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RESEARCH PAPER

Mitigating drought stress in chickpea (*Cicer arietinum* L.) through seed priming under late sown conditions

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Abstract: A study on mitigating drought stress in chickpea through seed priming under late sown conditions was carried out during *rabi* 2019-20 at the seed production block of ICAR-National Seed Project, Main Seed Unit, University of Agricultural Sciences, Raichur. The experiment consisted of ten treatments *viz.,* T_1: Control, T_2: Hydro priming, T_3: Seed priming with KNO_3 (0.5%), T_4: Seed priming with KNO_3 (1%), T_5: Seed priming with GA_3 (100 ppm), T_6: Seed priming with GA_3 (150 ppm), T_7: Seed priming with SA (50 µM), T_8: Seed priming with SA (100 µM), T_9: Seed priming with SNP (50 µM) and T_{10}: Seed priming with SNP (100 µM) which was laid out in randomized block design. The seeds were primed at 1:2 seed to solution ratio for 8 hours and evaluated for growth and yield parameters. The experimental results revealed that seed priming with salicylic acid @ 100 µM recorded significantly higher number of primary branches per plant (3.7 and 3.8), leaf area index (2.808 and 1.494), chlorophyll content (59.8 and 45.0) at 60 DAS and harvest and plant population (160), number of pods per plant (22.0), 100 seed weight (18.9 g), seed yield per plant (3.9 g) and seed yield per hectare (1125.9 kg) at harvest. While, gibberellic acid @ 150 ppm recorded significantly highest plant height (32.1 and 33.2) compared to all other treatments and control at 60 DAS and harvest.

Key words: Chickpea, Drought, Gibberellic acid, Salicylic acid, Seed priming, Seed yield

Introduction

Chickpea (*Cicer arietinum* (L.)) 2n=16, belongs to family leguminaceae. It is a cool season legume grown in several countries worldwide. Seed is the main edible part of the plant and is a rich source of protein (23.3 to 28.9%), carbohydrates (61.5%), fats (4.5%) and minerals (phosphorus, calcium, magnesium, iron, zinc).

In the world it is cultivated on 17.9 million ha with a production of 17.2 million tonnes and with an productivity of 965 kg/ha (Anon, 2019). In India, it is cultivated in an area of 9.67 million hectares with a production of 10.09 million tonnes and a productivity of 1043 kg/ha (Anon, 2020). Karnataka stands fifth in cultivation with 1.3 million ha area with a production of 0.73 million tonnes and productivity of 619 kg/ha (Anon, 2020).

The major chickpea growing areas are in the arid and semi arid zones and about 90 percent of the world's chickpea is grown under rainfed conditions (Kumar and Abbo, 2001) as a result of which 40-50 per cent reduction in yield globally is noticed (Ahmad *et al*., 2005). It is traditionally sown towards the end of rainy season during *rabi* and generally grown on progressively declining residual soil moisture.

This moisture deficit affects seed germination and seedling establishment in the field. Hence, it is very much necessary to address this problem through suitable seed quality enhancement techniques like seed priming. Seed priming is a physiological strategy that involves soaking of seeds in a solution of a specific priming agent followed by drying of seeds that initiates germination related process. This has been recognized as an important technology to obtain good germination, rapid growth, development and improved yields and alleviates the negative effects of drought on emergence (Anbessa and Bejiga, 2002). Hence with this background an experiment was designed to mitigate drought stress in chickpea through seed priming under late sown conditions in order to find out the best seed priming treatment to address this drought stress at seed germination stage.

Material and methods

The experiment was carried out at the seed production block of ICAR-National seed project, Main Seed Unit, University of Agricultural Sciences, Raichur. The experiment consists of ten treatments *viz.,* T_1: Control, T_2: Hydro priming, T_3: Seed priming with KNO_3 (0.5%), T_4: Seed priming with KNO_3 (1%), T_5: Seed priming with GA_3 (100 ppm), T_6: Seed priming with GA_3 (150 ppm), T_7: Seed priming with SA (50 µM), T_8: Seed priming with SA (100 µM), T_9: Seed priming with SNP (50 µM) and T_{10}: Seed priming with SNP (100 µM) which was laid out in randomized block design. The seeds were primed with the respective chemicals and their concentrations with 1:2 seed to solution ratio (weight by volume) for 8 hour (Laghari *et al.* 2016). The primed seeds were sown in three replications at spacing of 30 x 10 cm. Foliar spray with chickpea magic (0.75%) and 19:19:19 (0.75%) was given for all the treatments at 45 days after sowing as per package of practice.

The observations on plant height, number of primary branches per plant, leaf area index, chlorophyll content were recorded at 60 days after sowing and at harvest. While, the plant population, number of pods per plant, 100 seed weight, seed yield per plant and hectare were recorded at harvest. The data collected from the experiment were analyzed statistically by the procedure prescribed by Sundararaj *et al.* (1972).

Results and discussion

Seed priming with different chemicals and plant growth regulators significantly influenced the plant height both at 60 days after sowing and harvest under drought induced late sown conditions (Table 1). Among all the seed priming treatments, GA_3 at 150 ppm (T_6) recorded significantly highest plant height (32.1 and 33.2 cm) compared to all other treatments and control-T_1 (26.5 and 27.3 cm) respectively at 60 DAS and at harvest. However, GA_3 at 150 ppm (T_6) was on par with GA_3 at 100 ppm-T_5 (31.4 and 32.0 cm), SA at 100 µM-T_8 (30.0 and 31.2 cm), SA at 50 µM-T_7 (29.5 and 30.4 cm), KNO_3 at 0.5 %-T_3 (29.0 and 30.0 cm) and KNO_3 @1 %-T_4 (28.7 and 29.5 cm). It was noticed from the present study that there was 17.4 and 17.8 per cent increase in plant height at 60 DAS and harvest due to seed priming with GA_3 at 150 ppm. Gibberellic acid has contributed to better plant's resistance to drought stress and effectively maintained osmotic balance in the plant cell and might have also helped in better cell division and elongation resulting in more plant height (Hasan, 2015). Similarly, Azizi (2012) also envisaged the role of gibberellic acid in stimulating plant cell elongation and division leading to higher plant height, leaf area, grain weight and also yield. These findings are consistent with Kaya *et al.* (2009) who demonstrated that gibberellic acid contributes effectively to increase soybean stalk and contributed to increase of all bioactivities of the plant. Our results are also well supported with the findings of Arun *et al.* (2017) in cowpea and Reja *et al.* (2020) in chickpea.

The number of primary branches per plant at 60 DAS and harvest were significantly influenced by seed priming with different chemicals and plant growth regulators under drought induced late sown conditions (Table 1). In the present study, SA at 100 µM (T_8) recorded significantly higher number of branches per plant (3.7 and 3.8) compared to all other treatments and control (3.0 and 3.0) respectively at 60 DAS and harvest (Fig 1).

However, SA at 100 µM-T_8 was on par with SA 50 µM -T_7 (3.6 and 3.7) and GA_3 150 ppm-T_6 (3.6 and 3.6), GA_3 100 ppm-T_5 (3.5 and 3.6), KNO_3 at 0.5 %-T_3 (3.4 and 3.5) and KNO_3 1 %-T_4 (3.3 and 3.5). These results indicated that priming with SA at 100 µM enhanced the number of primary branches per plant by 18.9 and 21.0 per cent, at 60 DAS and harvest, respectively compared to control. Under drought stress the cell elongation of the plant might be inhibited by interruption of water flow from xylem to surrounding elongating cells leading to less number of branches (Manivannan *et al.*, 2007). But application of salicylic acid @ 500 ppm in coriander (Shanu *et al.*, 2013) and 1000 ppm in maize (Sahu *et al.*, 1993) significantly increased the number of branches per plant.

Development of optimal leaf area is important for photosynthesis and dry matter production. Water deficit stress mostly reduces leaf growth and in turns the leaf areas in many plant species (Jaleel *et al.*, 2009). Drought-induced reduction in leaf area is ascribed to suppression of leaf expansion through reduced photosynthesis (Anjum *et al.*, 2011). Similarly, Hussain *et al.*, (2009) revealed that in sunflower water stress reduced the LAI, leaf area duration (LAD), crop growth rate (CGR), relative water content (RWC), water potential, osmotic potential, turgor pressure, achene yield and water use efficiency. Nevertheless, exogenous application of SA appreciably improved these attributes under water stress. In our study seed priming with different chemicals and plant growth regulators

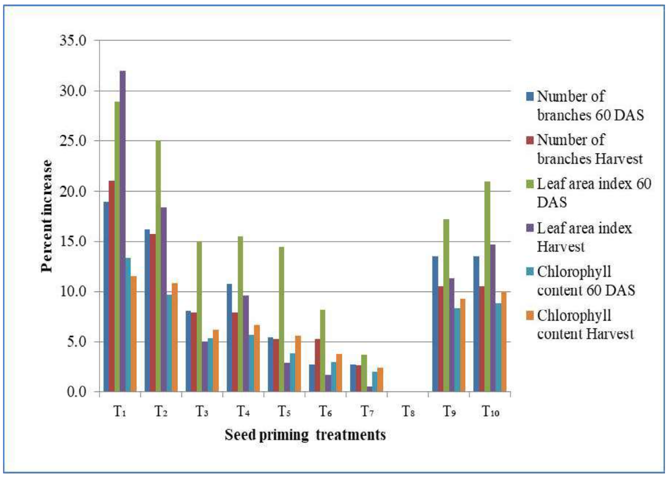

Fig. 1. Percent increase in the number of primary branches per plant, leaf area index and chlorophyll content due to seed priming with SA at 100 µM in chickpea under drought induced late sown conditions

Table 1. Influence of seed priming on plant height, number of primary branches per plant, leaf area index and chlorophyll content (SPAD values) in chickpea under drought induced late sown conditions

	Plant height (cm)		Number of primary branches per plant		Leaf area index		Chlorophyll content (SPAD values)	
Treatments	60 DAS	Harvest	60 DAS	Harvest	60 DAS	Harvest	60 DAS	Harvest
T_1	26.5	27.3	3.0	3.0	1.995	1.017	51.8	39.8
T_2	27.4	28.2	3.1	3.2	2.105	1.219	54.0	40.1
T_3	29.0	30.0	3.4	3.5	2.385	1.419	56.6	42.2
T_4	28.7	29.5	3.3	3.5	2.372	1.350	56.4	42.0
T_5	31.4	32.0	3.5	3.6	2.403	1.450	57.5	42.5
T_6	32.1	33.2	3.6	3.6	2.577	1.469	58.0	43.3
T_7	29.5	30.4	3.6	3.7	2.704	1.486	58.6	43.9
T_8	30.0	31.2	3.7	3.8	2.808	1.494	59.8	45.0
T_9	28.5	29.3	3.2	3.4	2.325	1.325	54.8	40.8
T_{10}	28.0	29.0	3.2	3.4	2.220	1.275	54.5	40.5
S.Em±	1.1	1.2	0.1	0.1	0.139	0.023	1.0	0.9
C.D. @ 5%	3.5	3.8	0.4	0.3	0.415	0.074	3.1	2.7

significantly influenced the leaf area index ((µmol m^{-1} s^{-1}) both at 60 DAS and harvest under drought (Table 1). The results revealed that among the various seed priming treatments, SA at 100 µM (T_8) recorded significantly higher leaf area index (2.808 and 1.494) compared to all other treatments and control (1.995 and 1.017) respectively, at 60 DAS and harvest. However, SA at 100 µM-T_8 was on par with SA 50 µM- T_7 (2.704 and 1.486), GA_3 150 ppm-T_6 (2.577 and 1.469) and GA_3 @ 100 ppm-T_5(2.403 and 1.450). The percent increase in LAI due to seed priming with SA @ 100 µM was 29.0 and 31.9 percent respectively, at 60 DAS and harvest compared to control (Fig 1). Under drought SA optimum concentration caused maintenance of relative water content and photosynthesis thus improves leaf area index. Similar to our results, higher leaf area due to treatment with SA has been reported in pearl millet (Mathur and Vyas, 2007), wheat (Hayat *et al*., 2005), corn and soybean (Khan *et al*., 2003). This significant improvement in LAI occurred due to enhanced translocation of photo-assimilates and regulation of enzymatic activities due to application of salicylic acid (Noreen and Ashraf, 2008). These results are in agreement with those of Fariduddin *et al.* (2003) who reported enhanced growth and development due to increased stimulation in physiological and biochemical processes.

Seed priming with different chemicals and plant growth regulators significantly influenced the chlorophyll content both at 60 DAS and harvest under drought induced late sown conditions (Table 1). Among all the seed priming treatments, SA at 100 µM (T_8) recorded significantly highest SPAD values (59.8 and 45.0) compared to all other treatments and control-T_1 (51.8 and 39.8). However, SA at 100 µM-T_8 was on par with SA 50 µM-T_7(58.6 and 43.9), GA_3 @ 150 ppm-T_6(58.0 and 43.3) and GA_3@ 100 ppm-T_5(57.5 and 42.5). The per cent increase in chlorophyll content was to the tune of 13.4 and 11.5 due to seed priming with SA @ 100 µM at 60 DAS and harvest, respectively compared to control (Fig 1). When the plants were subjected to drought stress, chlorophyll content was significantly reduced, this might be due to defense in photosynthetic pigments by water stress seems to be the consequence of closure of stomata, thereby decreasing CO_2 supply as well as internal CO_2 concentration (Tiwari *et al.* 2005; Hayat *et al.* 2008). However, they reported higher total chlorophyll a and chlorophyll b content in SA treated plants than control during drought stress. Increased photosynthetic pigment concentration in plants subjected to SA under drought stress may be the result of enhanced activity of Rubisco and PEP carboxylase under stress (Popova *et al.* 2003; Singh, Usha 2003). Our results are in agreement with the observations in tomato and cowpea plants treated with SA under drought stress (Hayat *et al.* 2008; Afshari *et al.* 2013), Sujatha (2001) in greengram, Askari and Ehsanzadeh (2015) in fennel.

Seed priming with different chemicals and plant growth regulators significantly influenced the plant population at harvest under drought induced late sown conditions (Table 2). The results revealed that among the various seed priming treatments, SA at 100 µM (T_8) recorded significantly higher plant population (160) compared to all other treatments and control (140) at harvest. However, SA at 100 µM-T_8 was on par with SA 50 µM-T_7(158), GA_3@ 150 ppm-T_6(155), GA_3@ 100 ppm-T_5(154), KNO_3 @ 0.5 %-T_3(152) and KNO_3 @ 1 %-T_4 (150). In the present study we could not get 100 per cent plant population under late sown and drought condition. Since both these conditions reduce the plant population per unit area. However, seed priming with drought mitigating chemicals would overcome this abiotic stress to some extent. It was noticed that seed priming with SA @ 100 µM-T_8 had better results that is 12.5 per cent improvement over control. It has been reported that the first and foremost effect of drought is impaired germination and poor plant stand and establishment which leads to a decrease in biological yield (Harris and others, 2002). Exogenous application of salicylic acid enhances the photosynthetic rate, maintains the stability of membranes and improves nutrition absorption and thereby additional ground cover of plants under stress condition (Joseph and others, 2010). Salicylic acid had a synergetic effect on auxin and gibberellin which are growth promoters responsible for growth and developments of plant.

Table 2. Influence of seed priming on plant population, number of pods per plant, 100 seed weight (g), seed yield per plant (g) and hectare^{-1} (kg) in chickpea under drought induced late sown conditions

Treatments	Plant population	Number of pods per plant	100 seed weight (g)	Seed yield	
				g/plant	Kg/ha
T_1	140	18.0	16.6	3.3	855.5
T_2	142	19.0	17.2	3.4	894.1
T_3	152	20.0	18.2	3.6	1013.3
T_4	150	19.5	17.9	3.6	1000.0
T_5	154	21.0	18.3	3.6	1026.7
T_6	155	21.5	18.6	3.7	1062.0
T_7	158	21.8	18.8	3.8	1111.8
T_8	160	22.0	18.9	3.9	1125.9
T_9	148	19.3	17.8	3.5	959.3
T_{10}	145	19.2	17.5	3.5	939.8
S.Em±	3.5	0.8	0.9	0.1	52.9
C.D.@ 5%	10.4	2.6	NS	0.3	158.5

The number of pods per plant were significantly influenced by seed priming with different chemicals and plant growth regulators under drought induced late sown conditions (Table 2). Among the various seed priming treatments, significantly higher number of pods per plant (22.0) were recorded in T_8 (SA @ 100 µM) compared to all other treatments and control-T_1 (18.0). However, SA 100 µM-T_8 was on par with SA 50 µM-T_7(21.8), GA_3 150 ppm-T_6 (21.5), GA_3 @ 100 ppm-T_5(21.0), KNO_3 @ 0.5 %-T_3(20.0) and KNO_3 @ 1 %-T_4 (19.5). These results indicated that priming with SA at 100 µM enhanced the number of pods per plant by 18.2 per cent compared to control (Fig 2). This might be due to involvement of salicylic acid in production of auxin leading to higher number of branches and consequently more number of pods per plant. Similarly, Safai (2013) reported more pods per plant in mungbean due to application of salicylic acid (1.5 mM) than control. Similarly, Leslie and Romani (1986) stated that the number of pods per plant was increased by foliar application of salicylic acid. Our results are also well supported with the findings of Sujatha (2001) in greengram, Rajabi *et al*. (2013) in chickpea and Khademian and Yaghoubian (2018) in chickpea.

Seed priming with different chemicals and plant growth regulators did not have any effect on 100 seed weight under drought induced late sown conditions (Table 2). However, numerically highest 100 seed weight (18.9 g) was recorded in SA @ 100 µM (T_8) compared to all other treatments and control (16.6 g). Ali and Mahmoud (2013) and Dawood *et al.* (2014) reported that 100 seed weight of mungbean and sunflower was enhanced by application of salicylic acid. However, Karim *et al.* (2011) observed that the effect of salicylic acid application was not significant on 100 seed weight. Seeds primed with salicylic acid allocated highest weight of 100 seeds (Shekari *et al*., 2010).

Seed priming with different chemicals and plant growth regulators significantly influenced the seed yield (g/plant) under drought induced late sown conditions (Table 2). Among all the seed priming treatments, SA @ 100 µM (T_8) recorded higher seed yield (3.9 g/plant) compared to all other treatments and control- T_1 (3.3 g). However, SA @ 100 µM-T_8 was on par with SA @ 50 µM-T_7 (3.8 g), GA_3 @ 150 ppm-T_6 (3.7 g), GA_3 @ 100 ppm-T_5 (3.6 g), KNO_3 @ 0.5 %- T_3(3.6 g) and KNO_3 @ 1 %-T_3(3.6 g). These results indicated that seed priming with SA (100 µM) enhanced the seed yield per plant by 13.2 per cent compared to control (Fig 2). Seed yield in legumes depends on a number of seeds plant^{-1} thereby increase the grain yield (Khan *et al*., 2010). SA effectively maintained osmoregulation, redox and protein homeostasis through improved carbon, amino acid and protein metabolism and it maintained sink strength through amino acid metabolism and proteases improving nitrogen use efficiency and stabilizing yield under drought stress (Sharma *et al*., 2018). Sadeghipour and Aghaei (2012) reported that salicylic acid improves the relative water content and photosynthesis as well as increased the growth and yield of common bean plants. Our results are also well supported by the findings of Rajabi *et al*. (2013) and Khademian and Yaghoubian (2018) in chickpea.

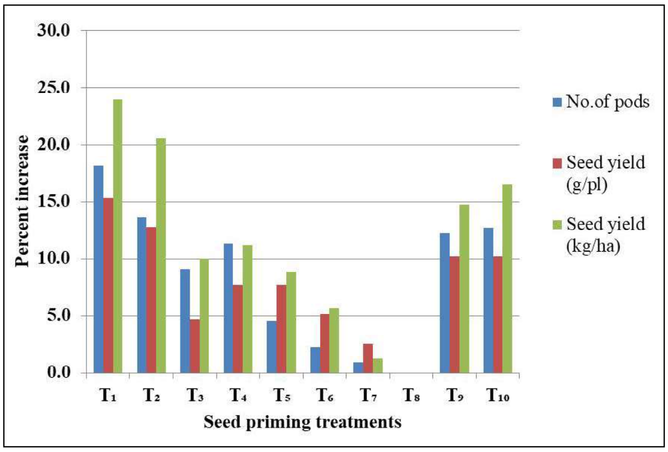

Fig. 2. Percent increase in the number of pods per plant, seed yield per plant and seed yield per hectare due to seed priming with SA at 100 µM in chickpea under drought induced late sown conditions

Seed priming with different chemicals and plant growth regulators significantly influenced the seed yield (Kg/ha) under drought induced late sown conditions (Table 2). Among all the seed priming treatments, SA @ 100 µM (T_8) recorded significantly highest seed yield (1125.9 Kg/ha) compared to all other treatments and control- T_1 (855.5 Kg). However, SA @ 100 µM-T_8 was on par with SA @ 50 µM-T_7 (1111.8 Kg), GA_3 @ 150 ppm-T_6 (1062.0 Kg), GA_3 @ 100 ppm-T_5 (1026.7 Kg), KNO_3 @ 0.5 %-T_3(1013.3 Kg) and KNO_3 @1 %-T_4 (1000.0 Kg). It was noticed from the present study that there was 24.0 per cent higher seed yield per ha due to seed priming with SA (100 µM) compared to control (Fig 2). Salicylic acid appears to increase stress resistance by increasing the activity of enzymes that acts to deal with stress. This leads to an increase in yield components and grain yield accordingly. Subedi (2005) showed that the number of seeds and plant yield in primed seeds was more in comparison to unprimed seeds. Similarly, Ahmad *et al.* (1995) stated that seed pretreatment with plant growth hormone as salicylic acid not only enhanced seed germination and emergence index, but also increased the final yield under normal and stress conditions. Our results are well supported by the findings of Ali and Mahmoud (2013) and Keikha *et al.* (2017) in mungbean and Vaisnad and Talebi (2015) in chickpea.

Conclusion

Based on the findings, it can be concluded that drought adversely affects the seed yield of chickpea. Among the different seed primed treatments imposed, seed priming with salicylic acid @ 100 µM or GA_3 @ 150 ppm at 1:2 seed to solution ratio for 8 hours recorded significantly higher seed yield of chickpea under drought induced late sown conditions.

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