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MITIGATIVE RESPONSE OF PRIMING AGAINST DROUGHT-INDUCED CHANGES IN MORPHOLOGICAL GROWTH AND YIELD OF MAIZE (ZEA MAYS L.)

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Abstract

The existence of new plant and their further growth is depending upon the healthy and high-quality seed. Priming techniques are a strategy that opens a new window to enhance the yield of crop via accelerating the initial phase of growth hence to understand the effect of the mitigative response of priming against drought-induced stress on morphological growth and yield of maize crop. The study was comprised of hydro, Osmo, and hormonal priming with KNO3, Mg (NO3)2, and GA3 of different concentrations. Results showed that [T5] i.e. 10 mM concentration of Mg (NO3)2 had a positive impact on all the parameters like plant height (cm), dry weight (g), stem diameter (cm), number of leaves, cob weight (g), grain yield (g), biological yield plant-1 (g), HI % and SPAD Unit recorded maximum % increase over control (43.46, 42.72, 53.99, 52.24, 48.75, 64.07, 36.84, 19.85 and 38.03) which was followed by T3 and T4 i.e. KNO3 and Mg (NO3)2 [15 and 7mM]. Results also indicated a strong positive relationship between the SPAD Unit and the rest of the morphological parameters studied in the present work under drought conditions.

Keywords: Drought, Grain yield, HI, Mitigative response, Seed priming and Spad unit.

INTRODUCTION

Maize (Zea mays L.) is the third most important cereal crop around the world because it has a wide range of adaptability. It is recognized as the queen of cereals because of its potential among the cereals. The United States of America is the highest producer of maize followed by Brazil, China, and Mexico while, Uttar Pradesh, Bihar, Rajasthan, and Madhya Pradesh are the leading states in India. It is commonly grown in the northern, central, and western parts of India with the production of 11.5 million tonnes in 6.4 million hectares area 23, 16. Drought is one of the overwhelming stress factors that limit physiological and morphological growth via manipulating the biochemical response of the maize plant which is responsible for the reduction in yield. Exposure to environmental stress like drought at initial growth stages had a detrimental effect on the establishment of healthy seedling growth over the field which results in poor plant stand and seedling growth 17, 4, 9, 7, 2. To overcome the prevailing issue, seed priming is one of the most suitable techniques which is not only able to defeat the prevailing situation at the initial phase but also had a positive impact on further growth stages of many plants 1, 24, 20. Many priming chemicals are popularly known to overcome the various issues in the plant i.e. (Mg (NO3)2, KNO3, ZnSO4, Ca (NO3)2, Salicylic acid, KCl, and NaCl but (Mg (NO3)2 and KNO3 is one of the best priming chemicals for improving the initial growth phase of plant as well as advance growth stages under the prevailing situation which help to improve the yield of various crops 17, 14, 18, 19.

MATERIALS AND METHODS

A pot experiment was undertaken in spring season 2019-2020 in Lovely Professional University, Jalandhar, India to assess the effect of seed priming treatments on morphological changes and yield of maize plants under drought conditions. Seeds of maize (Zea mays L) variety AHC 1212 were procured from an authentic shop of Ludhiana nearby the Punjab Agriculture University. Seeds were surface sterilized with 0.1% solution of sodium hypochlorite (NaOCl) before proceeding towards the seed priming treatments. Different seed priming chemicals/hydropriming were used in different concentrations i.e. KNO3 [10 and 15 mM], Mg (NO3)2 [7 and 10 mM], and GA3 [3 and 4 mM] for a certain period i.e. 16 hours thereafter seeds were dried back up to their original weight under by placing under the fan. The experiment was comprised of a total of eight treatments in a completely randomized design along with three replications in which an artificial drought was created before the flowering stage by holding the irrigation supply while the weather-related information was presented in (fig-4). Standard agronomical and cultural practices were followed during research work.

The observations regarding the plant height (cm), dry weight plant-1 (g), stem diameter (cm), and the number of leaves plant-1 were recorded at two stages i.e. pre-flowering and post-flowering [i.e. 60 and 90 DAS] while cob weight plant-1 (g), grain yield and biological plant-1 (g) were estimated at the time of harvest.

The parameter, harvest index % (HI %) was calculated according to the formula given by 6.

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield (grain yield)}}{\text{Biological yield}} \text{ X 100}$$

The SPAD unit reading was recorded in fully developed leaves at regular intervals of 30 days i.e. 30, 60, and 90 DAS by using at SPAD meter model number [SPAD-502 plus]. The Statistical analysis of the data received from the current research work was analyzed through SPSS software with the 23rd version. The mean data of all the parameters were subjected to analysis of variance and Duncan's Multiple Range Test.

RESULTS

Data presented in (table-1) shows the effect of different priming chemicals on plant height (cm) and dry weight of plant-1 (g) under drought conditions whereas pre and post-flowering times of 60 and 90 DAS were selected to record the data. Among the treatments, T5 [Priming with Mg (NO3)2 in 10 mM concentration] shows better performance for plant height and dry weight plant-1 [100.60, 115.87 cm and 57.07, 107.57 g] at both the time intervals which was followed by T3 and T4 i.e. [Priming with KNO3 in 15 mM and Priming with Mg (NO3)2 in 7 mM] as compare to control set [T0]. A significant difference was found among the treatment while a maximum % increase over control was also recorded in the same treatment i.e. T5 >T3 > T4 (41.09, 43.46, and 46.45, 42.45 %). Comparative studies among the PH and dry weight against SPAD Unit show a strong relationship (Fig 1a and 1b). Data depicted from (table-2) shows that T5 had a positive impact on stem diameter (cm) and a number of leaves plant-1 and recorded maximum value for both the parameters [3.91, 4.05 cm and 12.0, 10.02 plant-1] which was followed by T3 and T4 as compared to control (without primed seed). The statistical analysis of both the parameters also shows the significant difference for most of the treatments, especially among the T5, T4, T3, and control sets. The data of % increase over control shows a maximum value in T5 as compared to the rest of the treatments (61.57, 53.99, 50.0, and 52.24 %). The correlation of both the parameters against the SPAD Unit had a positive relationship (Fig-2a and 2b).

Table 1. *Effect of seed priming treatments on plant height (cm) and dry weight of plant-1 (g) of maize under drought conditions*

Treatment \ Days after sowing	Plant height (cm) and % increase over control		Dry weight of plant^{-1} (g) and % increase over control	
	60DAS	90DAS	60DAS	90DAS
T_0	71.30^{a}	80.77^{a}	38.97^{a}	75.37^{a}
T_1	76.30^{a}	83.33^{a}	42.73^{ab}	85.70^{b}

	[+7.01]	[+3.17]	[+9.65]	[+13.71]
T_2	83.24^{ab} [+16.75]	89.47^{b} [+10.77]	50.03^{cd} [+28.38]	94.77^{c} [+25.74]
T_3	97.90^{bc} [+37.31]	105.37^{c} [+30.46]	54.57^{de} [+40.03]	102.77^{de} [+36.35]
T_4	94.60^{bc} [+32.68]	104.50^{c} [+29.38]	52.70^{de} [+35.23]	97.37^{cd} [+29.19]
T_5	100.60^{c} [+41.09]	115.87^{d} [+43.46]	57.07^{e} [+46.45]	107.57^{e} [+42.72]
T_6	80.68^{a} [+13.16]	85.43^{a} [+5.77]	45.97^{bc} [+17.96]	88.46^{b} [+17.37]
T_7	71.60^{a} [+0.42]	80.07^{a} [-0.87]	42.19^{ab} [+8.26]	76.99^{a} [+2.15]

Notes:

1- Values present in parentheses shows % increase/decrease over control

2- Different alphabets indicate about the treatments are significant while the same alphabets indicate nonsignificant differences among the treatments according to DMRT ($p<0.05$)

Fig.1a. Effect of seed priming treatments on plant height (cm) and SPAD Unit in maize under drought conditions

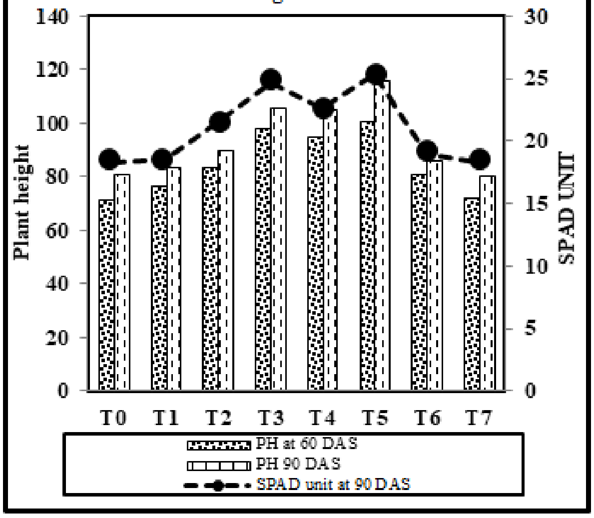
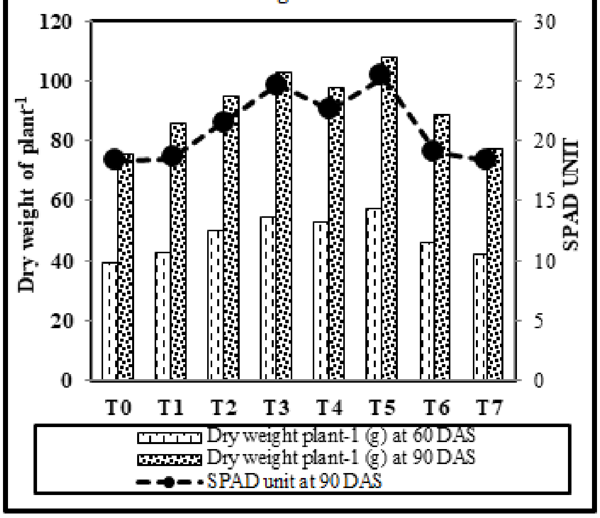


Fig.1b. Effect of seed priming treatments on dry weight plant^{-1} (g) and SPAD unit in maize under drought conditions



Note: T0= Control, T1= Priming with Distilled water, T2= Priming with KNO3, 10mM, T3= Priming with KNO3, 15mM, T4 = Priming with Mg (NO3)2, 7 mM, T5= Priming with Mg (NO3)2, 10 mM, T6= Priming with GA3, 3 mM and T7= Priming with GA3, 4 mM

Table 2. *Effect of seed priming treatments on stem diameter (cm) and number of leaves plant-1 in maize under drought conditions*

Days after sowing / Treatment	Stem diameter (cm) and % increase over control		Number of leaves plant^{-1} and % increase over control	
	60DAS	90DAS	60DAS	90DAS
T_0	2.42^{a}	2.63^{a}	8.0^{a}	6.7^{a}
T_1	2.62^{a}	2.93^{ab}	9.5^{abc}	7.7^{ab}

	[+8.26]	[+11.41]	[+18.75]	[+14.93]
T_2	3.34[b] [+38.08]	3.40[bc] [+29.28]	10.0[bcd] [+25.0]	8.2[abc] [+22.39]
T_3	3.45[b] [+42.56]	3.53[bc] [+34.22]	11.5[de] [+43.75]	9.2[bc] [+37.31]
T_4	3.70[b] [+52.89]	3.82[bc] [+45.25]	10.7[cde] [+33.75]	9.0[bc] [+34.33]
T_5	3.91[b] [+61.57]	4.05[d] [+53.99]	12.0[e] [+50.0]	10.2[c] [+52.24]
T_6	2.77[a] [+14.46]	2.94[ab] [+11.79]	9.5[abc] [+18.75]	7.8[ab] [+16.42]
T_7	2.56[a] [+5.79]	2.83[bc] [+7.60]	8.5[ab] [+6.25]	7.0[ab] [+4.48]

Notes:

1- Values present in parentheses shows % increase/decrease over control

2- Different alphabets indicate about the treatments are significant while the same alphabets indicate nonsignificant differences among the treatments according to DMRT ($p<0.05$)

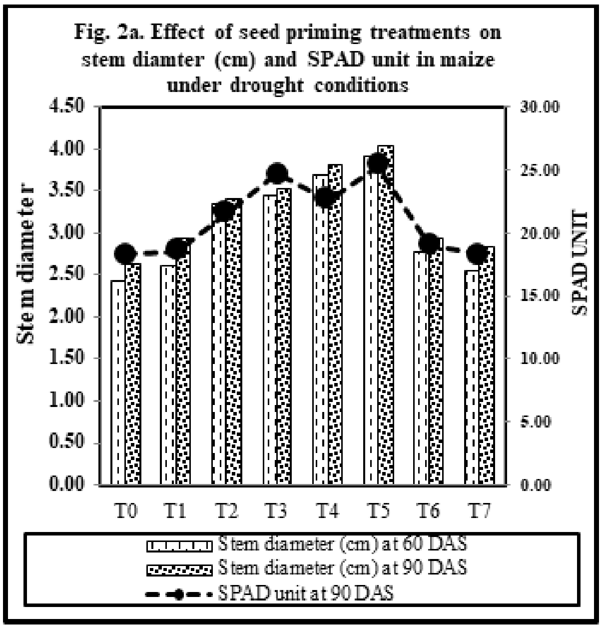


Fig. 2a. Effect of seed priming treatments on stem diamter (cm) and SPAD unit in maize under drought conditions

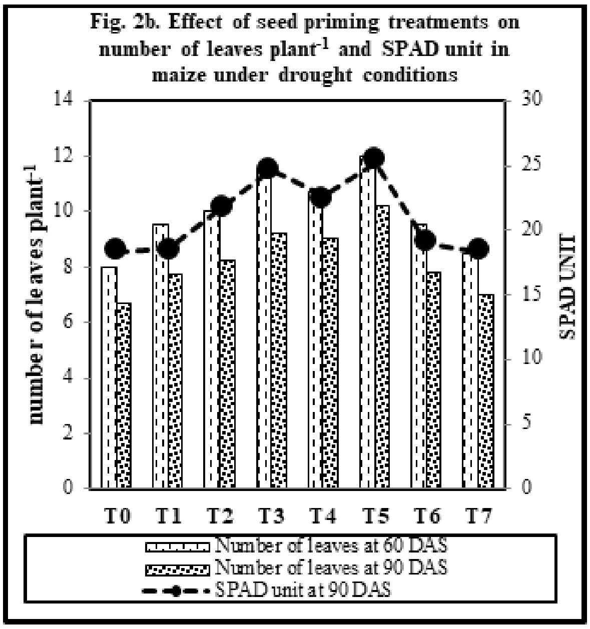
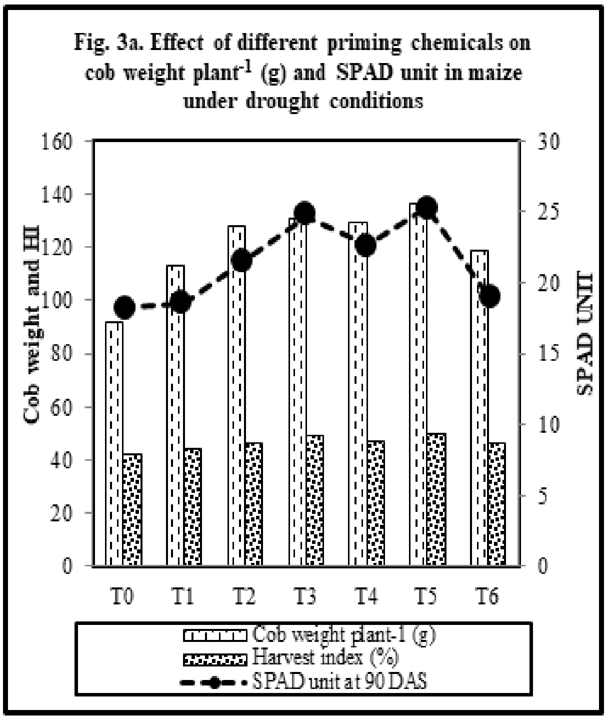


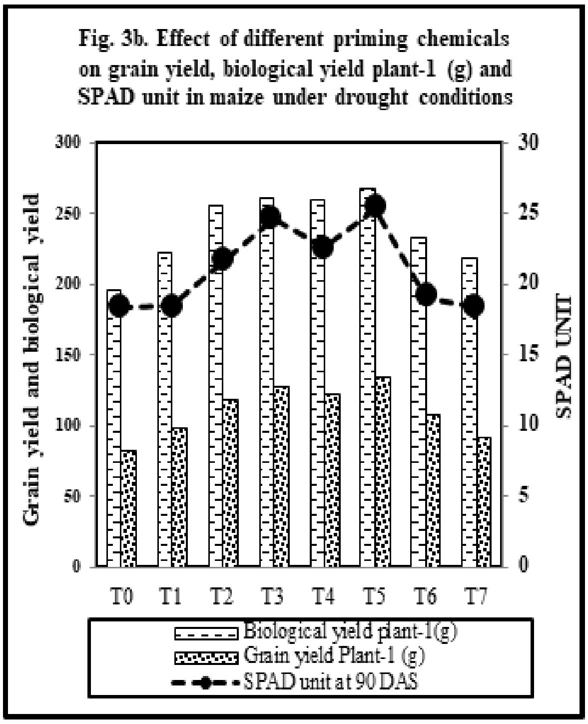
Fig. 2b. Effect of seed priming treatments on number of leaves plant^{-1} and SPAD unit in maize under drought conditions

Note: T0= Control, T1= Priming with Distilled water, T2= Priming with KNO3, 10mM, T3= Priming with KNO3, 15mM, T4 = Priming with Mg (NO3)2, 7 mM, T5= Priming with Mg (NO3)2, 10 mM, T6= Priming with GA3, 3 mM and T7= Priming with GA3, 4 mM

Table 3. *Effect of seed priming treatments on cob weight plant-1 (g), grain yield, biological yield plant-1 (g), and HI%, in maize under drought conditions*

Parameters / Treatment	Cob weight plant^{-1} (g)	Grain yield Plant^{-1} (g)	Biological yield plant^{-1} (g)	Harvest index (%)
T_0	91.68^{a}	81.67^{a}	195.61a	41.81^{a}
T_1	113.12^{b} [+38.97]	98.33^{b} [+20.40]	222.10b [+13.54]	44.27^{ab} [+5.88]
T_2	127.41^{d} [+38.97]	117.33^{d} [+43.66]	255.51c [+30.62]	45.92^{abc} [+9.83]
T_3	130.60^{de} [+42.45]	127.33^{ef} [+55.91]	261.10c [+33.48]	48.77^{bc} [+16.65]
T_4	129.42^{de} [+41.16]	121.67^{de} [+48.98]	259.45c [+32.64]	46.91^{bc} [+12.20]
T_5	136.37^{e} [+48.75]	134.00^{f} [+64.07]	267.67c [+36.84]	50.11^{c} [+19.85]
T_6	118.28^{c} [+29.01]	106.67^{c} [+30.61]	232.64b [+18.93]	45.99^{abc} [+10.0]
T_7	104.78^{b} [+14.29]	91.67^{b} [+12.24]	218.01b [+11.45]	42.06^{a} [+0.60]





Note: T0= Control, T1= Priming with Distilled water, T2= Priming with KNO3, 10mM, T3= Priming with KNO3, 15mM, T4 = Priming with Mg (NO3)2, 7 mM, T5= Priming with Mg (NO3)2, 10 mM, T6= Priming with GA3, 3 mM and T7= Priming with GA3, 4 mM

Table 4. *Effect of different priming chemicals on SPAD UNIT in maize under drought conditions*

Days after sowing Treatment	SPAD unit and % increase over control	
	60DAS	90DAS
T_0	43.00^{a}	18.33^{a}
T_1	45.30^{abc} [+5.08]	18.53^{a} [+1.08]
T_2	46.13^{abc} [+7.13]	21.57^{bc} [+15.02]
T_3	49.07^{cd}	24.70^{d}

	[+12.37]	[+25.79]
T_4	47.54^{bcd} [+9.55]	22.63^{cd} [+19.0]
T_5	50.83^{d} [+15.40]	25.30^{d} [+27.55]
T_6	46.20^{abc} [+6.93]	19.00^{ab} [+3.53]
T_7	44.13^{ab} [+2.56]	18.33^{a} [+0.0]

Notes:

1- Values present in parentheses shows % increase/decrease over control

2- Different alphabets indicate about the treatments are significant while the same alphabets indicate nonsignificant differences among the treatments according to DMRT ($p<0.05$)

Data related to yield and yield attributes of maize plant (table-3) also reveals the positive impact of T5 on cob weight (g), grain yield, and biological yield plant-1 (g) and HI % i.e. [136.37, 136. 134. 267.67 and 50.11] which followed by the treatment T3 and T4 as compared to the control set [91.68, 81.67, 195.61 g and 41.81 %]. Data related to % increase over the control set shows that T5 had a maximum % increase for the entire yield and yield attributes (48.67, 64.07, 36.84, and 19.85%). Yield and yield attributes are also positively correlated with the SPAD Unit (fig-3a and 3b). The parameter SPAD Unit is a crucial parameter that represents the greenness of the plant (table-4). Among the seed priming treatments, T5 shows maximum reading regarding the SPAD Unit [32.57, 85.83, and 25.30] which was followed by T3 and T4 [31.97, 49.07, 24.70 and 29.03, 47.54, 22.63] as compared to the control set. Among the interval of observation, the maximum SPAD Unit was recorded at 60 DAS as compared to 30 and 90 DAS. The data regarding the % increase over control also shows a similar trend as earlier T5> T3>T4 (28.74, 18.21 and 38.03 %) at 30, 60, and 90 DAS.

DISCUSSION

The results of a present piece of work reveal the impact of the entire set of priming treatments which includes hydropriming, osmopriming, and hormonal priming on morphological, yield, and yield attributes of maize under drought conditions. Among the entre sets of priming treatments, [T5] i.e. Mg (NO3)2, 10 mM concentration shows better performance for most of the parameters recorded during the conduct of work which was followed by [T3 and T4] i.e. KNO3 and Mg (NO3)2 [15 mM and 7 mM concentration. The results are well correlated with the finding of 14 who reported that seed priming with Mg (NO3)2 does not only improve the performance of seed germination and seedling growth but also improves plant height, dry weight, and the number of leaves 5, 22. An increase in dry weight of maize plant along with the leaves number and SPAD Unit [which represents the greenness in the plant] had a positive correlation to yield of the crop (1b, 2b, 3a, and 3b). It is well correlated with the finding of 15, 10, 12, 3. Yield and yield attributes like cob weight, grain yield, biological yield, and HI% are also reported utmost in T5 even though its correlation with SPAD Unit is also positive (table-3 and fig- 3a and 3b). 21 reported a positive relation of SPAD reading with yield and yield attributing characters in maize 8. An increase of greenness in terms of the SPAD Unit represented chlorophyll content in the plant because both are positively correlated with each other (table-4). It contributes not only accelerates the rate of photosynthesis in the plant but also contributes to enhancing and improving the morphological growth and yield of crops under drought conditions 11, 13.

CONCLUSION

In conclusion, it can be suggested that the seed priming treatments with salts of Mg and K nitrate help to improve morphological as well yield and yield attributing characters of maize plants under drought conditions. It started to act positively since the beginning of plant life while its positive effect carryforward on consecutive phases of plant growth and yield of the crop. The major aim of correlation studies between SAPD Units against morphological and yield attributes is to predict the behaviors of entire treatments and their impact because Magnesium is one of the essential and central atoms of the chlorophyll molecule.

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