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Response of Irrigation and Nitrogen Fertilization on Uptake of Primary Nutrients by Maize

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was accomplished from November 2018 to April 2019 at the site for agricultural research of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh to assess the effect of irrigation and nitrogen application on uptaking of primary nutrients by maize plant. A Randomized Complete Block Design (RCBD) with two factors and three replications was used to execute the experiment. Four irrigation treatments (I_1, I_2, I_3 and I_4: irrigation concerning 20%, 40%, 60% and 80% of soil available water, respectively) as factor A and three nitrogen doses [N_1, N_2 and N_3: Nitrogen application at 75%, 100% and 125% of prescribed dose (PD) as per fertilizer recommendation guide (FRG)] as factor B was implemented. The crop responded

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significantly in uptaking N, P, K to different levels of irrigation and nitrogen. The uptake of N at its highest level (141.66 Kg ha^{-1}) was observed in treatment I_3N_3 but the maximum uptake of P (49.17 Kg ha^{-1}) and K (159.39 Kg ha^{-1}) were found under the treatment I_4N_2. The addition of irrigation and nitrogenous fertilizer also enhanced the N (0.08%), P (8.75 ppm) and K (0.18 meq/ 100g) content of post-harvest soils. The maximum total consumptive use of water of the crop was found to be 446 mm in I_4 treatment regardless N levels. Irrigation at 80% of soil available water using 100% N on prescribed dose (I_4N_2), appeared to be the most acceptable combination for optimal nutrient absorption by maize in the specified region.

Keywords: Irrigation; nitrogen; phosphorus; potassium; uptake.

1. INTRODUCTION

The widespread implementation of fertilizer and irrigation has increased crop output and food security over the past few decades. For the purpose of growing food crops, irrigation and fertilization are crucial as they strengthen soil fertility and growth environment by modifying the soil water contents and nutrients availability which enhance crop yield and nutrient uptake by plants. Therefore, for greater soil health and more profitable crop production, it is essential to improve the usage of the available water and fertilizer [1].

Maize is considered as the third most dominant food crop in the world. It is commonly known as the "miracle crop" considering its high genetic potential than other cereal crops. In Bangladesh, it is thought to be most significant food crop after rice and wheat because of its diversified uses. The grain of Maize is used to make a wide range of food items including soup, bread, corn flakes, khichuri, bhutta polao etc. Starch, protein, oil, fiber, and minerals are plentiful in maize grain [2]. According to certain investigations, maize is regarded as richer in nutrients than rice in terms of protein, phosphorus, and carotene [3]. Maize is becoming more popular in the world because of its flexible characteristics of adaptability to versatile agro-climates. It responds significantly well to management factors, particularly irrigation and nitrogen.

One of the key components of agricultural techniques is irrigation. The performance of a plant mostly relies on water status of soil as an ideal water level is necessary for many important physiological processes in plants [4]. Optimum moisture level facilitates the supply of required nutrients and their successive assimilation by plants. On the other hand, a lack of water causes a crop to uptake lower amount of nutrients, which results in a reduction of crop yield and quality [5]. So, effective irrigation planning is essential for better agricultural production and water use efficiency.

Nutrients have a prominent role in the growth and development of plants. Nitrogen, phosphorus and potassium are known as the primary plant nutrients. These nutrients stimulate plants enzymatic activity and biochemical processes which promote plant growth. Deficits of nutrients may impact plant health and ultimately crop yield [6]. Nitrogen is one of the primary nutrients that involves in the improvement of crop productivity and soil fertility [7,8,9]. It is an integral ingredient of many plant molecules and also facilitates the way in which plants use potassium, phosphorus, and other elements. Nitrogen is very important for maize cultivation to achieve the highest yield potential. But nitrogenous fertilizer can be raised to a certain extent before having a negative impact on environment. [10,11].

Maize can use nitrogen at a maximum efficiency of about 50%, but with improper management, that efficiency can range from 30% to 40% [11]. Irrigation water liquefies the fertilizers which makes the nutrients accessible to the crop. So, for healthy crop growth giving appropriate irrigation and nutrients is vital at the right times in right amounts. Considering this viewpoint, an experiment has been performed to find out the best convenient combination of irrigation strategy and nitrogen level that will improve plant's uptake of primary nutrients as well as nutrients in soil.

2. MATERIALS AND METHODS

The experimental site was at the Bangabandhu Sheikh Mujibur Rahman Agricultural University's research farm in Gazipur, Bangladesh. The study was performed in the shallow red-brown terrace soil of Salna series under the order Inceptisols which is a part of AEZ-28 named Madhupur Tract. The average annual rainfall in the nation is 2500 mm, most of which falls during the monsoon season (June to October) but in the dry season, sometimes erratic or no rainfall occurs.

The minimum and maximum air temperature of the study area over the course of the experiment was laid between 13.1 to 32.87°C with a total precipitation of 400.81mm. The study area's initial soils of the was analysed for bulk density (1.41 g cm-3), porosity (47.4%), field capacity (30.1%), pH value about 5.8, organic carbon (0.62%), total nitrogen (0.062%), available phosphorus (7.22 mg kg^{-1}), available sulphur (12.01 mg kg^{-1}) and exchangeable potassium [0.15 cmol (+) kg^{-1}].

2.1 Experimental Design and Treatments

The experiment was run using a Randomized Complete Block Design (RCBD) with three replications. Two factors made up experimental treatments. Factor A included four irrigation schedules (I_1, I_2, I_3 and I_4: irrigation concerning 20%, 40%, 60% and 80% of soil available water, respectively) and factor B was formed with three dosages of nitrogen [N_1, N_2 and N_3: Application of fertilizer containing 75%, 100% and 125% of the prescribed nitrogen dose (PD) according to the fertilizer recommendation guide (FRG) developed by Bangladesh Agricultural Research Council (BARC)]

A high yielding maize cultivar BARI Hybrid Maize-9, released by Bangladesh Agricultural Research Institute (BARI) was served as the test crop in the experiment. After plowing and levelling the land, treatment wise plots were formed maintaining a unit plot size of 3 m × 2 m. Then N, P, K and S were applied as urea, triple super phosphate (TSP), muriate of potash (MoP) and Gypsum to meet the nutrient requirements of plants. One third of the N and the entire quantity of all other remaining nutrients were delivered at the final stage of land preparation. The remaining two thirds of N were top-dressed at knee height and tassel appearance. Seeds were sown at a distance of 75 × 25 cm on 5 December 2018 maintaining two seeds per hill. Intercultural actions were carried out when necessary. Prior to 40 days after emergence of seedlings, the soil was lightly watered 10 times to promote seed germination and seedling establishment. Later the soil was irrigated in line with the treatment strategy to raise the soil's moisture level up to field capacity.

The following formula was used to determine how much soil water was available to the plant

Available water= Field capacity-Wilting point

The amount of water applied through irrigation was calculated as follows:

$$IR = \{(MFC - MBI) \div 100\} \times \rho b \times D$$ Where,

IR= Irrigation requirement (cm).

MFC= Soil moisture (%) at field capacity,MBI= Soil moisture (%) before irrigation, ρb= Soil bulk density (g cm^{-3}) and D= Rooting depth (cm).

2.2 Harvesting and Data Collection

Harvesting of the crops was performed after turning 50-60% of the cobs into straw color from green. Four plants were randomly selected and tagged earlier in each plot for data collection. The plants were cut at the bottom, finely diced air-dried in the laboratory and finally oven-dried for 72 hours at 65°c. Then the oven-dried plant samples were grinded and prepared for chemical analysis.

Nutrient uptake from the soil was calculated by using the formula: Nutrient uptake = (% A x Y) ÷ 100 kg ha^{-1} [12]

Where,

%A = Nutrient content of plant dry matter in percent Y = Total dry matter production of plant (kg ha^{-1})

Soil moisture used by the crop was determined by using the following formula:

$$Sm = \{(MS - MH) / 100\} \times \rho b \times D$$

Where,

Sm = Soil moisture used by the crop (cm)

MS = Soil moisture percentage at sowing (weight basis)

MH = Soil moisture percentage at harvest (weight basis)

ρb = Bulk density (g cm^{-3})

D = Rooting depth (cm)

Total consumptive use of water was calculated by the following equation:

$$Wc = IR + Pe + Sm$$

Where,

Wc = Total consumptive of water (mm)

IR = Total amount of irrigation water applied (mm)

Pe = Effective rainfall (mm)

Sw = Soil moisture contribution (mm)

2.3 Analysis of Soil Primary Nutrients

Soil samples were analysed for assessing nitrogen, phosphorus and potassium contents. Total nitrogen was measured by Micro-kjeldahl method following concentrated sulphuric acid digestion and distillation with 40% NaOH. Then the evolved ammonia was collected in boric acid indicator and titrated against 0.02 N H2SO4 [13]. Available phosphorus was ascertained by Bray and Kurtz [14] method. Exchangeable potassium was extracted with 1 N NH4Ac as described by Jackson [15] and measured by Flame Photometer. Available Sulfur was obtained by turbid-metric method [16].

2.4 Statistical Analysis

Statistix 10 software was used to statistically evaluate the data for the various parameters. The Duncan's Multiple Range Test (DMRT) was applied to determine the difference between the treatment means.

3. RESULTS AND DISCUSSION

3.1 Irrigation Effect on the Uptake of Primary Nutrients

The uptake of primary nutrients N, P and K by maize plants responded significantly to various levels of irrigation. Data in Fig. 1. Presented that the maximum uptake of N, P and K (111.55, 30.94 and 121.63 kg ha^{-1} respectively) by maize was occurred under the treatment I_4 (irrigation concerning 80% of soil available water) and the minimum (44.87, 10.55 and 53.26 kg ha^{-1} respectively) was found under I_1 treatment (irrigation concerning 20% of soil available water). Increased irrigation frequency or treatment I_4 led to better plant uptake of nutrients through enhancing nutrients replenishment to soil solution and their subsequent uptake by plants. Similar findings were reported by Silber et al. [17].

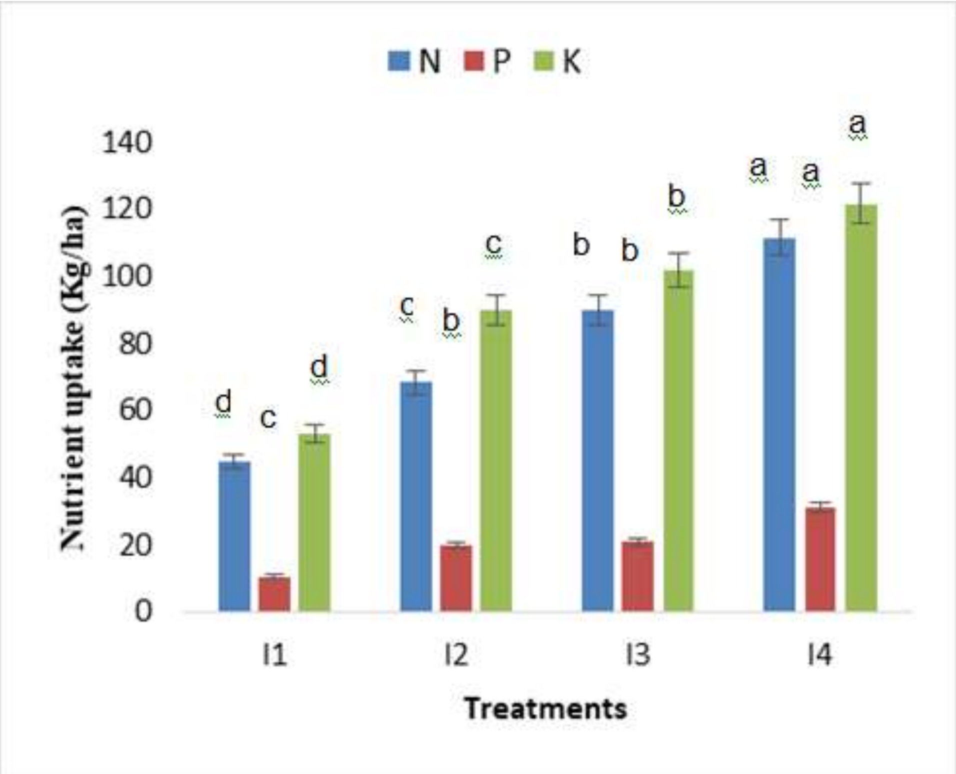

Fig. 1. Effect of various levels of irrigation on the uptake of primary nutrients by maize

3.2 Nitrogen Application Effect on the Uptake of Primary Nutrients

Application of nitrogen at different doses significantly influenced the uptake of N, P and K by maize plants (Fig. 2). The maximum N uptake (94.408 kg ha^{-1}) was observed under N_3 treatment (applying N at 125% of PD) whereas P (25.97 kg ha^{-1}) uptake was maximum under treatment N_2 (applying N 100% N of PD). The K (109.63 kg ha^{-1}) also gave the maximum result under N_2 treatment which was closely followed by the treatment N_3 (107.99 kg ha^{-1}) having no significance difference between them. The lowest N (54.810 kg ha^{-1}), P (11.27 kg ha^{-1}) and K (57.52 kg ha^{-1}) uptake was recorded under N_1 treatment (applying N at 75% of PD). According to the findings, applying more nitrogen enabled plants to superior uptake of nitrogen. On the other hand, lower nitrogen application resulted in decreased plant nutrient uptake rates due to inadequate availability of nitrogen and poor growth of the plants. 18. Morgan and Connolly [18] found alike results.

3.3 Interaction Effect on the Uptake of Primary Nutrients

Table1 illustrates the significant interactive effects of irrigation and nitrogen on the plant uptake of primary nutrients. The maximum uptake of N (141.66 kg ha^{-1}) was appeared in treatment I_3N_3 (irrigation concerning 60% of soil available water and applying N at 125% of PD) which was statistically equivalent to the treatment I_4N_2 (138.11 kg ha^{-1}) and I_4N_3 (130.01 kg ha^{-1}). The treatment I_4N_2 (irrigation concerning 60% of soil available water and applying N at 100% PD) also resulted in the greatest uptake of P (49.17 kg ha^{-1}) and K (159.39 kg ha^{-1}) respectively which was statistically close to the treatment I_3N_3 (151.05 kg ha^{-1}) in case of K uptake. The minimum uptake of N (28.67 kg ha^{-1}), P (6.39 kg ha^{-1}) and K (26.18 kg ha^{-1}) was found under I_1N_1 treatment. Maintenance of optimum soil moisture and N level has favored improved plant growth as well as transpiration rate, which facilitates nutrients uplift by plants. Similar outcomes were projected by Pirzad et al.[19].

3.4 Irrigation Effect on Soil Primary Nutrient Contents

Post-harvest soils were analyzed for determining the primary nutrient contents to assess the nutritional status of soils shown in Table 2. Among the primary nutrients nitrogen content in post-harvest soil was increased with increased level of irrigation while the highest amount of N (0.068%) was detected from the treatments I_4

Table 1. Interaction effect of irrigation and nitrogen on the uptake of primary nutrients by maize

Treatment (I × N)	N	P	K
	Kg ha^{-1}		
I_1N_1	28.67 d	6.39 j	26.18 g
I_1N_2	56.39 c	13.46 gh	75.48 e
I_1N_3	49.55 cd	11.82 hi	58.13 f
I_2N_1	65.90 bc	14.53 gf	74.82 e
I_2N_2	82.38 b	24.79 d	106.20 c
I_2N_3	56.41 c	20.67 e	89.29 d
I_3N_1	58.15 bc	10.41 i	57.07 f
I_3N_2	70.43 bc	16.46 f	97.47 cd
I_3N_3	141.66 a	35.45 b	151.05 a
I_4N_1	66.52 bc	13.75 gh	71.99 e
I_4N_2	138.11 a	49.17 a	159.39 a
I_4N_3	130.01 a	29.89 c	133.51 b
CV (%)	18.79	7.69	6.21
LSD (0.05)	25.03	2.68	28.34

Legends, I1N1: Irrigation at 20% soil available water (SAW) +N at 75% of prescribed dose (PD), I1N2: Irrigation at 20% SAW +N at 100% of PD, I1N3: Irrigation at 20% SAW +N at 125% of PD, I2N1: Irrigation at 40% SAW +N at 75% of PD, I2N2: Irrigation at 40% SAW +N at 100% of PD, I2N3: Irrigation at 40% SAW +N at 125% of PD, I3N1: Irrigation at 60% SAW +N at 75% of PD, I3N2: Irrigation at 60% SAW +N at 100% of PD, I3N3: Irrigation at 60% SAW + N at 125% of PD, I4N1: Irrigation at 80% SAW +N at 75% of PD, I4N2: Irrigation at 80% SAW + N at 100% of PD, I4N3: Irrigation at 80% SAW + N at 125% of PD

Table 2. Effect of irrigation level on the primary nutrient concentrations of post-harvest soil

Irrigation level	N (%)	P (ppm)	K (meq/100g soil))
I_1	0.041 b	7.57 a	0.148 ab
I_2	0.062 a	6.58 b	0.150 a
I_3	0.066 a	5.69 c	0.128 c
I_4	0.068 a	6.82 b	0.139 bc
CV (%)	10.89	8.72	8.67
LSD (0.05)	0.0063	0.57	0.01

Legends, I1, I2, I3 and I4: Irrigation concerning 20%, 40%, 60% and 80% soil available water

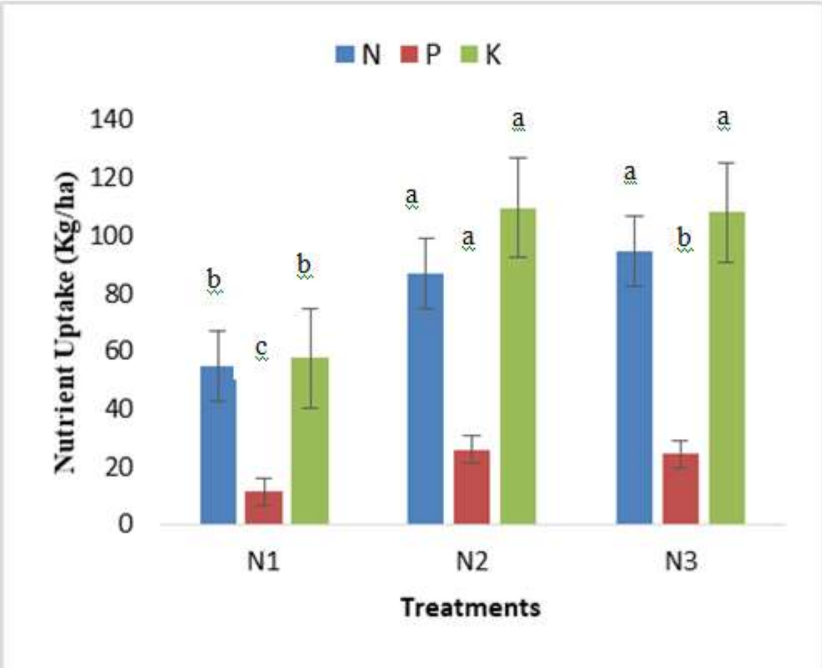

Fig. 2. Effect of various levels of nitrogen application on the uptake of primary nutrients by maize

following the treatments I_3 (0.066%) and I_2 (0.062%) having no discernible difference between them. The greatest level of P (7.57 ppm) and K (0.15 meq/100g soil) was obtained from I_1 and I_2 treatment respectively and the lowest (5.69 ppm P and 0.128 meq/100g soil K) was found under I_3 treatment (irrigation concerning 60% of soil available water). This study indicated the treatments with lesser nutrient uptake by plants experienced increased residual soil nutrients.

3.5 Nitrogen Application Effect Soil Primary Nutrient Contents

The effect of nitrogen application at various extents was found significant on primary nutrient contents in post-harvest soils with the exception of K content (Table 3). The K content in post-harvest soil did not show any significant difference, remaining at the same level in all treatments. However, N and P content varied significantly across the treatments where the maximum content was recorded under N_2 (0.069 % N) treatment (applying N at 100% of PD) and N_3 (7.36 ppm P) treatment (applying N at 125% of PD) respectively. These findings demonstrated that when the application of nitrogenous fertilizer increased the N and P content of post-harvest soils also improved. Similar findings also documented by Zhang et al [20].

3.6 Interaction Effect Soil Primary Nutrient Contents

Table 4 summarizes the interaction effects of irrigation and Nitrogen on primary nutrient contents viz. N, P and K in post-harvest Soil. The data indicated that treatments I_2N_2 and I_1N_3 resulted in the maximum residual N (0.08%)

followed by the treatments I_1N_2, I_2N_3 and I_4N_3 having same N content (0.07%) showing no significant differences among them and the lowest (0.05%) was observed with I_1N_1 and I_2N_1 treatments. According to these findings, the N content of soil was risen as the input of nitrogenous fertilizer increased as well as due to diminished leaching losses of N at lower to moderate moisture condition. The highest residual P status of post-harvest soil (8.75 ppm) was recorded with treatment I_1N_1 whereas I_3N_3 (8.46 ppm) and I_1N_3 (8.37 ppm) were remained in the same group. The maximum K content (0.18 meq/100g soil) was found with I_2N_1 treatment and the lowest (0.12 meq/100g soil) was with I_3N_1 treatment. Similar findings were documented by Navera et al [21].

3.7 Interaction Effect on Soil Moisture Contribution and Total Consumptive Use of Water

The interaction effects of irrigation and nitrogen on soil moisture contribution and total consumptive use of water of maize are shown in Fig. 3. The soil moisture contribution was found maximum with treatment I_1N_3 (14.15 mm) and closely followed by the I_1N_2 (13.74 mm), I_1N_1 (13.53 mm), I_2N_2 (10.63 mm) whereas, the minimum was observed with I_4N_1 (3.32 mm) treatment. This means more irrigation was given for less water contribution by soil as irrigation might partially fulfilled the moisture requirement of crop but on the contrary , natural soil moisture content alone I_1N_3 (14.15 mm), can contribute for the moisture retention in the soil. Irrespective of N-levels the soil moisture contribution followed the order $I_1 > I_2 > I_3 > I_4$. The maximum total consumptive use of water (445.73 mm) was recorded with I_4N_3 treatment followed by I_4N_2 **(**445.48 mm) and I_4N_1 **(**444.12 mm) and the minimum was attained from treatment I_1N_1 (284.63 mm). The results indicated that irrigation at 80% available water that is to say, with highest irrigation frequency (I_4 treatment) total consumptive use of water by plants was highest than all other treatments.

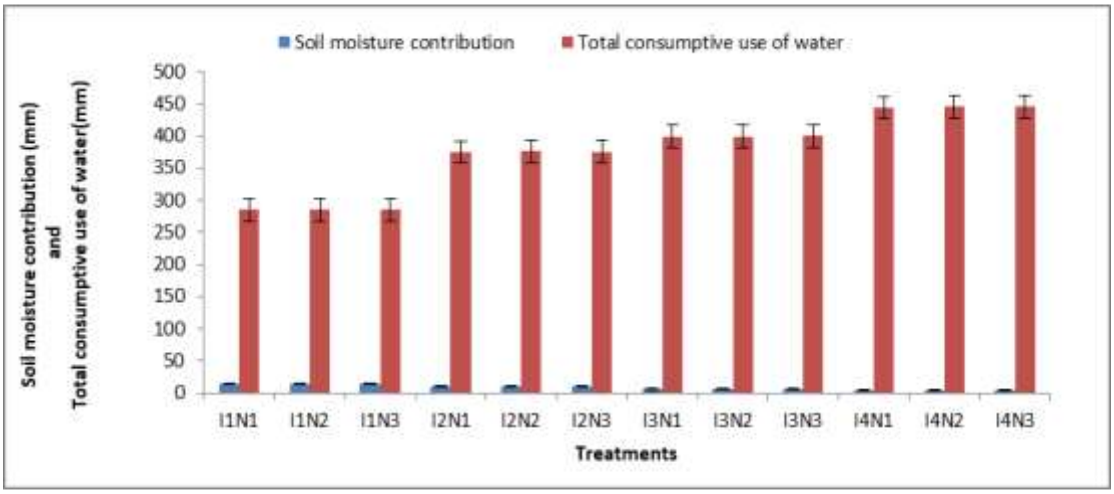

Fig. 3. Soil moisture contribution (mm) and total consumptive use of water (mm) as affected by combined application of irrigation and nitrogen

Table 3. Effect of nitrogen level on the primary nutrient concentrations of post-harvest soil

Nitrogen level	N (%)	P (ppm)	K (meq/100g soil))
N_1	0.056 b	6.48 b	0.14
N_2	0.069 a	6.15 b	0.14
N_3	0.053 b	7.36 a	0.14
CV (%)	10.89	8.72	8.67
LSD (0.05)	0.0055	0.49	0.01

Legends, N1, N2 and N3: Applying N at 75%, 100% and 125% of prescribed dose (PD) as per fertilizer recommendation guide, 2012 (FRG)

Table 4. Interaction effect of irrigation and nitrogen on nitrogen, phosphorus and potassium contents of post-harvest soil

Treatment (I × N)	N (%)	P (ppm)	K (meq/100g soil)
I_1N_1	0.05 c	8.75 a	0.15 bc
I_1N_2	0.07 ab	5.59 d	0.14 bc
I_1N_3	0.08 a	8.37 ab	0.15 bc
I_2N_1	0.05 c	5.75 d	0.18 a
I_2N_2	0.08 a	6.87 c	0.14 bc
I_2N_3	0.07 ab	7.12 c	0.14 bc
I_3N_1	0.05 c	4.05 f	0.12 d
I_3N_2	0.06 c	4.55 ef	0.14 bcd
I_3N_3	0.06 c	8.46 ab	0.15 bc
I_4N_1	0.06 c	7.37 c	0.13 bcd
I_4N_2	0.06 c	7.60 bc	0.15 b
I_4N_3	0.07 ab	5.48 de	0.13 cd
CV (%)	10.89	8.72	8.67
LSD (0.05)	0.01	0.98	0.02

Legends, I1N1: Irrigation at 20% soil available water (SAW) +N at 75% of prescribed dose (PD), I1N2: Irrigation at 20% SAW +N at 100% of PD, I1N3: Irrigation at 20% SAW +N at 125% of PD, I2N1: Irrigation at 40% SAW +N at 75% of PD, I2N2: Irrigation at 40% SAW +N at 100% of PD, I2N3: Irrigation at 40% SAW +N at 125% of PD, I3N1: Irrigation at 60% SAW +N at 75% of PD, I3N2: Irrigation at 60% SAW +N at 100% of PD, I3N3: Irrigation at 60% SAW + N at 125% of PD, I4N1: Irrigation at 80% SAW +N at 75% of PD, I4N2: Irrigation at 80% SAW + N at 100% of PD, I4N3: Irrigation at 80% SAW + N at 125% of PD

4. CONCLUSION

The extreme uptake of primary nutrients by maize was resulted from providing irrigation at 80% of the soil available water with nitrogenous fertilizer at 100% of the dose suggested by the Fertilizer Recommendation Guide and irrigation at 60% available water employing 125%, prescribed dose. The treatments of irrigation and nitrogen levels stated above also contributed to the maximum total consumptive use of water by plant. The N, P, k contents of post-harvest soils was risen when the plant's uptake was reduced. The most effective combination for maize's optimal nutrient uptake in the targeted area seems to be irrigation at 80% of the soil's available water while supplying 100% N of the recommended dose.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Wang X, Xing Y. Effects of irrigation and nitrogen on maize growth and yield components. In Global changes and natural disaster management: geo-information technologies. Springer International Publishing .2017;63-74.
2. Reddy YR, Reddy GH. Principles of Agronomy. 3rd edn, Kalyani Publishers, Ludhiana, India. 2003; 203-11.
3. Rimmi SN, Islam MS, Alam MS, Khan MAR, Binte BI. Yield response of maize to irrigation and nitrogen fertilization. Agricultural Science Digest; 2022 DOI: 10.18805/ag.DF-493.
4. Patel JB, Patel VJ, Patel JR. Influence of different methods of irrigation and nitrogen levels on crop growth rate and yield of maize (*Zea mays L*.). Indian Journal of Crop Science. 2006;1(1and 2):175-177.
5. Prasanna AL, Bairagya MD, Devi TM, Zaman AU. Effects of irrigation regime and nitrogen level on yield and yield attributes of summer maize (*Zea mays L*.). International Journal of Current Microbiology and Applied Sciences. 2019; 8(7):727-733.
6. Jayachandran V, Seshadri P. Role of primary and secondary plant nutrients in crop production. Farm and factory; 1973.

7. Alam MS, Khanam M, Rahman MM. Environment-friendly nitrogen management practices in wetland paddy cultivation. Frontiers in Sustainable Food Systems. 2023;*7*:1020570.
8. Hasnat M, Alam MA, Khanam M, Binte BI, Kabir MH, Alam MS, Rahman MM. Effect of nitrogen fertilizer and biochar on organic matter mineralization and carbon accretion in soil. Sustainability. 2022;14(6):3684.
9. Rahman MM, Alam MS, Islam MM, Kamal MZU, Rahman GM, Haque MM, Biswas JC. Potential of legume-based cropping systems for climate change adaptation and mitigation. In Advances in Legumes for Sustainable Intensification. Academic Press. 2022:381-402.
10. Ghulam A, Abid H, Ashfaq A, Syed AW. Water use efficiency of maize as affected by irrigation schedules and nitrogen rates. Agricultural Journal of Social Science. 2005; 8(4):339-342.
11. Sajedi NA, Ardakani MR, Naderi A, Madani H, Mashhadi A, Boojar M.. Response of maize to nutrients foliar application under water deficit stress conditions. American Journal of Agriculture Biological Science. 2009;4(3):242-248.
12. Khanam M, Alam MS, Kamal MZU, Akter M, Binte BI, Alam MA. Efficacy of organic and inorganic fertilizers on growth, yield and nutrient uptake of cauliflower in acidic soil of Bangladesh. European Journal of Agriculture and Food Sciences. 2022; 4(3):24-29.
13. Black CA, Evans D, White JL, Ensminger LE, Clark FE. Methods of soil analysis. Part I and II. American Society of Agronomy, Inst. Publisher Madisson, Wisconsin.1965;1-1572.
14. Bray RH, Kurtz LT. Determination of total, organic and available form of phosphorus in soils. Journal of Soil Science. 1945; 59:39-45.
15. Jackson ML. Soil chemical analysis. Prentice-Hall of India (Pvt.) Ltd. New Delhi; 1962.
Available:https://doi.org/10.1002/jpln.1959 0850311
16. Hesse PR. A textbook of soil chemical analysis, Chemical Publication. *Co.,* New York. 1971.
17. Silber A, Xu G, Wallach R. High irrigation frequency: the effect on plant growth and on uptake of water and nutrients. In XXVI International Horticultural Congress: Toward Ecologically Sound Fertilization Strategies for Field Vegetable Production. 2002;627:89-96.
18. Morgan JÁ, Connolly EÁ. Plant-soil interactions: nutrient uptake. Nature Education Knowledge. 2013; 4(8):2.
19. Pirzad A, Shakiba MR, Zehtab-Salmasi S, Mohammadi SA, Darvishzadeh R, Samadi A. Effect of water stress on leaf relative water content, chlorophyll, proline and soluble carbohydrates in Matricaria chamomilla L. Journal of Medicinal Plants Research. 2011;5(12): 2483-2488.
20. Zhang R, Nie L, Huang M, Yang H, Shi C, Wei Y, Nie H. Effects of Irrigation and Nitrogen Application on Soil Nutrients in Triploid Populus tomentosa Stands. Forests. 2022;13(7):1046.
21. Navera UK, Mahmud MGA, Rahman MR. Irrigation water requirement for maize crop cultivation. Journal of Agricultural Water Management. 2009;15(2):74-95.

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