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Physiological Traits of Maize as Influenced by Irrigation Scheduling and Nitrogen Levels

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ABSTRACT

A field experiment was conducted at research farm of Agricultural Research Institute, P.J.T.S.A.U, Hyderabad during *rabi* 2019-20. The treatments comprising of three irrigation scheduling at 60% DASM (I_1), 40% DASM (I_2) and 20% DASM (I_3) as main plots and three nitrogen levels viz., 90 (N_1), 180 (N_2) and 240 kg (N_3) N ha^{-1} as sub-plots replicated thrice. The results indicated that, the physiological parameters viz SPAD chlorophyll, photosynthesis rate, relative leaf water content and stomatal conductance and coolness of canopy with reference to ambient temperature were increased with increasing nitrogen dose from 90 to 240 kg N ha^{-1} under I_2 and I_3 irrigation scheduling. Whereas reverse trend was observed under I_1 irrigation scheduling. In this paper, an attempt was made to know how the physiological traits were influenced by irrigation and nitrogen levels.

Keywords Relative water content, Spad, Stomatal conductance, Photosynthetic rate, Canopy temperature.

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INTRODUCTION

Maize, a miracle crop, queen of cereals is known for the highest genetic yield potential among cereals. It is grown over a wide range of climatic conditions in semi-arid and sub tropics of Indian subcontinent. In India, maize is the third most important cereal crop after rice and wheat with an area of 9.2 m ha, production of 28.7 million tonnes and productivity of 3115 kg ha^{-1} in 2016-17 (FAOSTAT 2017). Maize is very sensitive to water and other environmental stresses in the period one week before flowering to two weeks after flowering (Cakir 2004). Maize crops present sensitivity to low soil water availability, especially in the critical period, which starts at flowering and lasts until grain filling. Responses to stress are multiple and interconnected. It is well established that stress impairs numerous metabolic and physiological processes in plants (Levitt 1980). It leads to growth reduction, reduction in the content of chlorophyll pigments and water, and changes in fluorescence parameters (Yang *et al.* 2006). Further the water stress occurring at different crop developmental stages could potentially limit biomass accumulation and consequently reduce grain yield of the maize crop. Most of the damaging effect of drought is associated with the photosynthetic process of the plant.

The beneficial effect of nitrogen on plant growth and development can be harnessed fully under optimal soil moisture conditions. When crop experiences severe water stress, it effects the water and nutrient uptake, causes closure of stomata, decrease in photosynthesis rate and thus accumulation of N in plant tissue and reduction in leaf chlorophyll content. The present study was planned to identify the effect of irrigation and nitrogen levels on physiological characters of maize.

MATERIALS AND METHODS

Experiment was conducted during *rabi* 2019 at Agro Climate Research Center, A.R.I., Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad. The site of experiment is located at N17°32”, E78°39” and 542.3 MSL in the Southern Telangana Agro-Climatic Zone in Telangana State which falls under semi-arid tropics (SAT). The soil is sandy loam in texture and neutral in reaction. The field was laid out in ridges and furrows at 60 cm apart. The plant-to-plant spacing adopted within the row was 20 cm. All the treatments were uniformly irrigated initially up to 15 days after sowing to ensure better establishment of the crop. The other standard management practices as recommended by the P.J.T.S. Agricultural University for the state of Telangana were followed.

SPAD chlorophyll meter readings

The leaf chlorophyll meter readings was measured by using SPAD meter and is recorded for five plants in each plot.

Photosynthetic rate

The leaf photosynthetic rate was measured by using portable photosynthesis system (LI-6800) and expressed as μmol CO_2 m^{-2} s^{-1}.

Canopy temperature (°C)

The canopy temperature of maize was measured using portable photosynthesis system (LI-6800) and Infrared Thermometer (IRT) (Blad and Rosenberg 1976) and the mean value of five observations in each plot was expressed as °C.

Relative leaf water content (RLWC)

The Relative Leaf Water Content (RLWC) was estimated according to Barrs and Weatherley (1962) and calculated by using following formula and expressed as per cent.

$$\text{Relative leaf water content} = \frac{\text{Fresh weight (g) - dry weight (g)}}{\text{Turgid weight (g) - dry weight (g)}}$$

Stomatal conductance

The leaf stomatal conductance was measured by using portable photosynthesis system (LI-6800) and expressed as μmol CO_2 m^{-2} s^{-1}.

RESULTS AND DISCUSSION

SPAD Chlorophyll meter readings at different phenophases

The index of greenness (spad chlorophyll value) was increased from six leaf stage to silking and reduced towards maturity irrespective of the treatment combinations (Fig.1). The crop greenness was higher with irrigations scheduled at 20 % DASM (I_1) and decreases with increasing the interval between the irrigation which were scheduled at 40 % DASM (I_2) and 60 % DASM (I_1) irrespective of the crop growth phases (Table 1). Decrease in chlorophyll content with diminishing available water was also reported by Hossein *et al*. (2017).

The response of the crop greenness (spad chlorophyll value) was conspicuous with increase in nitrogen dose from 90 kg N ha^{-1} to 240 kg N ha^{-1} irrespective of the crop growth phases. Among the

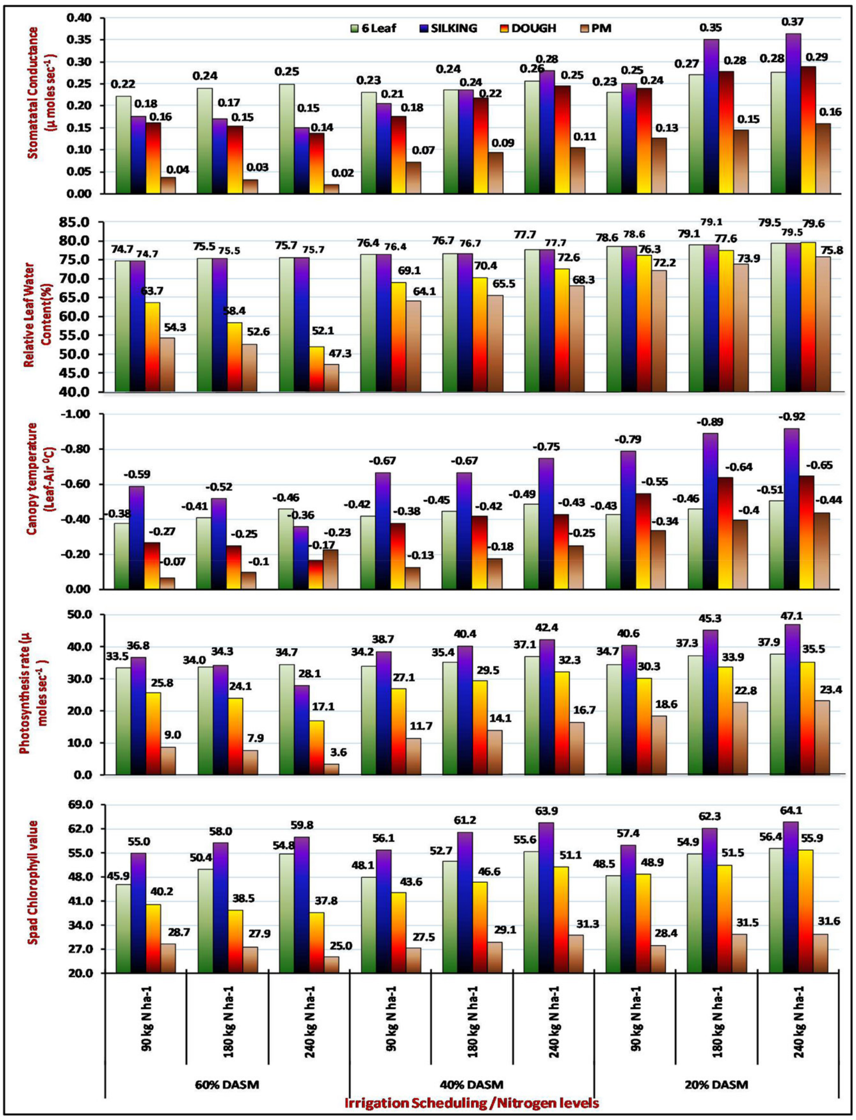

Fig. 1. Spad chlorophyll values, photosynthesis rate, canopy temperature, relative leaf water content and stomatal conductance at different phenophases of maize as influenced by irrigation scheduling and nitrogen levels.

different treatment combinations, the crop irrigation scheduled at I_3 (20 % DASM) in conjunction with N_3 (240 kg N ha^{-1}) recorded more chlorophyll content at six leaf, dough and physiological maturity stages, respectively. There is a close correlation exist between leaf chlorophyll content and nitrogen availability in plant system. Increase in N application increased N content and chlorophyll content in maize (Rambo *et al.* 2010).

Among the different treatment combinations, the crop irrigation scheduled at I_1 (60 % DASM) in conjunction with N_3 (240 kg N ha^{-1}) recorded low spad values, at silking, dough and physiological maturity (Table 1). Whereas the crop irrigation scheduled at I_3 (20 % DASM) in conjunction with N_3 (240 kg N ha^{-1}) recorded higher spad values at silking, dough and physiological maturity. In contrast to this, Hossein *et al.* (2017) showed that increase of N, resulted in

Table 1. SPAD meter readings of maize at different growth stages as influenced by irrigation scheduling and nitrogen levels.

Treatments	6th leaf stage				Silking stage			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	45.94	50.39	54.79	50.37	55.03	58.00	59.83	57.62
I_2	48.08	52.69	55.64	52.14	56.07	61.20	63.90	60.39
I_3	48.46	54.94	56.40	53.27	57.43	62.30	64.10	61.28
Mean	47.50	52.67	55.61	51.93	56.18	60.50	62.61	59.76

	CD (P=0.05)	SEm ±	CD (P=0.05)	SEm ±
Main (I)	1.00	0.26	1.90	0.48
Sub (N)	0.88	0.29	1.61	0.52
Sub (N) at same main (I)	1.53	0.50	NS	0.90
Main (I) at same or different sub (N)	1.59	0.48	NS	0.88

Table 1. Continued.

Treatments	Dough stage				Physiological maturity stage			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	40.23	38.47	37.77	38.82	28.67	27.90	24.97	27.18
I_2	43.63	46.57	51.13	47.11	27.53	29.10	31.33	29.32
I_3	48.93	51.47	55.93	52.11	28.37	31.47	31.60	30.48
Mean	44.27	45.50	48.28	46.01	28.19	29.49	29.30	28.99

	CD (P=0.05)	SEm ±	CD (P=0.05)	SEm ±
Main (I)	4.45	1.13	1.56	0.40
Sub (N)	0.76	0.25	0.96	0.31
Sub (N) at same main (I)	1.32	0.43	1.66	0.54
Main (I) at same or different sub (N)	4.57	1.19	2.05	0.59

Note: I_1: 60% DASM, I_2:40% DASM, I_3:20% DASM, N_1: 90 kg N ha^{-1}; N_2: 180 kg N ha^{-1}; N_3: 240 kg N ha^{-1} DDSM (Depletion of Available Soil Moisture).

increase of chlorophyll content in both normal and stress condition.

The beneficial effect of nitrogen on plant growth and development can be harnessed fully under optimal soil moisture conditions. When crop experiences severe water stress, it effects the water and nutrient uptake, causes closure of stomata, decrease in photosynthesis rate and thus accumulation of N in plant tissue and reduction in leaf chlorophyll content (Fig. 1).

Photosynthesis rate (μ moles sec^{-1})

The crop irrigation scheduled at 20 % DASM (I_3) recorded higher photosynthetic rate and was decreased with increase in interval between two successive irrigations which was scheduled at 40 % DASM (I_2) and 60 % DASM (I_1) from silking to physiological maturity stages (Table 2). The prolonged soil moisture stress leads to reduction in cell enlargement and growth, turgor loss, cellular and metabolic activities, photosynthetic inhibition (Osakabe *et al.* 2014). Further Luca *et al.* (2009) also reported a greater reduction in net photosynthetic rate and stomatal conductance due to increase in water stress.

The photosynthetic rate increased with increase in nitrogen dose from 90 kg N ha^{-1} (N_1) to 180 kg N ha^{-1} (N_2) and further to 240 kg N ha^{-1} (N_3) at silking, dough and physiological maturity stages (Table 2).

Table 2. Photosynthetic rate of maize at different growth stages as influenced by irrigation scheduling and nitrogen levels.

	6th leaf stage				Silking stage			
Treatments	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	33.51	33.95	34.69	34.05	36.80	34.33	28.13	33.09
I_2	34.17	35.42	37.07	35.55	38.72	40.40	42.36	40.49
I_3	34.66	37.26	37.94	36.62	40.61	45.26	47.07	44.31
Mean	34.12	35.54	36.56	35.41	38.71	40.00	39.19	39.30

	CD (P=0.05)	SEm ±	CD (P=0.05)	SEm ±
Main (I)	0.70	0.18	1.23	0.31
Sub (N)	0.68	0.22	0.90	0.29
Sub (N)at same main (I)	1.17	0.38	1.55	0.50
Main (I) at same or different sub (N)	1.18	0.36	1.76	0.52

Table 2. Continued.

	Dough stage				Physiological maturity stage			
Treatments	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	25.83	24.12	17.07	22.34	8.95	7.93	3.61	6.83
I_2	27.14	29.52	32.26	29.64	11.69	14.10	16.69	14.16
I_3	30.28	33.89	35.47	33.21	18.58	22.77	23.45	21.60
Mean	27.75	29.17	28.27	28.40	13.07	14.93	14.58	14.20

	CD (P=0.05)	SEm ±	CD (P=0.05)	SEm ±
Main (I)	1.17	0.30	0.23	0.06
Sub (N)	0.88	0.28	0.31	0.10
Sub (N)at same main (I)	1.52	0.49	0.54	0.17
Main (I) at same or different sub (N)	1.69	0.50	0.49	0.15

Note: I_1: 60% DASM, I_2:40% DASM; I_3:20% DASM, N_1, 90 kg N ha^{-1}; N_2, 180 kg N ha^{-1}, N_3: 240 kg N ha^{-1}, DASM (Depletion of Available Soil Moisture).

Nitrogen (N) is a critical element for plant growth and productivity that influences photosynthesis. Ya-wei *et al.* (2019) revealed that, low-N stress significantly decreased chlorophyll content and actual photochemical efficiency of PSII (ΦPSII) of leaves in maize crop. Zhao *et al.* (2005) reported that decreased photosynthetic rate due to N deficiency was mainly associated with lower stomatal conductance in sorghum.

Among the different treatment combinations, the crop irrigation scheduled at I_1 (60 % DASM) in conjunction with N_3 (240 kg N ha^{-1}) recorded low photosynthesis rate, at silking, dough and physiological maturity. Whereas the crop irrigation scheduled at I_3 (20 % DASM) in conjunction with N_3 (240 kg N ha^{-1}) recorded higher photosynthesis rate at silking, dough and physiological maturity (Table 2).

Canopy temperature (T_{leaf}-T_{air} ^{0}C)

The canopy temperature measured was always lower than the ambient temperature. Higher the negative value implies cooler the canopy (Table 3).

The canopy under 20 % DASM (I_3) was cooler and was increased with increasing interval between two successive irrigation scheduled at 40 % DASM (I_2) to 60 % DASM (I_1) at silking, dough and physiological maturity stages. This trend was differed at 6 leaf stage of the crop.

Water stress which was created under I_1 (60 % DASM) treatment increased the temperature of the canopy through closure of stomata and perspiration

Table 3. Effect of irrigation and nitrogen levels on canopy temperature (T_{leaf} -T_{air}) (°C).

	Canopy temperature															
	6 leaf stage				Silking stage				Dough stage				Physiological maturity stage			
Treat-ments	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	-0.38	-0.41	-0.46	-0.42	-0.59	-0.52	-0.36	-0.49	-0.27	-0.25	-0.17	-0.23	0.07	0.10	0.23	0.13
I_2	-0.42	-0.45	-0.49	-0.45	-0.67	-0.67	-0.75	-0.69	-0.38	-0.42	-0.43	-0.41	-0.13	-0.18	-0.25	-0.19
I_3	-0.43	-0.46	-0.51	-0.47	-0.79	-0.89	-0.92	-0.87	-0.55	-0.64	-0.65	-0.62	-0.34	-0.40	-0.44	-0.39
Mean	-0.41	-0.44	-0.49	-0.45	-0.68	-0.69	-0.68	-0.68	-0.40	-0.44	-0.42	-0.42	-0.13	-0.16	-0.15	-0.15
Factors	SEm ±	SEd	CD		SEm ±	SEd	CD		SEm ±	SEd	CD		SEm ±	SEd	CD	
Main (I)	0.002	0.003	0.008		0.012	0.017	0.049		0.011	0.015	0.044		0.003	0.005	0.014	
Sub (N)	0.005	0.006	0.014		0.008	0.011	NS		0.012	0.016	NS		0.007	0.009	NS	
Sub (N) at same main (I)	0.004	0.011	NS		0.021	0.019	0.048		0.019	0.028	0.068		0.006	0.016	0.037	
Main (I) at same or different sub (N)	0.007	0.010	NS		0.016	0.023	0.059		0.020	0.028	0.066		0.010	0.014	0.032	

Note: I_1: 60% DASM, I_2:40% DASM, I_3:20% DASM, N_1: 90 kg N ha^{-1}, N_2: 180 kg N ha^{-1}, N_3: 240 kg N ha^{-1},DASM (Depletion of Available Soil Moisture) .

decrease. The prolonged water stress decreases the area of the leaf, so more light penetration rises the temperature. These negative effects nullified with increase in frequency between two successive irrigations (I_2 to I_3). Similar results were also reported by Abbas *et al.* (2014).

The canopy temperature of maize was influenced by nitrogen levels. With increase in nitrogen dose from 90 kg N ha^{-1} (N_1) to 180 kg N ha^{-1} (N_2) and further to 240 kg N ha^{-1} (N_3), the canopy temperature was decreased at silking, dough and physiological maturity stages (Table 3).

Canopy temperature is a good indicator of any type of stresses whether temperature, moisture or nutrients in crops. The higher foliage under higher nitrogen levels helped in bringing down the temperature of the maize canopy. These results are in line with the findings of Sukhjeet *et al.* (2018).

The interaction between irrigation scheduling and nitrogen levels influenced the canopy temperature of maize. At silking, dough and physiological maturity, under optimum soil moisture (I_3: 20 % DASM) or mild water stress (I_2: 40 % DASM) conditions, with increase in nitrogen dose from N_1 to N_3 level, the canopy temperature was decreased (Table 3). In contrast to this, under severe soil moisture stress (I_1: 60 % DASM), with increasing nitrogen dose from N_1 to N_3 level, the canopy temperature was also increased. The crop irrigation scheduled at 60 % DASM in conjunction with 240 kg N ha^{-1} (I_1N_3) recorded higher canopy temperature and with 20 % DASM in conjunction with 240 kg N ha^{-1} (I_3N_3) recorded lower canopy temperature compared to other treatment combinations at silking, dough and physiological maturity stages.

When the maize crop treated with either optimal soil moisture (I_3) or mild water stress (I_2) conditions in association with increase in nitrogen dose from N_1 to N_3 levels, responded positively in accumulation of above ground biomass and mutual shading of leaves might have caused in lower canopy temperature. The beneficial effects of incremental nitrogen dose to put forth biomass were not harnessed by the crop under severe moisture stress (I_1) situation and hence the canopy temperature increased with increasing nitrogen dose.

Relative leaf water content (%)

The maize crop maintained higher relative leaf water

Table 4. Relative water content of maize at different growth stages as influenced by irrigation scheduling and nitrogen levels.

	6^{th} leaf stage				Silking stage				Dough stage				Physiological maturity stage			
Treatments	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	74.7	75.5	75.7	75.3	63.7	58.4	52.1	58.1	54.3	52.6	47.3	51.4	28.7	27.9	25.0	27.2
I_2	76.4	76.7	77.7	77.0	69.1	70.4	72.6	70.7	64.1	65.5	68.3	66.0	27.5	29.1	31.3	29.3
I_3	78.6	79.1	79.5	79.1	76.3	77.6	79.6	77.8	72.2	73.9	75.8	74.0	28.4	31.5	31.6	30.5
Mean	76.6	77.1	77.7	77.1	69.7	68.8	68.1	68.9	63.5	64.0	63.8	63.8	28.2	29.5	29.3	29.0
	CD (P=0.05)			SEm±	CD (P=0.05)			SEm±	CD (P=0.05)			SEm±	CD (P=0.05)			SEm±
Main (I)	0.33			0.08	0.28			0.07	0.16			0.04	1.56			0.40
Sub (N)	0.21			0.07	0.22			0.07	0.25			0.08	0.96			0.31
Sub (N)at same main (I)	0.37			0.12	0.37			0.12	0.44			0.14	1.66			0.54
Main (I) at same or different sub (N)	NS			0.13	0.41			0.12	0.39			0.12	2.05			0.59

Note: I_1: 60% DASM, I_2:40% DASM, I_3:20% DASM, N_1: 90 kg N ha^{-1}, N_2: 180 kg N ha^{-1}, N_3: 240 kg N ha^{-1}, DASM (Depletion of Available Soil Moisture).

content up to silking stage and thereafter it was decreased as crop reached to dough and physiological maturity (Fig.1).

With increase in frequency of irrigations from I_1(60 % DASM) to I_2 (40 % DASM) and further to I_3 (20 % DASM), the RLWC of maize increased at silking, dough and physiological maturity stages of the crop (Table 4). At six leaf stage the influence of irrigation scheduling on RLWC was not conspicuous.

Under frequent irrigations (I_3), the roots could able to supply sufficient water as per the transpiration demand set by the above ground biomass and hence the crop could maintain higher RLWC. On the other hand, with increase in interval between two successive irrigations (I_2 to I_1), the deficiency in available soil moisture in root zone arises and that leads to reduction in RLWC. These results are in conformation with the findings of Viswanatha *et al.* (2002) who reported that irrigation scheduled at 0.8 Epan maintained higher plant relative water content (81.10 %) compared to irrigation scheduled at 0.6 Epan. Similarly, Jabasingh and Saravana Babu (2014) reported that the relative water content in leaves of different maize cultivars decreased significantly and with drought stress, the membrane permeability of the leaf cell markedly increased.

The Relative Leaf Water Content (RLWC%) of the maize increased with increase in the nitrogen dose from 90 kg N ha^{-1} (N_1) to180 kg N ha^{-1} (N_2) and further to 240 kg N ha^{-1} (N_3) at six leaf, silking, dough and physiological maturity stages (Table 4).

The increase in relative leaf water content with increase in nitrogen levels might be due to improved water flux through the plant and have promoted the absorption of soil moisture (Ramachandiran and Pazhanivelan 2015). Increase in relative leaf water content with increasing nitrogen levels was also reported by Pradhan *et al.* (2013).

The combined effect of irrigation scheduling and nitrogen levels on RLWC at different phenophases was conspicuous. Under I_3 (20 % DASM) or I_2 (40 % DASM) irrigation scheduling, enhancing the nitrogen dose from 90 kg N ha^{-1} (N_1) to180 kg N ha^{-1} (N_2) and further to 240 kg N ha^{-1} (N_3), the RLWC was increased throughout the crop growth stages. This trend was also observed under I_1 (60 % DASM) irrigation scheduling at six leaf and silking stage whereas from dough to physiological maturity stage, it was in reverse order. Among the different treatment combinations, the crop irrigation scheduled at I_1 (60 % DASM) in conjunction with N_3 (240 kg N ha^{-1}) recorded low RLWC, at silking, dough and physiological maturity. Whereas the crop irrigation scheduled at I_3 (20 % DASM) in

Table 5. Effect of irrigation and nitrogen levels on stomatal conductance (µ mol $C0_2$ m^{-2} s^{-1}).

	Stomatal conductance															
	6th leaf stage				Silking stage				Dough stage				Physiological maturity stage			
Treat-ments	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
I_1	0.222	0.241	0.250	0.238	0.177	0.172	0.152	0.167	0.163	0.155	0.139	0.152	0.038	0.032	0.021	0.031
I_2	0.231	0.237	0.257	0.242	0.206	0.237	0.281	0.241	0.177	0.219	0.247	0.214	0.073	0.094	0.107	0.091
I_3	0.233	0.273	0.278	0.261	0.252	0.352	0.365	0.323	0.241	0.280	0.290	0.270	0.128	0.146	0.161	0.145
Mean	0.229	0.250	0.262	0.247	0.212	0.254	0.266	0.244	0.194	0.218	0.225	0.212	0.080	0.091	0.096	0.089
Factors	SEm ±	SEd	CD		SEm ±	SEd	CD		SEm ±	SEd	CD		SEm ±	SEd	CD	
Main (I)	0.003	0.004	0.012		0.002	0.003	0.008		0.002	0.003	0.008		0.001	0.002	0.004	
Sub (N)	0.005	0.007	0.016		0.002	0.003	0.007		0.002	0.003	0.006		0.001	0.002	0.004	
Sub (N) at same main (I)`	0.009	0.013	0.028		0.004	0.005	0.011		0.004	0.005	0.011		0.002	0.003	0.007	
Main (I) at same or different sub (N)	0.008	0.011	0.026		0.004	0.005	0.013		0.004	0.005	0.012		0.002	0.003	0.007	

Note: I_1: 60% DASM, I_2:40% DASM, I_3:20% DASM, N_1: 90 kg N ha^{-1} , N_2: 180 kg N ha^{-1}, N_3, 240 kg N ha^{-1}.
DASM (Depletion of Available Soil Moisture).

conjunction with N_3 (240 kg N ha^{-1}) recorded higher RLWC at silking, dough and physiological maturity.

The complimentary effect of optimum soil moisture and nitrogen levels on growth and yield of maize was proved by several investigators. Whereas under deficit soil moisture condition the negative effect of higher dose of nitrogen fertilizers on growth and yield of maize was reported by Pandey *et al.* (2000), Samuel *et al*. (2006), Krishnaprabu (2018) and Song *et al.* 2019. At deficit irrigation, the crop subjected to water stress more early under higher nitrogen levels due to imbalance between above ground biomass demand and supply in rhizosphere.

Stomatal conductance (µ moles sec^{-1})

The stomatal conductance of maize was reached to peak at silking stage and decreased as crop advances towards maturity under I_2 and I_3 irrigations whereas under I_1 it was decreased gradually from six leaf stage to physiological maturity (Fig. 1).

The crop irrigated at 20 % DASM (I_3) exhibited higher stomatal conductance and was decreased with increase in the interval between two successive irrigations scheduled at 60 % (I_1) and 40 % (I_2) irrespective of the crop growth phases (Table 5).

The crop found more sensitive to irrigation scheduling at silking stage as the reduction in stomatal conductance was maximum with increasing the water stress when compared to rest of the crop growth phases. The relative reductions in stomatal conductance were mostly higher under deficit irrigation (I_1) than under optimal irrigation (I_3). This was because, under deficit irrigation, the crop suffered from water stress, which affected the leaves and roots, so the guard cells reduced the solute in the cells by regulating their own metabolic processes to increase in water potential, thus causing stomata closure (Yu and Wang 2010). Similarly, Parthasarathi *et al.* (2012) also reported that stomatal conductance values had a gradual decrease with decrease in irrigation levels as transpiration rate had a direct link with water content of the crop.

The stomatal conductance of maize was influenced by nitrogen levels throughout the crop growth period. It was increased with increase in the nitrogen dose from 90 kg N ha^{-1} (N_1) to180 kg N ha^{-1} (N_2) and further to 240 kg N ha^{-1} (N_3) irrespective of the crop growth phases (Table 5).

The increase in stomatal conductance with increase in nitrogen dose was due to improved root's hydraulic conductance and water flux through the plant (Radin 1990).

The interaction effect of irrigation scheduling and nitrogen levels on stomatal conductance at different phenophases was conspicuous. Under high water stress condition (I_1), the stomatal conductance was decreased with increase in nitrogen dose from 90 kg N ha^{-1} to 240 kg N ha^{-1} from silking to physiological maturity stage. Whereas under mild water stress (I_2) or optimum soil moisture condition (I_3), the stomatal conductance was increased with increase in nitrogen dose from 90 kg N ha^{-1} to 240 kg N ha^{-1} irrespective of crop growth phases. Whereas the crop irrigation scheduled at I_3 (20 % DASM) in conjunction with N_3 (240 kg N ha^{-1}) recorded higher stomatal conductance, at silking, dough and physiological maturity.

These results are in line with the findings of Waraich and Ahmad (2010) who also stated that the irrigation and nitrogen application improved the transpiration rate and thus improved the stomatal conductance. Otoo *et al*. (1989) stated that increase in nitrogen levels along with irrigation levels increased stomatal conductance in rice crop.

CONCLUSION

Under high water stress condition (I_1), the leaf greenness index, photosynthesis rate and stomatal conductance was decreased with increasing nitrogen dose from 90 kg N ha^{-1} to 240 kg N ha^{-1} from silking to physiological maturity stage. Whereas under mild water stress (I_2) or optimum soil moisture condition (I_3), the spad chlorophyll values and photosynthesis rate were increased with increasing nitrogen dose from 90 kg N ha^{-1} to 240 kg N ha^{-1}. Under optimum soil moisture (I_3: 20 % DASM) or mild water stress (I_2: 40 % DASM) conditions, with increasing nitrogen dose from N_1 to N_3 level, the canopy temperature was decreased, but RLWC was increased. In contrast to this, under severe soil moisture stress (I_1: 60 % DASM), with increasing nitrogen dose from N_1 to N_3 level, the canopy temperature was also increased. The spad values recorded before irrigation was more and photosynthetic rate, leaf water content and stomatal conductance was more after irrigation when compared to before irrigation throughout the crop growth period.

At optimum soil moisture conditions, the maize crop enabled the plant to accumulate more and more nitrogen in tissues in response to incremental dose of nitrogen level which might have favored the increase in photosynthesis rate with incremental levels of N fertilizers. Whereas under severe moisture stress, the photosynthesis rate decreased with increase in nitrogen levels which might be due to amplification of stress with incremental nitrogen levels. Poor stomatal conductance, increase in canopy temperature and decrease in relative leaf water content at higher nitrogen dose under deficit irrigation evidences the amplitude of the stress experienced by the crop at silking, dough and physiological maturity stages.

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