5% level of probability. Here, 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 (I_3). F_1 = Recommended dose of inorganic fertilizer (RDF) (275-125-80-125-8 kg ha^{-1} of Urea, TSP, MOP, Gypsum and sulphur), 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}.

Table 3. Effect of irrigation and nutrient managements on chlorophyll content and total dry matter at different days after sowing

Treatments	Chlorophyll Content (SPAD value)				Total dry matter (g)			
	Days after sowing (DAS)				Days after sowing (DAS)			
	30	50	70	at harvest	30	50	70	at harvest
Irrigation level								
I_0	26.61b	34.06b	36.52a	37.29ab	0.43b	2.18a	12.40a	24.45c
I_1	26.64ab	36.96a	37.52a	35.32b	0.47ab	2.54a	17.68a	27.39bc
I_2	27.47a	34.97ab	38.20a	38.82a	0.51a	2.33a	16.10a	30.95ab
I_3	28.07a	37.09a	38.54a	38.99a	0.48ab	2.38a	15.16a	32.05a

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Sig. level	*	**	NS	*	*	NS	NS	*
CV (%)	13.37	4.28	6.71	12.80	8.09	7.4	7.3	14.78
Fertilizer level								
F_1	26.42b	37.58a	39.71a	40.84a	0.47a	2.58a	20.81a	32.02a
F_2	26.12b	33.23b	32.20c	32.42c	0.47a	1.99a	10.13b	25.31b
F_3	26.58ab	36.15a	39.02a	40.40a	0.47a	2.57a	15.18ab	25.90b
F_4	27.6a	36.13a	36.86b	36.77b	0.48a	2.29a	15.21ab	32.10a
Sig. level	*	*	***	***	NS	NS	***	**
CV (%)	11.75	10.18	8.32	9.68	7.08	35.87	5.29	16.37

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, *** = Significant at 0.1% level of probability. Here, 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 (I_3). F_1 = Recommended dose of inorganic fertilizer (RDF) (275-125-80-125-8 kg ha^{-1} of Urea, TSP, MOP, Gypsum and sulphur), 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}.

Table 4. Interaction effect of irrigation and nutrient management on chlorophyll content and total dry matter at different days after sowing

Interaction	Chlorophyll content (SPAD value)				Total dry matter $plant^{-1}$ (g)			
	Days after sowing (DAS)				Days after sowing (DAS)			
	30	50	70	at harvest	30	50	70	at harvest
$I_0 \times F_1$	27.86ab	33.83b-e	41.84a	39.72bcd	0.44cde	2.73a	20.40abc	35.13abc
$I_0 \times F_2$	25.01ab	33.54cde	32.41de	33.60def	0.38 e	1.66a	7.73d	27.00de
$I_0 \times F_3$	27.69ab	33.84b-e	36.38bcd	41.87abc	0.46b-e	2.13a	9.33cd	29.23bcd
$I_0 \times F_4$	25.99ab	35.04a-e	35.47bcd	33.98def	0.44cde	2.20a	12.13a-d	36.83ab
$I_1 \times F_1$	25.90ab	38.95abc	44.19a	37.09c-f	0.40de	2.73a	21.33ab	27.60cde
$I_1 \times F_2$	25.89ab	33.72cde	30.38e	31.88f	0.43de	1.83a	10.86bcd	21.13e
$I_1 \times F_3$	26.23ab	37.60a-e	39.54abc	34.18def	0.45cde	2.90a	18.20a-d	24.16de
$I_1 \times F_4$	28.41a	37.59a-e	35.97bcd	38.14b-f	0.58a	2.70a	20.33abc	36.66ab
$I_2 \times F_1$	26.16ab	38.22a-d	42.73a	44.06ab	0.54abc	2.66a	23.46a	40.60a
$I_2 \times F_2$	27.47ab	32.35e	34.52cde	31.96ef	0.53abc	2.60a	10.40bcd	30.00bcd
$I_2 \times F_3$	26.88ab	32.93de	35.92bcd	38.40b-e	0.48a-d	2.26a	16.40a-d	24.93de
$I_2 \times F_4$	29.39a	36.36a-e	39.64ab	40.89abc	0.49a-d	1.80a	14.13a-d	28.26cde
$I_3 \times F_1$	25.77ab	39.32ab	42.09a	42.50abc	0.48a-e	2.20a	18.06a-d	24.76de
$I_3 \times F_2$	26.11ab	33.31de	31.48de	32.23ef	0.56ab	1.86a	11.53bcd	23.13de
$I_3 \times F_3$	25.50ab	40.22a	44.24a	47.15a	0.46b-e	3.00a	16.80a-d	25.26de
$I_3 \times F_4$	22.90b	35.52a-e	36.35bcd	34.09def	0.41de	2.46a	14.26a-d	26.63de
Sig. level	*	*	*	*	*	NS	*	*
CV (%)	11.75	10.18	8.32	9.68	7.08	35.87	5.29	6.37

In a column, mean values with the same letter (s) or without do not differ significantly whereas mean values with dissimilar letter differ significantly (as per DMRT). * = Significant at 5% level of probability. Here, 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 (I_3). F_1 = Recommended dose of inorganic fertilizer (RDF) (275-125-80-125-8 kg ha^{-1} of Urea, TSP, MOP, Gypsum and sulphur), 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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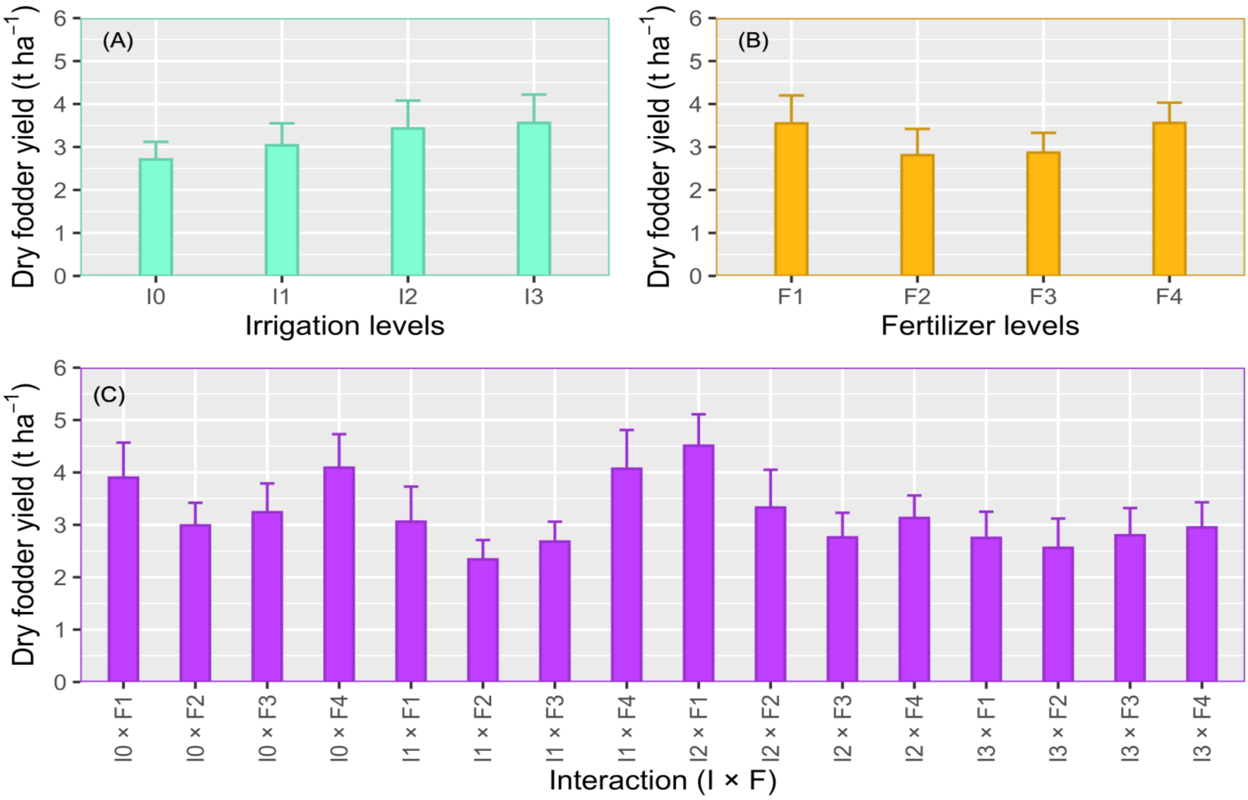

Figure 2. Interaction effect of irrigation and nutrient managements on dry fodder yield at different days after sowing

Here, 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 (I_3). F_1 = Recommended dose of inorganic fertilizer (RDF) (275-125-80-125-8 kg ha^{-1} of Urea, TSP, MOP, Gypsum and sulphur), 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}.

Dry Fodder Yield

The irrigation, nitrogen levels and their combined effects notably affected the quantity of dry fodder production at harvest (Figure 2). The maximum amount of dry fodder (3.56 t ha^{-1}) was observed when three irrigations applied at 20, 40 and 60 DAS (I_3), which was similar to the yield obtained with two irrigations at 20 and 40 DAS (I_2). Conversely, the lowest total dry fodder yield (2.71 t ha^{-1}) was found when no irrigation was applied (I_0). At the time of harvest, the highest yield of dry fodder (3.56 t ha^{-1}) was obtained from plots treated with 50 % recommended dose of fertilizer (RDF) along with PM at a rate of 5 t ha^{-1} (F_4), which was comparable to the yield achieved with RDF alone (F_1). Conversely, the lowest yield (2.81 t ha^{-1}) was obtained from plots treated solely with PM at 5 t ha^{-1} (F_2), which was similar to the yield obtained with 75% RDF along with PM at a rate of 2.5 t ha^{-1} (F_3). Regarding the interaction between irrigation and fertilizer treatments, the highest yield of dry fodder (4.51 t ha^{-1}) was observed when two irrigations were applied at 20 and 40 DAS in conjunction with RDF ($I_2 \times F_1$), while the lowest yield (2.34 t ha^{-1}) was recorded when only one irrigation was applied at 20 DAS along with PM at a rate of 5 t ha^{-1} ($I_1 \times F_2$). These results underscore the significance of employing coordinated approaches to manage water and nutrients for maximizing dry fodder production in agricultural settings. The findings suggest that the highest dry fodder yield was achieved through the application of substantial amounts of synthetic fertilizer, promoting rapid vegetative growth in the plants. Conversely, crops grown solely under rainfed conditions supplemented with poultry manure exhibited the lowest fodder yields. This difference in yield could be attributed to the accelerated division and elongation of meristematic cells facilitated by irrigation, which serves as a medium for nutrient dissolution in the soil, particularly due to the presence of sufficient moisture compared to plants experiencing water stress. Nitrogen emerges as a crucial nutrient for maize fodder, playing a pivotal role in various biological processes such as photosynthesis through its incorporation into chlorophyll pigment as well as facilitating water and mineral absorption. Thus, providing a sufficient provision of nitrogen fertilizers to the developing crop is crucial for attaining maximum growth and yield (Roy *et al.*, 2024; Khatun *et al.*, 2023). This assertion aligns with previous studies highlighting the importance of nitrogen management in enhancing crop performance and productivity (Asibi, 2019; Ciampitti, 2012).

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CONCLUSION

The highest dry fodder yield was found when three irrigations applied at 20, 40 and 60 DAS, which was at par with two irrigations at 20 and 40 DAS. The highest dry fodder yield was obtained from when treated with 50% recommended dose of fertilizer (RDF) along with poultry manure @ 5 t ha^{-1}, which was comparable to the yield achieved with RDF alone. Regarding the interaction between irrigation and fertilizer treatments, the highest yield of dry fodder was observed when two irrigations were applied at 20 and 40 DAS fertilized with RDF while the lowest yield was recorded when only one irrigation (at 20 DAS) along with poultry manure @ 5 t ha^{-1}.

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Conflict of Interest

The authors certify that they have no financial or other competing interests to disclose with relation to the current work.

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