Journal of Applied and Natural Science
14(2), 443 - 449 (2022)
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Research Article

Climate nutrient management for various sources and levels of fertilizers on soil nutrients, growth and yield of maize (*Zea mays* l.) in Madurai district, Tamil Nadu, India

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Article Info
https://doi.org/10.31018/jans.v14i2.3384
Received: March 8, 2022
Revised: May 22, 2022
Accepted: May 27, 2022

How to Cite
Senthilkumar, A. *et al.* (2022). Climate nutrient management for various sources and levels of fertilizers on soil nutrients, growth and yield of maize (*Zea mays* l.) in Madurai district, Tamil Nadu, India. *Journal of Applied and Natural Science*, 14(2), 443 - 449. https://doi.org/10.31018/jans.v14i2.3384

Abstract
Global climate change is expected to soil processes and properties, which are important for restoring soil fertility and low productivity. The field experiment was conducted at Research Farm, Agricultural College, and Research Institute, Madurai district, Tamil Nadu, during *Kharif* season 2021 to study of various sources and fertilizers' levels to influence under deficit and excess water conditions on soil fertility, growth, and yield of maize (*Zea mays)*. The study revealed that excess and deficit water condition in moisture regime irrigations at Irrigation water / Cumulative Pan Evaporation (IW/CPE) ratio of 1.0 along with nutrient management practices (N_8) 125 % Soil Test Crop Response (STCR) - NPK soil application by 1 % foliar spray of micronutrient mixture. Significantly higher of mean values available nitrogen (225 kg ha^{-1}), available phosphorous (20.81 kg ha^{-1}), available potassium (351 kg ha^{-1}), dry matter production (DMP) (16,404 kg ha^{-1}), plant height (250 cm) and yield (9,030 kg ha^{-1}) and was comparable with IW/CPE ratio of 0.8, 0.6 along with others nutrient management practices at 100 % and 75 % STCR - NPK followed by foliar sprays 2 % NPK (19:19:19) and Pink-pigmented facultative methylotrophs (PPFM) 1 %. Hence, under a normal water availability situation, irrigation at an IW/CPE ratio of 0.8 was good enough to produce a higher yield, while under deficit and excess water conditions IW/CPE ratio of 1.0 along with125 % STCR-NPK by foliar spray of micronutrient mixture of 1 % was suitable for obtaining optimum nutrient management for enhancing soil fertility, growth and yield of maize.

Keywords: Foliar spray, Maize, Moisture regime, Nutrient management, Yield

INTRODUCTION

Climate changes in soils are expected mainly due to changes in soil moisture conditions and an increase in soil temperature and CO_2 content due to climate change. Climate change is forecast to significantly impact agriculture through direct and indirect effects on crops, soils, livestock, and pests. Although climate change is a slow process with relatively small changes in temperature and rainfall over a long period, never the less these slow climate changes nonetheless affect various soil processes, particularly those related to soil fertility.

Maize (*Zea mays* L.) growth and yield are more sensitive to nutrient applications under deficit and excess water conditions. Fertilizer and improper water management are the two main factors that negatively affect the growth and productivity of maize in conditions of deficit and excess water. Careful use of the right combination of fertilizers to replenish the nutrient supply systems is a key factor in the system that aims to increase crop production for sustainable agriculture (Amanullah *et al.,* 2019a). One of the causes of the yield gap is the reckless use of fertilizers to fill this gap in maize productivity. The latest production technology package, which provides for the use of foliar fertilizer in conditions of water stress at the right time, should be used to increase maize production as well as farmers' net profits under deficit and excess water conditions.

In the coming decades, efficient water management in deficit and excess water conditions could enhance crop productivity. The use of modern technologies, particularly irrigation water management and nutrient application, is essential to maximize crop production and benefits for farmers (Pandey *et al.,* 2020). Water shortage during the vegetative stages of the development phase limits the grain yield in many maize production areas. In northern China, maize is the second-most (following wheat) important cereal crop, which is frequently subjected to delays in irrigation or water stress, causing a significant yield reduction (Li, 2017).

The balanced use of nitrogen (N), phosphorus (P), and potassium (K) fertilizers could play a fundamental role in increasing grain yields in cereals under deficit and excess water conditions. Among the limiting factors, the proper level and ratio of STCR - NPK is of prime importance (Asghar *et al*., 2020). The foliar application of NPK (19:19:19) could increase the productivity of plants many times over under deficit conditions. They also provide a considerable amount of water at the time of the deficit and excess water conditions. In addition to providing a nutrient for plant growth, the application of N could enhance the plant's drought tolerance to increase the yield in times of water deficit (Li, 2017). Under deficit and excess water, conditions is the main constraint on maize cultivation and leads to serious yield reductions of 40 % worldwide (Sanjeev *et al*., 2017). Irrigation water is becoming a critically scarce and expensive resource due to increasing industrial demand and urban consumption. Groundwater is being depleted at an alarming rate, so particular attention has been paid to strategy development to reduce irrigation water losses and enhance plant water productivity. Excess and deficit irrigation is an option where water availability limits conventional irrigation and reduces the risk of yield reduction due to terminal dry spells (Singh *et al*., 2020).

Pink pigmented facultative methylobacteria (PPFM) are associated with the roots, leaves, and seeds of most land plants and use volatile C_1 compounds such as methanol which growing plants produce during the cell division phase (Irvine *et al*., 2018) and increase the concentration of CO_2 in the stomata that leads to an accelerated rate of photosynthesis and reduce the rate of photorespiration in C_3 plants. Grain yield was by 22.6 - 26.4 % due to a decrease in kernel number and weight (Pandey *et al*., 2020), and decreased by 37 % due to a decline of 18 % in kernel weight and 10 % in kernel number underwater under excess conditions (Karam *et al*., 2013). Poor water availability and high temperatures result in significant stress during critical phases of maize (*Zea mays* L.) development (Al-Kaisi *et al.,* 2013). These stress factors lead to management challenges with insects, diseases, and plants' reduced nutrient availability and uptake. Therefore, the present study was designed to assess the various sources and levels of fertilizers in moisture regime irrigations at IW/CPE ratio of 0.6, 0.8, 1.0 and the nutrient management practices (75 %, 100 %, and 125 %) of STCR - NPK along with foliar applications of NPK (19:19:19), PPFM and micronutrient mixture combination and its improving maize of soil fertility, growth and yield under deficit and excess water conditions for maize.

MATERIALS AND METHODS

A field experiment was conducted during the *Kharif* season of 2021 at the Research Farm of the Agricultural College and Research Institute, Madurai, Tamil Nadu (95^o4' North latitude, 78^o0' East longitude, and 147 m above MSL) in sandy clay loam soil as per the soil taxonomy *(Typic Haplustalfs)* it was observed that the initial characterization of the experimental soil samples results (Table 1). The main plot comprised of three moisture regimes *viz.,* I_1 - Irrigation at IW/CPE ratio of 0.6, I_2 - Irrigation at IW/CPE ratio of 0.8, and I_3 - Irrigation at IW/CPE ratio of 1.0.The subplot comprises of ten nutrient management practices *viz.,*N_1 -Control (no foliar application) , N_2 -125 % ;N_3 -100 % and N_4 - 75 % STCR - NPK along with foliar spray of 2 % N:P:K (19:19:19) N_5 -125 % ; N_6 -100 % ; N_7 - 75 % STCR - NPK along with foliar spray of 1 % PPFM, N_8 -125 % ; N_9 -100 % N_{10} -75 % STCR - NPK along with foliar spray of 1 % micronutrient mixture,(N_2-N_{10} based on STCR - NPK). The treatments were imposed in a split-plot design in three replications. Each replication consisted of 30 treatments.

Soil Test Crop Response (STCR) approach was applied in each plot to treatments wise in the form of urea, diammonium phosphate, and muriate of potash, respectively. Sowing was done on 03 March 2021. The maize - COH (M) 6 seeds, the hybrid matures in 110 days. It is resistant to turcicum leaf blight and downy mildew. Individual plot size: 20 m^2, spacing was 60cm x 30cm; irrigation was given at the time of sowing, followed by life irrigation on the fifth to the seventh day.

Table 1. Physicochemical and biological properties of initial soil characters

A. Mechanical analysis	Experiment values
Coarse sand fraction (%)	21.27
Fine sand fraction (%)	16.12
Silt fraction (%)	27.18
Clay fraction (%)	34.03
Textural class	Sandy clay loam
B. Soil Physical properties	
Bulk density (Mg m^{-3})	1.30
Particle density (Mg m^{-3})	2.59
Pore space (%)	48.50
C. Electro-chemical properties	
pH	7.42
EC (dS m^{-1})	0.28
CEC (cmol (p^+) kg^{-1})	15.30
D. Chemical properties	
Available N (kg ha^{-1})	200
Available P (kg ha^{-1})	18.80
Available K (kg ha^{-1})	317
Available S (mg kg^{-1})	8.42
Available Fe (mg kg^{-1})	14.20
Available Zn (mg kg^{-1})	1.23
Available Mn (mg kg^{-1})	5.30
Available Cu (mg kg^{-1})	2.37
Exchangeable Ca^{2+} (cmol (p+) kg^{-1}	11.30
Exchangeable Mg^{2+} (cmol (p+) kg^{-1}	7.20
Exchangeable Na^+ (cmol (p+) kg^{-1}	2.00
Exchangeable K^+ (cmol (p+) kg^{-1}	1.40
Organic Carbon (g kg^{-1})	6.23
$CaCO_3$ (%)	2.30
Total N (%)	0.03
Total P (%)	0.05
Total K (%)	0.62
E. Biological properties	
Bacterial count (x 10^6 CFU)	10.20
Fungal count (x 10^4 CFU)	3.68
Actinomycetes count (x 10^3 CFU)	8.63

The subsequent irrigations were scheduled based on the moisture regimes of the main plot as per the IW/CPE. All the plots were irrigated at a depth of 50 mm and were measured using the Parshall flume. The other practices of growing maize were adequately taken for the management of experimental plots throughout the cropping season. Soil properties were analyzed at the critical stage (25 DAS). The plant height was measured on dry matter production (DMP), and yield was computed at the harvest stage. The statistical analysis was carried out by AGRES software at a 5 % level of significance.

RESULTS AND DISCUSSION

Soil available nitrogen status

The application of moisture regimes and nutrient management practices significantly influenced the available nitrogen status of the soil. Among the moisture regimes, the IW/CPE ratio of 1.0 significantly recorded the maximum mean values, available nitrogen status (219 kg ha^{-1}) followed by that of the IW/CPE ratio of 0.8 (208 kg ha^{-1}) compared to the IW/CPE ratio of 0.6 (206 kg ha^{-1}). Among the nutrient management practices, the maximum mean values availability of nitrogen (225 kg ha^{-1}) was recorded in the nutrient management practices (N_8) that received 125 % STCR - NPK by foliar spray of micronutrient mixture at 1 %; NPK (19:19:19) at 2 % (222 kg ha^{-1}) (N_2); Pink-pigmented facultative methylotrophs at 1 % (218 kg ha^{-1}) (N_5) followed by 100 % and 75 % STCR - NPK compared to control (N_1) (199 kg ha^{-1}) under deficit and excess water conditions. Integration of moisture regimes and nutrient management practices significantly influenced the available nitrogen status, the maximum being with the application of IW/CPE ratio of 1.0 along with 125 % STCR - NPK by foliar spray of micronutrient mixture at 1 % under deficit and excess water conditions. Among the stages, a slight increase in available nitrogen status (225 kg ha^{-1}) was recorded in critical stage (25 DAS) soils compared to that of preplanning soils (200 kg ha^{-1}) (Table 2). Similarly (Amanullah *et al.,* 2019 b) found an increase in different forms of nitrogen levels, and the time of application influences leaf area, height, and biomass of maize planted at low and high density. Singh (2020) showed that the nitrogen response of maize under temporary flooding conditions increases the effect of plant population, N application, and irrigation on yield of synthetic maize Karim *et al.,* (2013).

Soil available phosphorous status

The application of moisture regimes significantly influenced the available phosphorous status of the soil compared to nutrient management practices. The maximum phosphorous status availability (19.94 kg ha^{-1}) was registered in the soils that received an IW/CPE ratio of 1.0 followed by that an IW/CPE ratio of 0.6 (19.66 kg ha^{-1}) compared to IW/CPE ratio of 0.8 (18.90 kg ha^{-1}). In the case of nutrient management practices, the values ranged from 20.81 in 125 % STCR - NPK by foliar spray of micronutrient mixture at 1 % to 18.80 kg ha^{-1} in control plots. The higher status of available phosphorous status in the moisture regimes treatments may be attributed to the better conservation of phosphorous applied through nutrient management practices and moisture regimes under deficit and excess water conditions in these treatments. The maximum availability of phosphorous status (21.88 kg ha^{-1}) was recorded in the treatment that received an IW/CPE ratio of 1.0 along with 125 % STCR - NPK by foliar spray of micronutrient mixture at 1 % and was on par with IW/CPE ratio of 0.6 under excess water conditions. In water deficit irrigation IW/CPE ratio of 0.6 along with (N_8) 125 % STCR - NPK by foliar spray of micronutrient

Table 2. Influence of deficit and excess water conditions on soil available nutrient status at a critical stage (25 DAS of maize)

Moisture Regimes	Nutrient management practices										
	N_1	**N_2**	**N_3**	**N_4**	**N_5**	**N_6**	**N_7**	**N_8**	**N_9**	**N_{10}**	**Mean**
	Soil available nitrogen (kg ha^{-1})										
$I_{1.0}$	204.32	234.00	220.00	210.70	227.59	215.80	207.80	237.30	223.00	212.60	219.31
$I_{0.8}$	198.50	216.40	210.70	200.59	213.20	208.59	199.40	217.80	210.30	205.50	208.10
$I_{0.6}$	196.00	215.70	205.20	200.00	214.00	201.30	198.20	220.50	210.70	201.80	206.34
Mean	199.60	222.03	211.96	203.76	218.26	208.56	201.80	225.20	214.66	206.63	
	Soil available phosphorus (kg ha^{-1})										
$I_{1.0}$	18.93	20.79	19.90	19.39	20.30	19.72	18.97	21.88	20.15	19.44	19.94
$I_{0.8}$	18.72	19.35	18.71	18.54	18.94	18.67	18.87	19.76	18.86	18.64	18.90
$I_{0.6}$	18.75	20.30	19.89	19.03	20.00	19.86	18.86	20.80	19.88	19.28	19.66
Mean	18.80	20.14	19.50	18.99	19.74	19.41	18.90	20.81	19.63	19.12	
	Soil available potassium (kg ha^{-1})										
$I_{1.0}$	319.80	355.19	344.80	324.80	350.30	330.00	320.39	353.79	345.69	325.500	337.02
$I_{0.8}$	317.40	347.10	337.80	319.10	348.49	327.30	317.70	348.40	348.00	320.400	333.17
$I_{0.6}$	314.99	344.10	324.40	318.60	337.70	320.50	315.50	351.30	331.20	318.700	327.70
Mean	317.39	348.79	335.66	320.83	345.49	325.93	317.86	351.16	341.63	321.533	

	Soil available nitrogen (kg ha^{-1})				**Soil available potassium (kg ha^{-1})**				**Soil available potassium (kg ha^{-1})**			
	I	**N**	**I at N**	**N at I**	**I**	**N**	**I at N**	**N at I**	**I**	**N**	**I at N**	**N at I**
SEd	1.31	2.42	4.196	4.196	0.14	0.22	0.391	0.399	3.72	2.39	6.45	6.57
LSD (0.05)	3.74	4.87	NS	NS	0.42	0.45	NS	NS	7.49	6.83	NS	NS

$I_{1.0}$; $I_{0.8}$; $I_{0.6}$ - Irrigation at IW/CPE ratio. and N_1 - RDF , N_2 -125 % ;N_3 -100 % and N_4 - 75 % STCR - NPK along with foliar spray of 2 % N:P:K (19:19:19) ; N_5 -125 % ; N_6 -100 % ; N_7 - 75 % STCR - NPK along with foliar spray of 1 % PPFM, N_8 -125 % ; N_9 -100 % N_{10} -75 % STCR - NPK along with foliar spray of 1 % micronutrient mixture (N_2-N_{10} based on STCR - NPK). Means followed by different letters within a category of treatments are statistically different from each other using the least significant difference (LSD) test (p<0.5)

mixture at 1 % available phosphorous (19.76 kg ha^{-1}) was recorded in an IW/CPE ratio of 0.8 along with 100 % and 75 % STCR - NPK at 2 % NPK (19:19:19) and 1 % Pink-pigmented facultative methylotrophs and was significantly higher than the control (N_1) under deficit and excess water conditions. A slight increase in soil available phosphorous status was registered in critical stage (25 DAS) soils (20.81 kg ha^{-1}) compared to that of the pre-planting soils (18.80 kg ha^{-1}) (Table 2).

Soil available potassium status

The application of moisture regimes and nutrient management practices significantly influenced the available potassium status of the soil under deficit and excess water conditions. Like available nitrogen and phosphorus, the highest available K content was recorded in the moisture regimes IW/CPE ratio of 1.0 significantly recorded the maximum mean values, available potassium status (337 kg ha^{-1}) followed by that of IW/CPE ratio of 0.8 (333 kg ha^{-1}) compared to IW/CPE ratio of 0.6 (327 kg ha^{-1}). Among the nutrient management practices, maximum mean values availability of potassium (351 kg ha^{-1}) was recorded in the nutrient management practices (N_8) that received 125 % STCR - NPK by foliar spray of micronutrient mixture at 1%; NPK (19:19:19) at 2 % (348 kg ha^{-1}) (N_2); Pink-pigmented facultative methylotrophs at 1 % (345 kg ha^{-1}) (N_5) followed by 100 % and 75 % STCR - NPK compared to control (N_1) (317 kg ha^{-1}) under deficit and excess water conditions. Integration of moisture regimes and nutrient management practices significantly influenced the available potassium status, the maximum being with the application of IW/CPE ratio of 1.0 along with 125 % STCR - NPK by foliar spray of micronutrient mixture at 1 % under deficit and excess water conditions. Among the stages, a slight increase in available potassium status (337 kg ha^{-1}) was recorded in critical stage (25 DAS) soils compared to that of preplanning soils (317 kg ha^{-1}) (Table 2). Aown *et al.* (2012) to foliar application of potassium under water deficit conditions improved the growth and

Table 3. Influence of deficit and excess water conditions on dry matter production (kg ha^{-1}) and plant height (cm) at harvest stages of maize

Moisture Regimes	Nutrient management practices (kg ha^{-1})										
	N_1	N_2	N_3	N_4	N_5	N_6	N_7	N_8	N_9	N_{10}	Mean
	Dry Matter Production (kg ha^{-1})										
$I_{1.0}$	16,485	16,488	16,176	16,170	16,480	16,190	16,165	16,488	16,197	16,172	16,301
$I_{0.8}$	15,499	16,360	15,709	15,667	16,349	15,722	15,655	16,367	15,730	15,700	15,875
$I_{0.6}$	13,308	16,353	14,234	14,165	15,790	14,266	13,500	16,358	14,268	14,200	14,644
Mean	15,097	16,400	15,373	15,334	16,206	15,392	15,106	16,404	15,398	15,357	
	Plant Height (cm)										
$I_{1.0}$	251.70	259.50	254.30	245.80	257.20	256.60	250.00	258.70	251.80	248.20	253.38
$I_{0.8}$	243.10	254.80	248.70	245.20	251.49	252.19	245.50	252.50	247.49	252.49	249.34
$I_{0.6}$	219.60	235.20	229.50	224.60	230.59	232.50	225.20	233.90	227.79	218.30	227.72
Mean	238.13	249.83	244.16	238.53	246.43	247.10	240.23	248.36	242.36	239.66	

	Dry Matter Production (kg ha^{-1})				Plant Height (cm)			
	I	N	I at N	N at I	I	N	I at N	N at I
SEd	206.90	95.86	358.36	353.23	2.67	1.89	4.64	4.79
LSD (0.05)	415.96	273.30	742.65	732.01	5.38	5.40	NS	NS

$I_{1.0}$; $I_{0.8}$; $I_{0.6}$ - Irrigation at IW/CPE ratio. and N_1 - RDF , N_2 -125 % ;N_3 -100 % and N_4 - 75 % STCR - NPK along with foliar spray of 2 % N:P:K (19:19:19) ; N_5 -125 % ; N_6 -100 % ; N_7 - 75 % STCR - NPK along with foliar spray of 1 % PPFM, N_8 -125 % ; N_9 -100 % N_{10} -75 % STCR - NPK along with foliar spray of 1 % micronutrient mixture (N_2-N_{10} based on STCR - NPK). Means followed by different letters within a category of treatments are statistically different from each other using the least significant difference (LSD) test ($p<0.5$)

yield of wheat. Similarly, Alston (2019) reported that the effects of soil water content and foliar fertilization increase with nitrogen and phosphorus in the late season on the yield and composition of wheat.

Influence of deficit and excess water conditions on maize

Moisture regimes and nutrient management practices significantly influenced the crop DMP and plant height of maize (Table 3). IW/CPE ratio of 1.0 along with 125 % STCR - NPK by foliar spray of 1 % micronutrient mixture recorded significantly higher DMP (16,404 kg ha^{-1}) was on par with IW/CPE ratio of 0.8 over 0.6. Lower DMP (15,097 kg ha^{-1}) and IW/CPE ratio of 1.0 along with 125 % STCR - NPK by foliar spray of 2 % NPK (19:19:19) was recorded to significantly higher plant height (250 cm) in IW/CPE ratio of 0.8 and 0.6 along with 100 % and 75 % STCR - NPK. The reduction in dry matter accumulation under a lower moisture regime because of reduced water availability leading to water deficit conditions for most of the crop growing period. Biomass accumulation is sensitive to water stress and the degree of reduction of biomass accumulation depends on the severity of water stress. Similar results are in line with Chipman et al. (2021) for nitrogen and dry matter allocation for two soybean genotypes in response to water stress during reproductive growth. Another report by Arif *et al.* (2016) on the response of wheat to foliar application of nutrients depending on the intensity and duration of the stress

Yield

Moisture regimes and nutrient management practices significantly influenced the yield of the crop (Fig. 1). IW/CPE ratio of 1.0 and 0.8 along with 125 % STCR - NPK by foliar spray of 1 % micronutrient mixture recorded

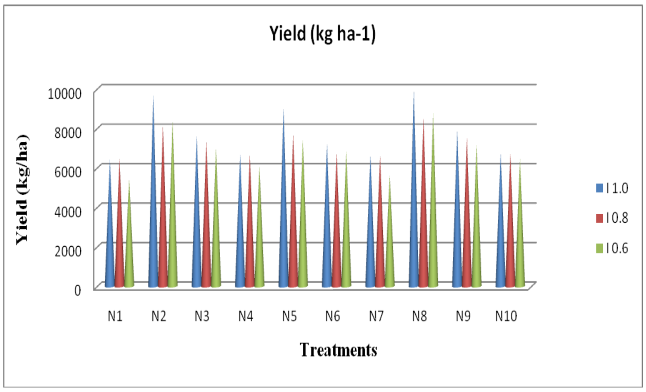

Fig. 1. *Influence of deficit and excess water on yield (kg ha^{-1}) of maize $I_{1.0}$; $I_{0.8}$; $I_{0.6}$ - Irrigation at IW/CPE ratio. and N_1 - RDF , N_2 -125 % ;N_3 -100 % and N_4 - 75 % STCR - NPK along with foliar spray of 2 % N:P:K (19:19:19) ; N_5 -125 % ; N_6 -100 % ; N_7 - 75 % STCR - NPK along with foliar spray of 1 % PPFM, N_8 -125 % ; N_9 -100 % N_{10} -75 % STCR - NPK along with foliar spray of 1 % micronutrient mixture (N_2-N_{10} based on STCR - NPK).*

Table 4. Pearson Correlations study on dry matter production (DMP), plant height, yield, and available nutrients of maize

	Pearson Correlations						
		DMP	**Plant height**	**Yield**	**Aval N**	**Aval P**	**Aval K**
DMP	Correlation	1	.842**	.664**	.679**	.328	.633**
	DMP		.000	.000	.000	.077	.000
Plant Height	Correlation		1	.546**	.607**	.165	.504**
	Plant Height			.002	.000	.384	.005
Yield	Correlation			1	.933**	.805**	.920**
	Yield				.000	.000	.000
Aval N	Correlation				1	.816**	.888**
	Aval.N					.000	.000
Aval	Correlation					1	.666**
	Aval.P						.000
Aval K	Correlation						1
	Aval.K						

**Correlation is significant at the 0.01 level (2-tailed).

significantly higher yield (7188 and 7142 kg ha^{-1}) and significantly lower yield was recorded in IW/CPE ratio of 0.6. The increase in yield could be attributed to greater and more consistent available soil moisture due to an increased level of irrigation that resulted in better crop growth and yield components. The lower yield in irrigation at IW/CPE of 0.6 along with 100 % and 75 % STCR - NPK at 2 % NPK (19:19:19) and 1 % Pink-pigmented facultative methylotrophs was significantly higher than the control (N_1) which might be attributed to the decrease in the synthesis of metabolites and reduction in absorption and translocation of nutrients from soil to plant under deficit and excess water conditions supply. According to Amanullah *et al.* (2013), increasing the foliar application of nitrogen at different growth stages influences maize's phenology, growth, and yield. Further, Amanullah *et al.* (2019c) reported the effects of plant density and N on phenology and yield (7102 kg ha^{-1}) of maize. Similar findings were reported by Sanjeev *et al.* (2017) to improve the yield and yield components of winter maize as influenced by plant density and N levels.

Pearson correlations on DMP, plant height, yield, and available nutrients of maize are mentioned in Table 4. The correlations indicated that soil available nutrients were positively correlated with available N (r = 0.679**) available P (r = 0.328**) and available K (r = 0.633**). Grain yield was positively and significantly correlated with plant height (r = 0.546**) and DMP (r = 0.842**).

Conclusion

From the present study, it can be concluded that irrigating at an IW/CPE ratio of 0.8 is ideal for obtaining a higher yield of maize (*Zea mays*) under normal conditions. Subsequently, change is expected to be observed in India's rainfall pattern with climate change. Under excess water conditions, irrigation at an IW/CPE ratio of 1.0, along with 125 % STCR-NPK by foliar application of 1 % micronutrient mixture, was found to be suitable for obtaining optimum soil available nutrient status and yield.

Conflict of interest

The authors declare that they have no conflict of interest.

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