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Impact of Irrigation Scheduling and Nitrogen Management Through Drip Irrigation System on Nutrient Content and Uptake of *Rabi* Maize (*Zea mays* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The state of the soil's nutrients can be significantly impacted by improper irrigation and nitrogen application, which may accelerate nutrient losses and cause soil erosion and ground water pollution. A field experiment was conducted during consecutive two *rabi* seasons of the years 2021 and 2022 at Regional Research Station, Anand Agricultural University, Anand, Gujarat, India to study the "Impact of irrigation scheduling and nitrogen management through drip irrigation system on nutrient content and uptake of *rabi* maize (*Zea mays* L.)". The soil of the experimental field was loamy sand in texture, with low organic carbon and available nitrogen, medium available phosphorus and high potassium with soil pH 8.21. The experiment was carried out in split plot design with four levels of irrigation scheduling based on Alternate Day Pan Evaporation Fraction (ADPEF) were considered in main plot *viz*., I_1 : Irrigation scheduling at 0.8 ADPEF, I_2 : Irrigation

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scheduling at 1.0 ADPEF, I_3 : Irrigation scheduling at 1.2 ADPEF and I_4 : Control (Flood irrigation) and three nitrogen management treatments *viz*. N_1 : 100% RDN through inorganic fertilizer, N_2 : 75% RDN through inorganic fertilizer + Bio NPK consortium, N_3 : 50% RDN through inorganic fertilizer + Bio NPK consortium + 5 t/ha FYM were assigned in sub plots, comprised of 12 treatment combinations. Result of the experiment showed that irrigation scheduling at 1.2 ADPEF (I_3) recorded significantly higher N content in grain and stover and it was remained at par with irrigation scheduling at 1.0 ADPEF (I_2) during 2021, 2022 and pooled analysis. P and K content in grain and stover was found non-significant due to various irrigation scheduling treatments during individual years and on pooled basis. Irrigation scheduling at 1.2 ADPEF (I_3) recorded significantly higher N, P uptake by grain and stover and K uptake by grain during 2021, 2022 and on pooled basis. K uptake by stover found significantly higher under irrigation scheduling at 1.2 ADPEF (I_3) during 2021-22 and pooled basis. While K, uptake by stover found non-significant. Nitrogen management with 100% RDN through inorganic fertilizer recorded significantly the highest N content in grain and stover and pooled analysis. While, P and K content grain and stover found non- and pooled analysis. Application of 100% RDN through inorganic fertilizer found significantly higher N, P and K uptake by grain and stover and pooled basis. Interaction effect of irrigation scheduling and nitrogen management treatments was found significantly higher N uptake by grain and K uptake by stover (pooled basis) under irrigation scheduling at 1.2 ADPEF with 100% RDN through inorganic fertilizer (I_3N_1).

Keywords: Irrigation scheduling; nitrogen management; nutrient; content; uptake; maize; drip Irrigation.

1. INTRODUCTION

Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as “queen of cereals” because it has the highest genetic yield potential among the cereals.

Maize or Corn is the third most important cereal crop after rice and wheat for India. Globally it is highly valued for its multifarious uses as food, feed, fodder and raw material for large number of industrial products. It is grown on 188 million ha area in more than 170 countries across the globe with 1060 million MT of production. Worldwide China has maximum area under maize followed by USA, both together representing 39% of world maize area. Since 2005, India ranks 4th in terms of area with 9.2 million ha land under maize. The USA is the top maize producer followed by China, contributing 34% and 22% of world maize production. However, India remained among the top 10 producers of maize in the world since 1961 and presently ranks 7th with annual output of 28 million MT. Productivity of maize in India is little above 3 t/ha, which is very less than world average (5.6 t/ha) [1].

As maize is one of the most important cereal crop in our country, its demand is increasing day by day with our increasing population. To meet this rising demand, we should work towards maximizing maize production. This can be achieved only by maximizing productivity as there is no scope for increasing an area under production. Productivity can be maximized by adopting high yielding cultivars and appropriate agronomic practices like, optimum seed rate, time of sowing, irrigation scheduling, fertilizer uses, weed management and time of harvesting *etc*. Among all the above-mentioned factors, irrigation scheduling plays a vital role in enhancing yield.

Irrigation scheduling means deciding when to irrigate, how to irrigate and how much to irrigate. If we take irrigated crop of maize, we should know irrigation requirement of crop which can be known based on depletion of available moisture, critical growth stage for irrigation and climatological approaches. In climatological approach, we measure the value of pan evaporation. Since evaporation is directly related to ET (Evapotranspiration) of crop, irrigation scheduled based on necessity of the crop. This ADPEF (Alternate Day Pan Evaporation Fraction) method of irrigation scheduling is based on this approach itself, while on the basis of daily evaporation data we are applying irrigation on every alternate day.

After scheduling of irrigation, the most important things to be considered is how to irrigate *i.e.* method of irrigation. Mostly farmers adopt flood irrigation or which have very low irrigation efficiency like, micro irrigation. The estimated potential area that can be brought under micro irrigation in India is around 15 million ha [2].

Among all micro irrigation methods, drip irrigation has the highest efficiency of about 90%. Drip irrigation is actually the most efficient method of watering the crops. This is done through narrow tube that deliver water directly to the root zone.

Unlike all other food crops, maize also requires proper nutrient management for better growth and development. Nitrogen is vital plant nutrient and major determining factor required for maize production [3]. It is very essential for growth and makes up about 1-4% of dry matter of plants. Nitrogen is a component of protein and nucleic acids and when nitrogen is suboptimal, growth is reduced [4]. Its availability in sufficient quantity throughout the growing season is essential for optimum growth and development of maize. But at present, nitrogen is universally deficient in Indian soils with 99% of soils responding to nitrogen application [5]. Nitrogen also mediates the utilization of phosphorus, potassium and other elements in plant [6]. Plant uptake nitrogen in the form of nitrate (NO_3) and ammonia (NH_4) [7]. Optimal amount of these elements in the soil cannot be utilized efficiently if nitrogen is deficient in plants. Therefore, nitrogen deficiency can result in losses of maize yields.

The success of nutrient uptake and content mainly depends upon the application of irrigation and fertilizers. For that every attempt is necessary for achieving twin objectives of higher water and fertilizer use efficiency. Under these circumstances drip irrigation is one such hi-tech system and reported that water use efficiency is high as 70-90% [8].

2. MATERIALS AND METHODS

A field experiment was conducted on "Impact of irrigation scheduling and nitrogen management through drip irrigation system on nutrient content and uptake of *rabi* maize (*Zea mays* L.)" during *rabi* season of the year 2021-2022 and 2022-2023 in plot no. A 17 at Regional Research Station, Anand Agricultural University, Anand, Gujarat, India. Geographically, Anand is situated at 22^0 35' N latitude, 72^0 55' E longitude with an elevation of 45.1 m above the mean sea level.

The topography of the experimental field was level, had a moderate slope, and had adequate drainage. The soil, which is particularly deep and alluvial in nature, is known locally as Goradu soil and is emblematic of the area. The soil has a loamy sand texture. It was determined that the soil retains moisture fairly well. The soil responds well to manure, fertilizers and irrigation. It is quite suitable for variety of crops of tropical and sub - tropical regions. The depth of ground water table is being more than 10 meter. Hence, there is no any problem of high-water table in this area. The maize variety "GAYMH 3" was used in present investigation as a test crop. The field experiment was set up in a "Split Plot Design" (SPD) with three replications.

The main plot treatments consisted of four methods of irrigation scheduling based on Alternate Day Pan Evaporation Fraction (ADPEF) *i.e.*, I_1 : Irrigation scheduling at 0.8 ADPEF, I_2 : Irrigation scheduling at 1.0 ADPEF, I_3 : Irrigation scheduling at 1.2 ADPEF and I_4 : Control (Flood irrigation) and sub plot consisted of three nitrogen management treatments *i.e.*, N_1 : 100% RDN through inorganic fertilizer, N_2 : 75% RDN through inorganic fertilizer + Bio NPK consortium, N_3 : 50% RDN through inorganic fertilizer + Bio NPK consortium + 5 t/ha FYM, comprised of 12 treatment combinations. The experiment was conducted at same site during both the year without changing in randomization of treatments in experimental plot. Recommended dose of NPK, *viz*. 150 kg N, 60 kg P_2O_5 and 00 kg K_2O/ha was applied uniformly through urea, diammonium phosphate respectively. RDF of P_2O_5 was applied as a basal dose. While, nitrogen was applied in five equal split at basal, 20, 30, 40 and 50 DAS throgh drip system for different irrigation scheduling. Where, for the treatment I_4: Control (Flood irrigation) applied in furrow. The sowing of maize variety GAYMH 3 was done by dibbling method with 60 × 20 cm spacing with seed rate 20 kg/ha to maintain required plant population and plant-to-plant distance. The crop was harvested at maturity with the help of sickle and harvested produced of net plot was kept for sun-drying. The harvested crop was tied in labelled bundles and kept for sun-drying. Then the threshing was carried out. The observations were recorded on the different soil and plant parameters, viz. NPK content and uptake from grain and stover were recorded after harvest of crop during both the years.

3. RESULTS AND DISCUSSION

3.1 Nitrogen, Phosphurus and Potassium Content in Grain of Maize

3.1.1 Effect of irrigation scheduling

3.1.1.1 Grain

A detailed examination of the data presented in Table 1 showed that different irrigation schedule treatments during 2021–22, 2022–23, and pooled results had a substantial impact on nitrogen content in grain. Among the different treatments application to the *rabi* maize, irrigation scheduling at 1.2 ADPEF (I_3) was recorded significantly higher nitrogen content (1.76, 1.79 and 1.77%) in grain during 2021-22, 2022-23 as well as in pooled results, respectively and it was remained at par with irrigation scheduling at 1.0 ADPEF (I_2) and irrigation scheduling at 0.8 ADPEF (I_1) during 2021-22, 2022-23, Whereas on pooled basis irrigation scheduling at 1.2 ADPEF (I_3) at par with irrigation scheduling at 1.0 ADPEF (I_2). Significantly lower value of nitrogen content (1.66, 1.67 and 1.67%) in grain was recorded when crop irrigated through control (Flood irrigation) I_4 during 2021-22, 2022-23 as well as in pooled results, respectively. Application of nitrogen given through drip fertigation not only stimulated vegetative growth and foraging capacity of roots, but also encouraged the absorption, growth and translocation of more nutrients under high drip fertigation levels.

3.1.1.2 Stover

A perusal of data summarized in Table 2 revealed that the nitrogen content in stover was affected by various irrigation scheduling treatments during individual years and on pooled result. Among the different irrigation scheduling applied to the *rabi* maize, the irrigation scheduling at 1.2 ADPEF (I_3) was recorded significantly higher nitrogen content (0.698, 0.703 and 0.700%) in stover and it was remained statistically at par with irrigation scheduling at 1.0 ADPEF (I_2) during 2021-22 and 2022-23, respectively. Significantly lower nitrogen content (0.592, 0.612 and 0.602%) in stover was recorded when crop was irrigated through control (Flood irrigation) (I_4) during 2021-22 and 2022-23, respectively. The result might be due to Application of nitrogen given through drip fertigation not only stimulated vegetative growth and foraging capacity of roots, but also encouraged the absorption, growth and translocation of more nutrients under high drip fertigation levels.

3.1.2 Effect of nitrogen management

3.1.2.1 Grain

Analysis of data furnished in Table 1 indicated that the nitrogen content significantly affects by the various levels of nitrogen during both the year as well as pooled basic. It is apparent from the data that treatment receiving 100% RDN through inorganic fertilizer (N_1) recorded significantly the highest nitrogen content (1.80, 1.83 and 1.81%) in grain during 2021-22, 2022-23 as well as in pooled results, respectively Whereas, lower nitrogen content (1.60, 1.63 and 1.61%) in grain was recorded under the treatment receiving 50% RDN through inorganic fertilizer + Bio NPK Consortium + 5 t/ha FYM during 2021-22, 2022-23 as well as in pooled basis, respectively. Higher nitrogen content in N_1 treatment might be due to the application of 100% inorganic fertilizer through inorganic fertilizer. The essential elements like nitrogen were present with a considerable amount in treatment which probably promote the increase the nitrogen content in grain. These results are similar to those reported by Patel et al*.* [9] Dutta et al*.* [10] and Roja et al*.* [11].

Analysis of data furnished in Table 1 indicated that the phosphorus and potassium content in seed was not significantly affected by the various level of nitrogen during both the year as well as on pooled results.

3.1.2.2 Stover

Analysis of data furnished in Table 2 indicated that the nitrogen content was significantly affect by the various level of nitrogen during both the year as well as pooled basis. It is apparent from the data that treatment receiving 100% RDN through inorganic fertilizer (N_1) recorded significantly highest nitrogen content (0.747, 0.764 and 0.755%) during 2021-22, 2022-23 as well as in pooled results, respectively. In contrast to it, lower nitrogen content was recorded in 0.562, 0.569 and 0.565% during 2021-22, 2022-23 as well as in pooled basis, respectively. These might be due to the use of inorganic fertilizers recorded substantially higher nitrogen uptake by grain of maize. Addition of nitrogen in soil through adequate quantity of inorganic fertilizers which in turn enlarged efficiency of applied nitrogen resulted in higher uptake by stover.

Analysis of data furnished in Table 2 indicated that the phosphorus and potassium content in stover was not significantly affected by the various level of nitrogen during both the year as well as on pooled results.

3.2 Nitrogen, Phosphurus and Potassium Uptake in Grain of Maize

3.2.1 Nitrogen uptake by grain

3.2.1.1 Effect of irrigation scheduling

Analysis of data furnished in Table 3 indicated that irrigation scheduling at 1.2 ADPEF (I_3) was recorded significantly higher nitrogen uptake (111.47, 112.40 and 111.94 kg/ha) by grain during 2021-22, 2022-23 as well as in pooled results, respectively and it was remained statistically at par with irrigation scheduling at 1.0 ADPEF (I_2) during 2021-22, 2022-23 and pooled analysis. The significantly lower nitrogen uptake (89.90, 91.77 and 90.83 kg/ha) by grain was recorded when the crop was irrigated through control (Flood irrigation) I_4 during both the year as well as in pooled analysis, respectively. These might be due to adequate supply of required nutrient through irrigation scheduling at throughout the plant growth and also due to overall improvement in soil physico-chemical and biological properties might have increase the nitrogen uptake by maize grain. This result confirms the finding of Bhanvadia [12] Basava (2012), Dutta et al. [10] Pal [13] and Roja et al. [11].

3.2.1.2 Effect of nitrogen management

The mean data presented in Table 3 further indicated that the nitrogen uptake by grain was significantly affected by different level of nitrogen during both the year as well as pooled analysis. Significantly the highest nitrogen uptake (113.18, 114.38 and 113.78 kg/ha) was recorded in treatment receiving 100% RDN through inorganic fertilizer (N_1) during 2021-22, 2022-23 as well as in pooled results, respectively. In contrast to it, lower nitrogen uptake by grain was recorded in 80.61, 84.53 and 82.57 kg/ha was recorded during 2021-22, 2022-23 as well as in pooled results, respectively. The result might be due to adequate supply of required nutrient through inorganic fertilizers at early stage of plant growth and also due to overall improvement in soil physico-chemical and biological properties might have increase the nitrogen uptake by maize grain. This result confirms the finding of Bhanvadia [12] Basava (2012) and Lamm et al. [14].

3.2.1.3 Interaction effect

Analysis of data furnished in Table 5 indicated that interaction effect between drip irrigation scheduling and nitrogen management (I × N) for nitrogen uptake was found non-significant in the year 2021-22, While significantly affect during the year 2022-23 and in pooled basis, respectively. During the year 2022-23, application of irrigation scheduling through drip at 1.2 ADPEF and fertilized the crop with 100% RDN through inorganic fertilizer (I_3N_1) produced significantly maximum nitrogen uptake (122.96 kg/ha) and which was remained statistically at par with treatment combination I_2N_1 during 2021-22. Whereas, lower value of nitrogen uptake by grain of maize (67.53 kg/ha) was recorded under treatment I_4N_3 during 2022-23. Application of irrigation scheduling through at 1.2 ADPEF and fertilized the crop with 100% RDN through inorganic fertilizer (I_3N_1) produced significantly maximum nitrogen uptake (122.27 kg/ha) by grain during pooled analysis which was remained statistically at par with treatment combination I_2N_1 during pooled basis. Whereas, lower value of nitrogen uptake by grain of maize (66.89 kg/ha) was recorded under treatment I_4N_3 during pooled analysis.

3.2.2 Nitrogen uptake by stover

3.2.2.1 Effect of irrigation scheduling

The data presented in Table 4 indicated that, nitrogen uptake by maize stover was significantly affected due to different irrigation scheduling level during first year, second year and in pooled analysis. The irrigation scheduling at 1.2 ADPEF (I_3) recorded significantly higher nitrogen uptake (64.78, 67.53 and 66.16 kg/ha) by stover during 2021-22, 2022-23 as well as in pooled results, respectively and it was remained statistically at par with irrigation scheduling at 1.0 ADPEF (I_2) during 2021-22, 2022-23 and pooled analysis. The significantly lower nitrogen uptake (47.40, 51.48 and 49.44 kg/ha) by stover was recorded when crop was irrigated through control (Flood irrigation) (I_4) during both the year as well as in pooled analysis, respectively. Results might be due to adequate supply of required nutrient through irrigation scheduling at throughout the plant growth and also due to overall improvement in soil physico-chemical and biological properties might have increase the nitrogen uptake by maize grain. This result confirms the finding of Bhanvadia [12] Basava (2012), Dutta et al. [10] Pal [13] and Roja et al. [11].

3.2.2.2 Effect of nitrogen management

The mean data presented in Table 4 further indicated that the nitrogen uptake by stover was significantly affected by different level of nitrogen during both the year as well as pooled basis. Significantly the highest nitrogen uptake (68.59, 72.62 and 70.61 kg/ha) was recorded in treatment 100% RDN through inorganic fertilizer (N_1) during 2021-22, 2022-23 as well as in pooled results, respectively. In contrast to it, significantly the lowest nitrogen uptake (41.61, 45.04 and 43.33 kg/ha) by stover was recorded under treatment 50% RDN through inorganic fertilizer + Bio NPK + 5 t/ha FYM during 2021-22, 2022-23 as well as in pooled results, respectively.

The interaction effect between drip irrigation scheduling and nitrogen management (I × N) for nitrogen uptake by grain was found non-significant during 2021-22, 2022-23 and pooled analysis (Table 4).

3.2.3 Phosphorus uptake by grain

3.2.3.1 Effect of irrigation scheduling

Results presented in Table **3** indicated that, phosphorus uptake by maize grain was significantly affected due to different irrigation scheduling level treatments during 2021-22, 2022-23 and in pooled analysis.

Irrigation scheduling at 1.2 ADPEF (I_3) recorded significantly higher phosphorus uptake (19.95, 20.13 and 20.04 kg/ha) by grain during 2021-22, 2022-23 as well as in pooled analysis, respectively and it was remained at par with irrigation scheduling at 1.0 ADPEF (I_2) during 2021-22, 2022-23 and pooled analysis. The significantly lower phosphorus uptake (16.21, 16.48 and 16.34 kg/ha) by grain were recorded when crop irrigated through control (Flood irrigation) I_4 during both the year as well as in pooled results, respectively.

3.2.3.2 Effect of nitrogen management

The mean data presented in Table 3 indicated that the phosphorus uptake by grain was significantly affected by different level of nitrogen during both the year as well as pooled basis. Significantly higher phosphorus uptake (19.96, 19.97 and 19.96 kg/ha) was recorded in treatment 100% RDN through inorganic fertilizer (N_1) during 2021-22, 2022-23 as well as in pooled results, respectively and it was remaining at par with treatment N_2. it, significantly lower phosphorus uptake (15.02, 15.71 and 15.36 kg/ha) by grain was recorded under treatment N_3 during 2021-22, 2022-23 as well as in pooled results, respectively.

The interaction effect between drip irrigation scheduling and nitrogen management (I × N) for phosphorus uptake by grain was found non-significant during 2021-22, 2022-23 and in pooled analysis. (Table 3).

3.2.4 Phosphorus uptake by stover

3.2.4.1 Effect of irrigation scheduling

The mean data in Table 4 showed that irrigation scheduling at 1.2 ADPEF (I_3) was recorded significantly higher phosphorus uptake (15.23, 16.10 and 15.67 kg/ha) by stover during 2021-22 an in pooled analysis, respectively and it was remained statistically at par with irrigation scheduling at 1.0 ADPEF (I_2) during 2021-22, 2022-23 and pooled analysis. Significantly lower phosphorus uptake (12.58 and 13.70 and 13.14 kg/ha) by stover were recorded when crop irrigated through control (Flood irrigation) I_4 during 2021-22, 2022-23 and in pooled analysis, respectively.

3.2.4.2 Effect of nitrogen management

The mean data illustrated in Table 4 further indicated that the phosphorus uptake by stover was significantly affected by different level of nitrogen during both the year as well as in pooled analysis. Significantly higher phosphorus uptake (15.24, 16.09 and 15.67 kg/ha) by stover was recorded in treatment 100% RDN through inorganic fertilizer (N_1) during 2021-22, 2022-23 as well as in pooled analysis, respectively.

The interaction effect between drip irrigation scheduling and nitrogen management (I × N) for phosphorus uptake by stover was found non-significant during 2021-22, 2022-23 and in pooled analysis. (Table 4).

3.2.5 Potassium uptake by grain

3.2.5.1 Effect of irrigation scheduling

The mean data illustrated in Table 3 indicated that significantly higher potassium uptake (31.43, 31.55 and 31.49 kg/ha) by grain was found in irrigation scheduling at 1.2 ADPEF (I_3) during 2021-22, 2022-23 as well as in pooled analysis, respectively. It was remained at par with irrigation scheduling at 1.0 ADPEF (I_2) during 2021-22 and pooled basis and irrigation scheduling at 0.8 ADPEF (I_1) and irrigation

Table 1. Effect of irrigation scheduling and nitrogen management on N, P and K content by grain of *rabi* maize during 2021-22, 2022-23 and pooled basis

Treatments		N content in grain (%)			P content in grain (%)			K content in grain (%)		
		2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Main plot (Irrigation levels)										
I_1	Irrigation scheduling at 0.8 ADPEF	1.71	1.74	1.72	0.305	0.314	0.310	0.491	0.492	0.491
I_2	Irrigation scheduling at 1.0 ADPEF	1.73	1.76	1.75	0.306	0.311	0.309	0.490	0.496	0.493
I_3	Irrigation scheduling at 1.2 ADPEF	1.76	1.79	1.77	0.316	0.319	0.318	0.497	0.501	0.499
I_4	Control (Flood Irrigation)	1.66	1.67	1.67	0.300	0.305	0.303	0.484	0.490	0.487
S.Em. ±		0.02	0.02	0.01	0.009	0.012	0.007	0.011	0.013	0.009
C.D. at 5%		0.06	0.07	0.04	NS	NS	NS	NS	NS	NS
Sub Plot (Nitrogen levels)										
N_1	100% RDN through inorganic fertilizer	1.80	1.83	1.81	0.318	0.319	0.319	0.499	0.506	0.502
N_2	75% RDN through inorganic fertilizer + Bio NPK consortium	1.75	1.76	1.75	0.304	0.314	0.309	0.491	0.494	0.493
N_3	50% RDN through inorganic fertilizer + Bio NPK consortium + FYM at 5 t/ha	1.60	1.63	1.61	0.298	0.304	0.301	0.482	0.484	0.483
S.Em. ±		0.01	0.01	0.01	0.007	0.008	0.005	0.009	0.010	0.007
C.D. at 5%		0.04	0.04	0.03	NS	NS	NS	NS	NS	NS
I × N Interaction		NS	NS	NS	NS	NS	NS	NS	NS	NS
Significant year effect		-	-	NS	-	-	NS	-	-	NS

Table 2. Effect of irrigation scheduling and nitrogen management on N, P and K content by stover of *rabi* maize during 2021-22, 2022-23 and pooled basis

Treatments		N content in stover (%)			P content in stover (%)			K content in stover (%)		
		2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Main plot (Irrigation levels)										
I_1	Irrigation scheduling at 0.8 ADPEF	0.674	0.680	0.677	0.162	0.165	0.163	1.143	1.163	1.153
I_2	Irrigation scheduling at 1.0 ADPEF	0.693	0.696	0.695	0.164	0.166	0.165	1.148	1.167	1.157
I_3	Irrigation scheduling at 1.2 ADPEF	0.698	0.703	0.700	0.165	0.168	0.167	1.150	1.169	1.160
I_4	Control (Flood Irrigation)	0.592	0.612	0.602	0.159	0.165	0.162	1.142	1.175	1.158
S.Em. ±		0.012	0.010	0.008	0.003	0.004	0.003	0.017	0.016	0.012
C.D. at 5%		0.041	0.033	0.024	NS	NS	NS	NS	NS	NS
Sub Plot (Nitrogen levels)										
N_1	100% RDN through inorganic fertilizer	0.747	0.764	0.755	0.166	0.169	0.168	1.162	1.183	1.172
N_2	75% RDN through inorganic fertilizer + Bio NPK consortium	0.684	0.686	0.685	0.163	0.166	0.165	1.143	1.160	1.151

Treatments		N content in stover (%)			P content in stover (%)			K content in stover (%)		
		2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Main plot (Irrigation levels)										
N_3	50% RDN through inorganic fertilizer + Bio NPK consortium + FYM at 5 t/ha	0.562	0.569	0.565	0.158	0.163	0.160	1.132	1.164	1.148
S.Em. ±		0.010	0.007	0.006	0.003	0.004	0.002	0.012	0.010	0.008
C.D. at 5%		0.03	0.02	0.02	NS	NS	NS	NS	NS	NS
I × N Interaction		NS	NS	NS	NS	NS	NS	NS	NS	NS
Significant year effect		-	-	NS	-	-	NS	-	-	NS

Table 3. Effect of irrigation scheduling and nitrogen management on N, P and K uptake by grain of *rabi* maize during 2021-22, 2022-23 and pooled basis

Treatments		N uptake by grain (kg/ha)			P uptake by grain (kg/ha)			K uptake by grain (kg/ha)		
		2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Main plot (Irrigation levels)										
I_1	Irrigation scheduling at 0.8 ADPEF	92.76	95.91	94.34	16.51	17.34	16.93	26.39	27.13	26.76
I_2	Irrigation scheduling at 1.0 ADPEF	106.14	108.24	107.19	18.65	19.18	18.92	29.89	30.52	30.20
I_3	Irrigation scheduling at 1.2 ADPEF	111.47	112.40	111.94	19.95	20.13	20.04	31.43	31.55	31.49
I_4	Control (Flood Irrigation)	89.90	91.77	90.83	16.21	16.48	16.34	26.05	26.65	26.35
S.Em. ±		2.91	4.48	2.67	0.77	0.80	0.56	1.02	1.34	0.84
C.D. at 5%		10.07	15.50	8.23	2.68	2.78	1.72	3.55	4.63	2.60
Sub Plot (Nitrogen levels)										
N_1	100% RDN through inorganic fertilizer	113.18	114.38	113.78	19.96	19.97	19.96	31.33	31.67	31.50
N_2	75% RDN through inorganic fertilizer + Bio NPK consortium	106.41	107.33	106.87	18.52	19.18	18.85	29.79	30.20	29.99
N_3	50% RDN through inorganic fertilizer + Bio NPK consortium + FYM at 5 t/ha	80.61	84.53	82.57	15.02	15.71	15.36	24.20	25.02	24.61
S.Em. ±		2.12	1.54	1.31	0.58	0.67	0.44	0.68	0.89	0.56
C.D. at 5%		6.02	4.45	3.74	2.29	2.43	1.74	2.47	2.84	1.87
I × N Interaction		NS	Sig.	Sig.	NS	NS	NS	NS	NS	NS
Significant year effect		-	-	NS	-	-	NS	-	-	NS

Table 4. Effect of irrigation scheduling and nitrogen management on N, P and K uptake by grain of *rabi* maize during 2021-22, 2022-23 and pooled basis

Treatments		N uptake by stover (kg/ha)			P uptake by stover (kg/ha)			K uptake by stover (kg/ha)		
		2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Main plot (Irrigation levels)										
I_1	Irrigation scheduling at 0.8 ADPEF	54.05	57.53	55.79	12.81	13.82	13.31	90.46	97.34	93.90
I_2	Irrigation scheduling at 1.0 ADPEF	62.28	65.32	63.80	14.64	15.52	15.08	102.60	109.23	105.92
I_3	Irrigation scheduling at 1.2 ADPEF	64.78	67.53	66.16	15.23	16.10	15.67	106.38	111.83	109.10
I_4	Control (Flood Irrigation)	47.40	51.48	49.44	12.58	13.70	13.14	90.05	96.57	93.31
S.Em. ±		1.95	2.48	1.58	0.55	0.72	0.45	3.50	3.67	2.53
C.D. at 5%		6.76	8.59	4.87	1.90	2.49	1.39	12.09	NS	7.80
Sub Plot (Nitrogen levels)										
N_1	100% RDN through inorganic fertilizer	68.59	72.62	70.61	15.24	16.09	15.67	106.74	112.27	109.50
N_2	75% RDN through inorganic fertilizer + Bio NPK consortium	61.19	63.72	62.46	14.54	15.41	14.98	102.02	107.49	104.76
N_3	50% RDN through inorganic fertilizer + Bio NPK consortium + FYM at 5 t/ha	41.61	45.04	43.33	11.67	12.84	12.25	83.37	91.46	87.41
S.Em. ±		1.39	1.20	0.92	0.37	0.41	0.28	2.26	1.95	1.49
C.D. at 5%		4.07	3.58	2.71	1.22	1.21	0.80	6.38	5.55	4.23
I × N Interaction		NS	NS	NS	NS	NS	NS	NS	NS	Sig.
Significant year effect		-	-	NS	-	-	NS	-	-	NS

Table 5. Interaction effect of irrigation scheduling and nitrogen management on N uptake by grain and K uptake by stover of *rabi* maize

Treatments	N uptake by grain (kg/ha)			N uptake by grain (kg/ha)			K uptake by stover (kg/ha)		
	2022-23			Pooled			Pooled		
I \ N	N_1	N_2	N_3	N_1	N_2	N_3	N_1	N_2	N_3
I_1	109.54	104.68	73.50	108.95	104.45	69.61	105.22	103.28	73.22
I_2	117.06	111.90	95.75	116.85	111.33	93.39	113.30	107.52	96.94
I_3	122.96	112.93	101.32	122.27	113.17	100.38	115.84	109.07	102.41
I_4	107.94	99.83	67.53	107.06	98.55	66.89	103.67	99.16	77.10
S.Em. ±	3.07			2.62			2.98		
C.D. at 5%	8.90			7.49			8.46		

scheduling at 1.0 ADPEF (I_2) during 2022-23. Significantly lower potassium uptake (26.05, 26.65 and 26.35 kg/ha) by grain was recorded when crop was irrigated through control (Flood irrigation) I_4 during 2021-22, 2022-23 and pooled basis, respectively.

3.2.5.2 Effect of nitrogen management

Data presented in Table 3 showed that significantly higher potassium uptake (31.33, 31.67 and 31.50 kg/ha) by grain was recorded in treatment 100% RDN through inorganic fertilizer (N_1) during 2021-22, 2022-23 as well as in pooled basis, respectively. Which was remained statistically equivalent with N_2. Whereas, significantly the lowest potassium uptake (24.20, 25.02 and 24.61 kg/ha) by grain was recorded during both the year as well as in pooled results, respectively.

The interaction effect between drip irrigation scheduling and nitrogen management (I × N) for potassium uptake by grain was found non-significant during 2021-22, 2022-23 as well as in pooled analysis. (Table 3).

3.2.6 Potassium uptake by stover

3.2.6.1 Effect of irrigation scheduling

The data presented in Table 4 showed that significantly higher potassium uptake (106.38 and 109.10 kg/ha) by stover was found in irrigation scheduling at 1.2 ADPEF (I_3) during 2021-22 and pooled analysis, respectively. It was remained at par with irrigation scheduling at 1.0 ADPEF (I_2) during 2021-22 and pooled basis. The significantly lower potassium uptake (90.05 and 93.31 kg/ha) by stover were recorded when crop irrigated through control (Flood irrigation) I_4 during 2021-22 and pooled basis, respectively.

3.2.6.2 Effect of nitrogen management

The mean data presented in Table 4 further indicated significantly higher potassium uptake (106.74, 112.27 and 109.50 kg/ha) by stover was recorded in treatment 100% RDN through inorganic fertilizer (N_1) during 2021-22, 2022-23 as well as in pooled basis, respectively and it was remained statistically at par with treatment N_2 during the year 2021-22 and 2022-23. In contrast to it, significantly lower value of potassium uptake (83.37, 91.46 and 87.41 kg/ha) by stover was recorded during both the year as well as in pooled analysis, respectively.

3.2.6.3 Interaction effect

Analysis of data furnished in Table 5 showed that I_3: Irrigation scheduling at 1.2 ADPEF and fertilized the maize crop with N_1: 100% RDN through inorganic fertilizer which means treatment combination I_3N_1 produced significantly maximum potassium uptake (115.84 kg/ha) by stover in pooled analysis, which was remained statistically at par with treatment combination I_2N_1, I_3N_2 and I_2N_2) on pooled results.

4. CONCLUSION

Significantly higher N content in grain and stover were observed when crop irrigated with irrigation scheduling at 1.2 ADPEF and 100% RDN through inorganic fertilizer was recorded significantly higher nitrogen content. While, P and K content in grain and stover remained non-significant. N, P and K uptake by grain and stover were recorded significantly higher under treatment irrigation scheduling at 1.2 ADPEF and 100% RDN through inorganic fertilizer. While, interaction effect was found significantly higher under treatment irrigation scheduling at 1.2 ADPEF with 100% RDN through inorganic fertilizer for N uptake by grain and K uptake by stover.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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