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Physiological approaches for yield improvement in chickpea (*Cicer arietinum* L.) under drought condition

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Abstract
A field experiment was conducted at Agricultural Research Station, Kalaburgi, University of Agricultural Sciences, Raichur, during the rabi 2018-19 to assess the potency of plant growth regulators and nutrients which could be used to mitigate water stress and reduce the yield reduction in chickpea under drought condition. During investigation the treatments followed were foliar spray of 2% urea, seed priming with 2% $CaCl_2$, 0.1% boron, salicylic acid (100 ppm), cycocel (100 ppm), and formulations like pulse magic 8 g/l and chickpea special 8 g/l were evaluated under non irrigated condition on chickpea variety JG11. The result indicates that grain yield significantly reduced under water stress. All treatments showed promising effect on crop health under non-irrigated conditions. However, the significantly larger effect was noticed foliar spray of chickpea magic 8 g/l at 50% flowering. The plants followed foliar spray of chickpea magic 8 g/l attained significantly increased plant height, number of branches, total dry weight, relative water content, photosynthetic rate, number of pods per plant, 100- seed weight, grain yield and harvest index over control under drought condition.

Keywords: Chickpea magic, drought mitigation, 50% flowering stage, foliar spray, seed yield

Introduction

Pulses are the most important crops of the world because of their high nutritive value. In India pulses have been described as a "poor man's meat and rich man's vegetable". The importance of vegetable protein has been well recognized throughout the world. India with its predominantly vegetarian population has a distinction of being the world's producer cum consumer of grain legumes. Nevertheless, rapidly shooting up demographic pressure and almost static production have posed a formidable problem in alleviating the nutritional imbalance. In other hand the increasing population of the country poses serious challenges on the food front. To make up this short fall the only option at hand is to increase the productivity.

Among the pulses, chickpea (*Cicer arietinum* L.) is one of the oldest crops in the world and remain the most popular today, across the continent. Chickpea has been a part of certain traditional diets for over 7500 years. It provide a high quality protein, on an average 126 kg protein/ha and it is probably the second highest protein yielding legume. It is a cool season crop and an essential crop for arid and semi-arid regions and about 90% chickpea crop is grown in rain fed conditions without irrigation (Kumar and Abbo, 2001)[1]. In this context, drought remains as a major constraint on chickpea productivity with a global economic loss of about 40–50% (Millan *et al*., 2006) [2]. Drought stress exerts drastic effects on nutrient uptake, hinders the nodule formation and adversely affects yield and yield components.

An effective approach to increase the productivity of chickpea is through improving morphological and physiological mechanism of drought tolerance in high yielding genotypes. Thus, the study addresses field test of the effect of exogenous application of plant growth regulators and nutrients on morphology, physiology and yield of chickpea with the objective to explore the possibility of compensating yield reduction due to restricted soil moisture by foliar application of suitable chemical/ chemicals.

Materials and Methods

The field experiment was carried out during *rabi* season of the year 2018-19 at Agricultural Research Station, Kalaburgi, University of Agricultural Sciences, Raichur with chickpea variety JG11 under non-irrigated condition. The experiment was laid out in Randomized complete block design (RCBD) with 11 treatments in three replication involving Seed priming with 2% $CaCl_2$ followed by foliar spray of 2% urea at 1st flowering and salicylic acid 100 ppm at 50% flowering (T_1), Seed priming with 2% $CaCl_2$ followed by foliar spray of CCC 100 ppm at 50% flowering (T_2), Seed priming with 2% $CaCl_2$ followed by foliar spray of 0.1% boron at 50% flowering (T_3), Seed priming with 2% $CaCl_2$ (T_4), Foliar spray of CCC at 50% flowering (T_5), Foliar spray of salicylic acid 100 ppm at 50% flowering (T_6), Foliar spray of 0.1% boron at 50% flowering (T_7), Foliar spray of chickpea magic 8 g/l at 50% flowering (T_8), Foliar spray of pulse magic 8 g/l at 50% flowering (T_9), Water spray(T_{10}), no spray (control-T_{11}). Chickpea magic and pulse magic is novel formulations released by UAS, Raichur. Chickpea magic contains NPK along with micronutrient and plant growth regulators. Plant height was measured for three plants from base of the plant to the tip of main shoot and mean of plant height was worked out and expressed in centimeters. The total number of branches per plant was counted at each sampling and mean values of three plants was expressed as number of branches per plant. And total dry matter was obtained by taking the sum of leaf, stem and reproductive dry matter of the plant after keeping the sample in hot air oven at 80˚C for 48 hours. Relative water content was analyzed from 3rd leaf at different stages of growth and development as per Barr and Weatherley (1962) [3]. Photosynthetic rate (μ mol CO_2 m^{-2} s^{-1}) and stomatal conductance (m mol H_2O m^{-2} s^{-1}) was measured by using infra-red gas analyzer (TPS-2 potable photosynthesis system version 2.01). The measurements were made on the portion of leaves completely exposed to sunlight. Total chlorophyll content of the leaves was determined by following Dimethyl sulfoxide (DSMO) method devised by Hiscox and Israeistam (1967) [4]. The data was analyzed statistically following the method of Panse and Sukhatme (1967) [5]. Foliar spray was carried out at 50% flowering in all the treatments except in T_1. The data on morphological physiological and yield parameters were statistically analyzed and interpreted.

- Chickpea magic is a product developed and released by UAS, Raichur to increase the yield of chickpea. It contains NPK along with micronutrient and plant growth regulators.
- Pulse magic is a product developed and released by UAS, Raichur for increasing the yield of pulse crops. It contains 10 per cent nitrogen, 40 per cent phosphorous, 3 per cent micronutrient and 20 ppm plant growth regulator

Results and Discussion

The data on morphological parameters like plant height, total number of branches and total dry weight shows significant difference among the treatment in all the stages except 40 DAS. Since most of the treatments were imposed at 50% flowering stage. The plant height has increased from 40 DAS to harvest as the crop follows an indeterminate growth habit. Foliar spray of pulse magic (T_9) and chickpea magic (T_8) recorded highest plant height of 48.70 cm and 47.90 cm respectively at harvest (Table 1). The increased plant height may be due to the stimulating action of micronutrient Zn on plant hormone auxin which in turn increases the plasticity by softening the cell wall. It also lowers the water potential through hydrolysis of starch to sugars, resulting in the entry of water into the cell causing elongation and rapid cell division of growing part (Sargent, 1965) [6]. And significantly lesser plant height 33.02 cm was observed in foliar spray of CCC (T_5) at harvest. Thus reduced plant height is due to the retardation of transverse cell division, mainly in stellar cambium which is a zone of meristematic activity at the base of internodes (Grossman, 1990) [7]. Similarly Garai and Datta (2003) [8] found that the application of CCC reduced plant height in green gram and soybean when compared to control. The total number of branches (Table 1) increased on foliar spray of chickpea magic 8 g/l (T_8) over control by diverting the polar transport of auxins towards the basal nodes leading to breaking of lateral bud dormancy. The finding was similar to Dhaka and Anamika (2003) [9] that the application of chemical such as PGR and macronutrient in green gram increased the number of branches. Dry matter production is an important yield contributing character which is limiting during drought condition. Farjam *et al.* (2015) [10] showed that it is the plant biomass which is significantly affected by drought stress and highest was recorded under full watered condition. A significant difference in dry matter production was noticed at 60, 80 DAS, at harvest due to various treatments and highest dry matter production of was observed with foliar spray of chickpea magic 8 g/l (10.79 g plant $^{-1}$, 28.13 g plant $^{-1}$, 36.42 g plant $^{-1}$) due to the presence of PGR which governs various physiological processes and further translocation of photoassimilates (Table1). Similarly in blackgram higher TDM was reported by Surendar *et al.* (2013) [11] due to foliar application of PGR and micronutrients. The increase in TDM towards maturity is due to indeterminate growth pattern, higher rate of CO_2 assimilation and RUBISCO activity during crop growth. Thus total dry matter is an important parameter in boosting the source- sink relationship and yield potential noted by Nam *et al*. (1998) [12] and Katti *et al*. (1999) [13] in pigeonpea.

Relative water content (RWC) is a measure of the amount of water present in the leaf tissue in relation to turgid condition and the treatments having higher RWC under drought condition would be preferable to maintain higher water balance. The data in Table 2, higher RWC was recorded for pulse magic 8 g/l (T_9) at 60 DAS whereas at 80 DAS chickpea magic 8 g/l (T_8) shown an increased RWC followed by pulse magic 8 g/l (T_9). The ability of plant to maintain the turgor and related physiological process even under water stress condition has a great practical significance in terms of osmoregulatory activity (Awari *et al.*, 2017) [14]. The photosynthetic rate is a function of several biophysical and biochemical processes which involves diffusion of CO_2 from atmosphere to chloroplast and subsequent enzymatic reaction. Higher photosynthetic rate is observed with foliar spray of chickpea magic in Table 2. The significant increase in photosynthesis may be because plant growth regulators which in turn may cause prolonged chlorophyll synthesis, strengthening the physiological activity. The result is in conformity with findings of Khan *et al*. (2003) [15].

A promising effect of treatments on yield attributes were noticed under non irrigated conditions. In general, the yield of crop plants is attributed to total assimilation achieved during the growing season and the way it is partitioned between the desired storage structures and rest of the plant parts. The data indicated (Fig 1.) that these chemicals have differential influence on the distribution of assimilates between vegetative and reproductive organs and also revealed that foliar spray of chickpea magic 8 g/l significantly increased number of pods, 100-seed weight, harvest index and finally seed yield per plant, which are the most important yield determining components in chickpea. These results are similar to the finding of Vijaysingh (2017) [16] in black gram; Teggelli *et al*.

(2016) [17] in pigeonpea. Further the result are in agreement with result of Marimuthu and Surendran (2015) [18] in blackgram due to the application of NPK+ foliar application of 2% diammonium phosphate + foliar application of pulse wonder at 50% flowering resulted in higher seed yield.

Table 1: Effect of drought mitigating chemicals on plant growth of chickpea under non-irrigated condition

Treatment	40 DAS			60 DAS			80 DAS			At harvest		
	Plant height (cm)	Number of branches	Total dry weight (g plant^{-1})	Plant height (cm)	Number of branches	Total dry weight (g plant^{-1})	Plant height (cm)	Number of branches	Total dry weight (g plant^{-1})	Plant height (cm)	Number of branches	Total dry weight (g plant^{-1})
T_1	24.13	6.63	1.92	33.42	8.07	8.60	38.24	8.67	24.94	39.60	8.89	29.96
T_2	24.00	7.06	1.88	31.50	8.67	9.62	34.68	9.00	26.46	35.66	9.35	34.18
T_3	23.33	6.69	1.87	34.10	7.86	7.90	37.03	8.00	23.80	38.20	8.17	29.38
T_4	24.41	7.06	1.90	35.14	8.14	7.48	41.38	8.36	20.39	43.59	8.50	28.83
T_5	23.07	7.33	1.84	30.74	8.99	9.99	32.50	9.42	26.78	33.02	9.63	32.99
T_6	23.93	6.33	1.89	34.69	8.00	8.41	38.23	8.34	23.50	39.30	8.50	29.50
T_7	22.97	6.10	1.86	32.26	7.35	8.07	34.27	7.66	22.59	34.88	7.91	31.92
T_8	23.10	7.13	1.93	37.13	9.60	10.79	44.53	12.03	28.13	47.90	12.32	36.42
T_9	23.76	6.33	1.93	37.11	9.58	10.38	43.29	11.00	27.76	48.70	11.30	35.81
T_{10}	23.02	6.00	1.85	31.40	7.10	6.10	34.40	7.75	16.01	34.60	7.87	23.13
T_{11}	23.00	5.66	1.85	31.20	7.32	5.90	33.83	7.64	15.45	34.26	7.73	22.26
S.Em(±)	0.54	0.47	0.06	0.52	0.37	0.05	0.58	0.34	0.07	0.50	0.46	0.14
C.D. at 5%	NS	NS	NS	1.52	1.09	0.13	1.72	1.01	0.21	1.47	1.36	0.41

Table 2: Effect of drought mitigating chemicals on physiological parameters of chickpea under non-irrigated condition

Treatment	Relative water content (%)			Photosynthetic rate (μ mol CO_2 m^{-2} s^{-1})		
	40 DAS	60 DAS	80 DAS	40 DAS	60 DAS	80 DAS
T_1	83.20	67.22	58.45	6.16	23.50	20.20
T_2	83.31	65.88	59.00	6.14	23.81	20.61
T_3	81.93	67.33	59.41	6.15	22.26	19.56
T_4	84.72	67.23	58.91	6.12	20.93	17.73
T_5	76.98	65.06	59.11	6.17	23.46	20.24
T_6	76.01	67.69	58.32	6.12	22.67	19.46
T_7	76.27	66.26	59.80	6.12	23.13	20.85
T_8	76.86	69.09	61.94	6.13	24.01	21.05
T_9	77.96	69.35	61.80	6.10	23.92	20.98
T_{10}	78.23	54.03	47.37	6.17	19.64	16.59
T_{11}	75.50	54.27	46.23	6.09	19.59	16.29
S.Em(±)	1.07	0.95	0.85	0.04	0.28	0.29
C.D. at 5%	3.16	2.80	2.52	NS	0.82	0.86

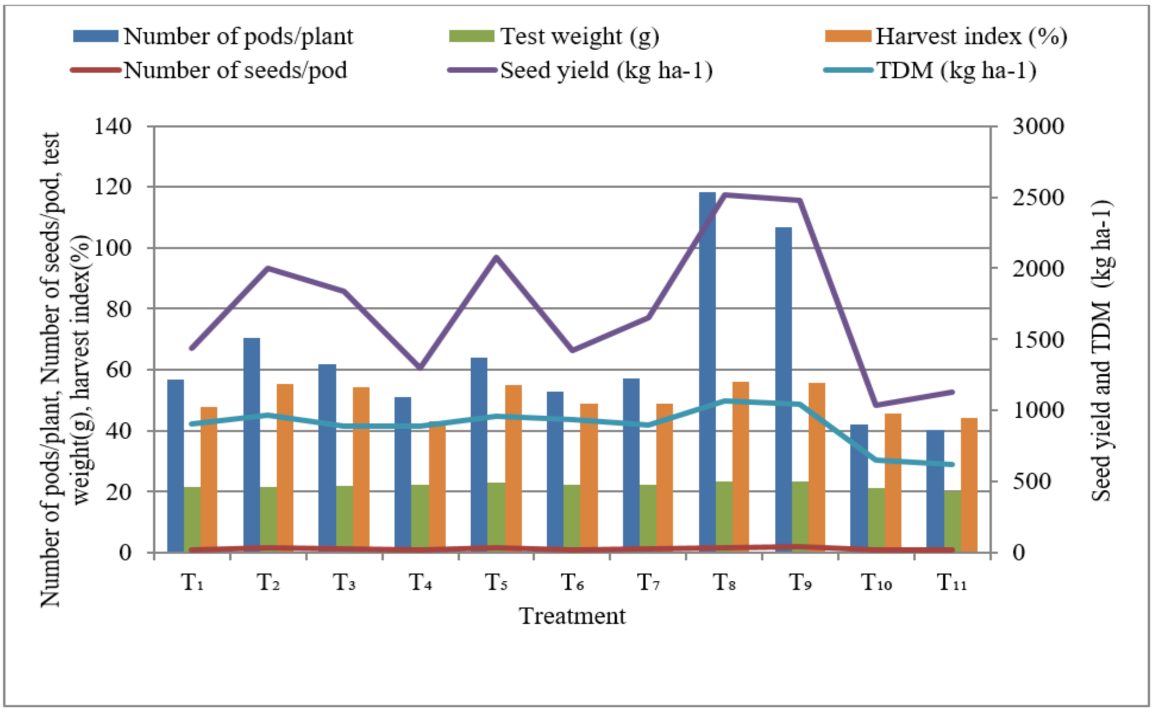

Fig 1: Influence of drought mitigating chemicals on yield and yield components at different growth stages of chickpea

Conclusion

Among the various treatments, which were applied to alleviate the reduction in yield of chickpea caused by water deficit, foliar spray of chickpea magic 8 g/l at 50% flowering stage with major constituent as plant growth regulators and nutrients, showed promising effect on growth and found most effective in compensating the yield loss. The improvement in yield is due to the increase in number of pods per plant, test weight, seed yield and harvest index even under drought condition.

Conflict of Interest: Authors declare that they have no conflict of interest

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