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GROWTH AND YIELD ENHANCEMENT THROUGH DROUGHT MITIGATION IN COWPEA (*Vigna unguiculata* L.) GROWN UNDER RESIDUAL MOISTURE CONDITIONS

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ABSTRACT

A field experiment on physiological approaches for drought mitigation in cowpea (*Vigna unguiculata* L.) was conducted during *rabi* 2019, at MARS, UAS, Raichur. The experiment was laid out in randomized complete block design with three replications and thirteen treatments. Basal dosage of fertilizer 25 : 50 kg N: P_2O_5 ha^{-1} was applied to all the treatment plots with foliar spray of treatments at 50% flowering stage. Among the treatments, foliar spray of pulse magic and chickpea magic @ 8 g l^{-1} had the profound effect in improving the growth attributes *viz*., plant height, leaf area index, leaf area duration, crop growth rate, specific leaf weight and net assimilation rate, ultimately seed yield. Further, the above said treatments respectively recorded higher number of pods per plant (16.21 and 15.34), seeds per pod (13.67 and 13.14), test weight (13.38 and 13.21 g) and seed yield (1387.00 and 1346.00 kg ha^{-1}), which was superior than other treatments. The superiority of the treatments in terms of yield enhancement might be due to its positive influence on growth and yield attributes.

KEYWORDS: Flowering stage, foliar spray, pulse magic, chickpea magic, 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. Among various pulse crops, cowpea (*Vigna unguiculata* L.) is an important food legume and grown over an area of 0.5 million ha in Karnataka. Physiological reasons for variation in productivity may be attributed to poor source-sink relationship, poor translocation efficiency at later stages of crop growth, shedding of floral parts and low harvest index.

Drought is one of the major abiotic constraint resulted in poor crop stand in cowpea encountered by poor farmers in marginal areas of India (Harris *et al*., 1999).

Drought causes drastic changes in growth, yield and as a result affect global grain production. The relative decrease in potential crop yield due to abiotic stress factors including drought, ranges from 54 to 82 per cent. Therefore, for sustaining food security, high priority should be given to minimize the detrimental effects of drought. Cultivation of drought tolerant crop varieties alone would not help to overcome the situation. It necessitates the development of alternate management technologies to mitigate water stress in crop plants for sustainable growth and yield (Bray *et al*., 2000). However, an alternative approach would be through incorporation of morphological and physiological mechanisms of drought tolerance in high yielding genotypes. Several morphological and phenological traits have been listed to play a significant role in crop adaptation to drought stress (Ludlow and Muchow, 1990). Through the present investigation, the conditions of cool winter followed by terminal drought which is prevalent in the north eastern dry zone and northern dry zone of Karnataka is trying to mitigate by using drought mitigating chemicals in cowpea, which includes seed priming with $CaCl_2$ and foliar spray of urea, salicylic acid (SA), boron, cycocel, chickpea magic and pulse magic, which induce the plants to become adaptive to water stress situations for a specified period. Pulse magic is a crop booster 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. Chickpea magic is also another novel product of Zonal Agricultural Research Station, Kalaburagi, University of Agricultural Sciences, Raichur of Karnataka which is released to enhance chickpea yield. Urea is known to

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increase the level of storage of N compounds, such as amino acids and proteins thus, foliar spray of urea directly affects N metabolism under stressful conditions and therefore amino acids synthesis (Dong *et al*., 2004). Osmopriming with calcium chloride solutions has proved effective in improving germination rate and plant stand establishment. Calcium also involved in the regulatory mechanism that activates plant to adjust to adverse environment like drought. The exogenous application of plant growth regulators (PGR) like CCC (Farooq and Bano, 2006) and salicylic acid (Azooz and Youssef, 2010) were effective in mitigating the adverse effects of water stress and enhanced the crop stability against extreme water deficit conditions. Cycocel acts as growth retardant by promoting root growth (for more water absorption) and suppressing leaf area development (for reducing transpiration loss of water) and delaying on set of leaf senescence. Salicylic acid delays the leaf senescence processes and also favour stem reserve utilization by the developing grains especially during the water deficit situations. Boron improves drought tolerance in plants by improving sugar transport, flower retention and pollen fertility. It detoxifies the accumulated free radical through activation of dismutase, and also elevate calcium and ABA mediated signalling (Valenciano *et al*., 2011). On the basis of roles and advantages of these chemicals, the investigation was carried to provide best drought mitigating practices with low cost of cultivation which directly helps the farmers in mitigating drought conditions.

MATERIALS AND METHODS

The field experiment was conducted during *rabi* 2019 at Main Agricultural Research Station, Raichur, UAS, Raichur under drought condition. It is situated at a 16º15' N latitude and 77º 20' E longitude with 389 meters above mean sea level. Experimental area received 0 mm of no rainfall during the cropping period (October to February), so it was maintained under residual moisture conditions in the field. The experiment was laid out in Randomized Complete Block Design (RCBD) with 13 treatments. The treatments *viz*., T_1- Seed priming with $CaCl_2$ @ 2%, T_2- Foliar spray with urea @ 2%, T_3- Foliar spray with CCC @ 100 ppm, T_4- Foliar spray with SA @ 100 ppm, T_5-Foliar spray with boron @ 0.1%, T_6-Seed priming with $CaCl_2$ @ 2% + foliar spray with urea @ 2%, T_7- Seed priming with $CaCl_2$ at 2% + foliar spray with CCC @ 100 ppm, T_8- Seed priming with $CaCl_2$ at 2% + foliar spray with SA @ 100 ppm, T_9- Seed priming with $CaCl_2$ at 2% + foliar spray with boron @ 0.1 %, T_{10}- Foliar spray with chickpea magic @ 8 g l^{-1}, T_{11}- Foliar spray with pulse magic @ 8 g l^{-1}, T_{12}- Water spray and T_{13}- Control with 3 replications using cowpea variety IT-38956-1 with a spacing of 30 × 10 cm. The foliar spraying was taken at 50% flowering. Basal dosage of fertilizer 25:50 kg N: P_2O_5 ha^{-1} was applied to all plots. Five plants were tagged at random in net plot area for recording various growth parameters like plant height (cm), leaf area index (Sestak *et al*., 1971), leaf area duration (days) (Power *et al*., 1967), crop growth rate (g cm^{-2} day^{-1}) (Watson, 1952), specific leaf weight (g cm^{-2}) (Radford, 1967), net assimilation rate (g cm^{-2} day^{-1}) (Watson, 1952) and also yield attributes was calculated and analyzed statistically using the 'F' test and critical difference (C.D) was calculated by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Growth parameters

The increment in the crop yield was due to increase in growth attributes in all stages of crop growth except 40 DAS as shown in Table 1 and 2. Among the treatments, foliar spray of pulse magic T_{11} recorded significantly higher plant height (33.47 and 44.77 cm) followed by foliar spray of chickpea magic T_{10} (32.70 and 43.77 cm) as compared to all other treatments. A significant lower plant height was recorded in control T_{13} (27.68 and 39.44 cm) at all stages of crop growth. Similar results obtained in the studies of Patil *et al.* (2018) and Avinash *et al*. (2020) in pigeonpea with foliar application of pulse magic @ 10 g l^{-1} showed significantly higher plant height at all the stages except at 45 and 90 DAS. Increase in plant height in barley might be due to stimulation of cell elongation, cell division and enlargement (Jalilian *et al*., 2014). Whereas, Hurde and Parjosavulesc (1981) and Zhang *et al*. (2009) reported that application of CCC reduced the plant height in soybean and alfalfa respectively.

From the present investigation it is revealed that leaf area index (LAI), leaf area duration (LAD), crop growth rate (CGR), specific leaf weight (SLW) and net assimilation rate (NAR) are gradually increased which is because of increased plant height and dry matter accumulation in plant due to the fact that the treatments sprayed with pulse magic T_{11} (8 g l^{-1}), chickpea magic T_{12} (8 g l^{-1}) and seed priming T_8 ($CaCl_2$ @ 2%) + foliar spray of SA (100 ppm). Pulse magic and chickpea magic are having similar composition but in different concentrations,

Table 1. Influence of drought mitigating chemicals on plant height, leaf area index and leaf area duration at different growth stages of cowpea

Treatment	Plant height (cm)			Leaf area index			Leaf area duration (days)	
	40 DAS	60 DAS	80 DAS	40 DAS	60 DAS	80 DAS	40 – 60 DAS	60 – 80 DAS
T_1 : Seed priming with $CaCl_2$ @ 2%	17.23	29.55	40.77	2.43	3.96	2.75	63.83	67.05
T_2 : Foliar spray with urea @ 2%	17.22	29.69	42.10	2.45	4.04	2.83	64.92	68.73
T_3 : Foliar spray with CCC @ 100 ppm	17.47	28.93	39.54	2.38	4.07	2.86	64.52	69.31
T_4 : Foliar spray with SA @ 100 ppm	18.00	29.85	40.34	2.46	4.39	3.17	68.47	75.52
T_5 : Foliar spray with boron @ 0.1%	18.06	29.10	41.10	2.36	3.90	2.69	62.67	65.97
T_6 : Seed priming with $CaCl_2$ @ 2% + foliar spray with urea @ 2%	17.25	29.78	41.59	2.46	4.35	3.12	68.15	74.73
T_7 : Seed priming with $CaCl_2$ at 2% + foliar spray with CCC @ 100 ppm	17.34	28.99	39.21	2.41	4.23	3.00	66.43	72.26
T_8 : Seed priming with $CaCl_2$ at 2% + foliar spray with SA @ 100 ppm	16.78	30.13	42.23	2.48	4.47	3.29	69.48	77.58
T_9 : Seed priming with $CaCl_2$ at 2% + foliar spray with boron @ 0.1%	17.01	29.18	41.24	2.37	3.93	2.67	63.02	66.08
T_{10} : Foliar spray with chickpea magic @ 8 g l^{-1}	17.66	32.70	43.77	2.51	4.92	3.61	73.89	84.95
T_{11} : Foliar spray with pulse magic @ 8 g l^{-1}	17.55	33.47	44.77	2.54	5.25	3.82	77.97	89.92
T_{12} : Water spray	17.51	28.66	40.34	2.35	3.75	2.56	60.97	63.08
T_{13} : Control	17.11	27.68	39.44	2.29	3.56	2.39	58.55	62.49
S.Em (±)	**0.43**	**0.86**	**1.09**	**0.06**	**0.12**	**0.09**	**1.93**	**1.90**
C.D. at 5%	**NS**	**2.52**	**3.17**	**NS**	**0.36**	**0.25**	**5.63**	**5.54**

that chiefly contain major nutrients, plant growth regulators and micronutrients. Mir *et al.* (2010) concluded that the factors of phytohormone and nutrient interactions in crop growth and production cause positive reactions to crop growth rates, which helps in photosynthesis and enhances metabolic rate, cell division and cell elongation which thereby, allow the plants to grow faster. The increase in growth attributes towards maturity is due to indeterminate growth pattern, higher rate of CO_2 assimilation during crop growth. Increase in LAI of cowpea plants might be due to established root system, improved emergence and seedling growth of primed seeds. CGR is influenced by LAI, leaf angle and amount of radiation energy intercepted. The favourable effect on NAR throughout the crop growth is due to early emergence, better leaf development and increase in total dry matter accumulation. Salicylic acid delays the leaf senescence processes and also favour stem reserve utilization by the developing grains especially during the water deficit situations. Calcium plays a critical role in signalling anti-drought responses and in many defence mechanisms that are induced by drought (Sadiqov *et al.*, 2002). The results are in close conformity with the investigation of Surendar *et al.* (2013) and Thakur *et al.* (2017) in blackgram and Avinash *et al.* (2020) in pigeonpea with foliar application of pulse magic @ 10 g l^{-1}. Sadeghipour and Aghaei (2012) reported the leaf area index of common bean was increased by application of SA @ 0.5 mM under drought condition. The obtained results were in line with findings of Vijaysingh (2017) in blackgram showing significantly higher crop growth rate with foliar application of pulse magic @ 10 g l^{-1}. Ganiger *et al.* (2003) reported that the application of growth regulators and urea at 35 days after sowing increased the growth of cowpea. Arun *et al.* (2020) revealed that the influence of seed priming increased the NAR at all water regimes as compared to control in cowpea.

Whereas, these growth parameters has a major role in increasing the yield parameters. This may be due to better availability of nutrients and better translocation of photosynthates from source to sink and may be due higher accumulation of photosynthates in the seeds.

Total dry weight

Maximum total dry weight was recorded with the foliar application of pulse magic @ 8 g l^{-1} (T_{11}) followed by foliar spray of chickpea magic @ 8 g l^{-1} (T_{10}) at all the stages of crop growth. Figure.1. The least was found with control (T_{13}). The PGRs and micronutrients present in these chemicals act on various physiological processes and ultimately increment in the dry matter content. These results were well supported with the results of Avinash *et al.* (2020) in pigeonpea and Thakur *et al.* (2017) in black gram showing significant higher total dry matter accumulation and its distribution to leaves, stem and pods with foliar application of pulse magic @ 10 g l^{-1}

Yield and yield components

Crop productivity depends on interaction of various growth and attributes functions in plants. The data on the number of pods per plant, pod length, pod weight, number of seeds per pod, test weight and seed yield per hectare indicate major variations in the use of drought mitigating chemicals in cowpea at 50 % flowering stage is depicted in Figure 2. Grain yield is the economic part of the total dry matter, this is the end product of the plants life cycle and it is of much interest to mankind. The pod length (16.84 cm & 15.64 cm), pod weight (1.61g and 1.58 g) was greater with the foliar spray of pulse magic (T_9) followed by chickpea magic (T_8) respectively, as compared to control (T_{13}). Yield is a compound character and is a sum total of the contribution made by a number of physiological characters. The above said parameters respectively recorded higher values in the plot sprayed with pulse magic (16.21, 13.67, 13.38 g and 1387 kg ha^{-1}) and it was on par with chickpea magic spray (15.34, 13.14, 13.21 g and 1346 kg ha^{-1}) followed by seed priming + foliar spray of SA (14.92, 12.23, 12.43g and 1279 kg ha^{-1}) as compared to control (11.52, 8.17, 10.08 g and 1021 kg). The maximum harvest index was observed in foliar spray of pulse magic @ 8 g l^{-1} (T_{11}) (41.89%) which was on par with foliar spray of chickpea magic @ 8 g l^{-1} (T_{10}) (40.28%) significantly greater than control and the rest of the treatments. Among these treatments minimum harvest index was observed in control (T_{13}) (32.57%) and followed by water spray (T_{12}) (33.21%). The increased HI (41.89%) could be attributed to the increased mobilization of metabolites to reproductive sinks. Extreme water stress induces flower shedding or pod set loss, thereby forcing assimilates to invest in vegetative development.

Flower drop decreased due to foliar spray of pulse magic. This helps in flower development, pod setting and increased number of pods per plant. Pod number plays an important role in yield determination. Our results are well supported with the findings of Patil *et al.* (2018) and

Table 2. Influence of drought mitigating chemicals on crop growth rate, specific leaf weight and net assimilation rate at different growth stages of cowpea

Treatment	Crop growth rate (g cm^{-2} day^{-1} × 10^{-2})			Specific leaf weight (g cm^{-2} × 10^{-2})			Net assimilation rate (g cm^{-2} day^{-1} × 10^{-2})	
	40 DAS	60 DAS	80 DAS	40 DAS	60 DAS	80 DAS	40 – 60 DAS	60 – 80 DAS
T_1 : Seed priming with $CaCl_2$ @ 2%	0.153	0.166	0.940	0.940	0.802	0.835	0.063	0.067
T_2 : Foliar spray with urea @ 2%	0.185	0.223	0.878	0.878	0.851	0.835	0.078	0.084
T_3 : Foliar spray with CCC @ 100 ppm	0.196	0.208	0.935	0.935	0.880	0.880	0.083	0.081
T_4 : Foliar spray with SA @ 100 ppm	0.237	0.219	0.876	0.876	0.986	0.931	0.095	0.078
T_5 : Foliar spray with boron @ 0.1%	0.157	0.236	0.907	0.907	0.825	0.852	0.068	0.084
T_6 : Seed priming with $CaCl_2$ @ 2% + foliar spray with urea @ 2%	0.219	0.217	0.898	0.898	0.953	0.898	0.088	0.078
T_7 : Seed priming with $CaCl_2$ at 2% + foliar spray with CCC @ 100 ppm	0.202	0.213	0.921	0.921	0.894	0.877	0.083	0.079
T_8 : Seed priming with $CaCl_2$ at 2% + foliar spray with SA @ 100 ppm	0.246	0.234	0.901	0.901	0.991	0.971	0.097	0.088
T_9 : Seed priming with $CaCl_2$ at 2% + foliar spray with boron @ 0.1%	0.160	0.219	0.961	0.961	0.851	0.862	0.069	0.085
T_{10} : Foliar spray with chickpea magic @ 8 g l^{-1}	0.256	0.261	0.928	0.928	0.996	1.009	0.096	0.090
T_{11} : Foliar spray with pulse magic @ 8 g l^{-1}	0.285	0.286	0.927	0.927	1.056	1.083	0.102	0.091
T_{12} : Water spray	0.137	0.146	0.921	0.921	0.812	0.795	0.061	0.063
T_{13} : Control	0.114	0.121	0.965	0.965	0.823	0.780	0.053	0.055
S.Em (±)	**0.0062**	**0.0065**	**0.026**	**0.026**	**0.027**	**0.027**	**0.003**	**0.002**
C.D. at 5%	**0.0180**	**0.0190**	**NS**	**NS**	**0.077**	**0.079**	**0.007**	**0.007**

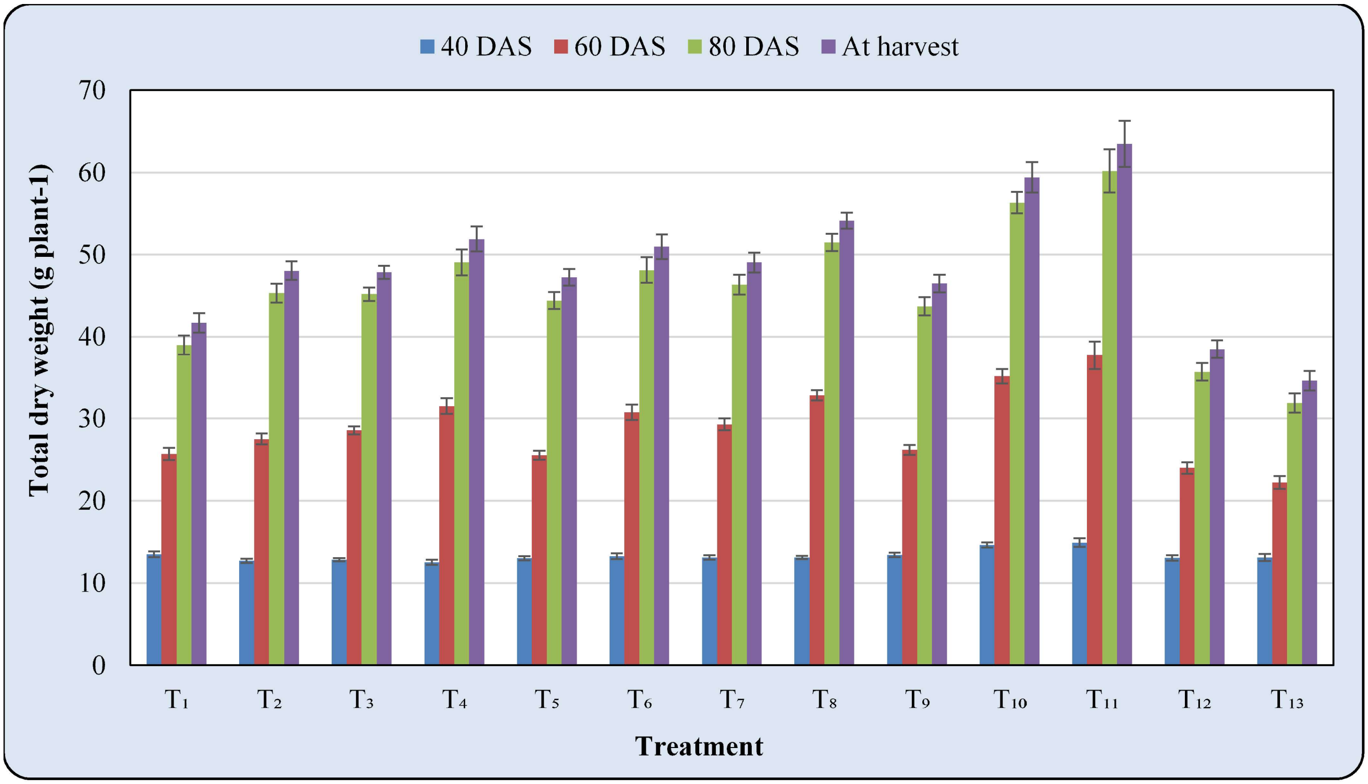

Figure 1. Effect of drought mitigating chemicals on total dry weight of cowpea at different growth stages.

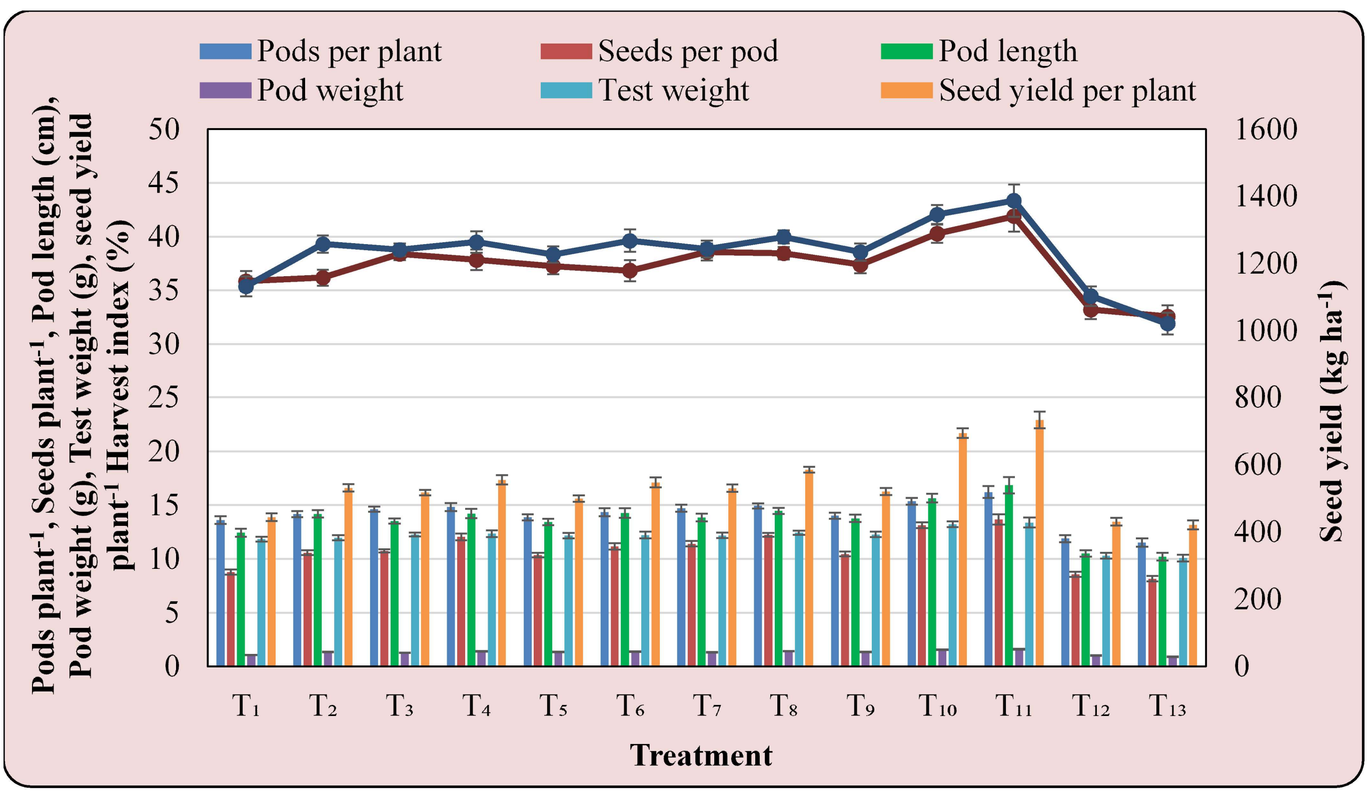

Figure 2. Effect of drought mitigating chemicals on yield and yield components of cowpea at harvest.

Avinash *et al*. (2020) in pigeonpea and Teggelli *et al*. (2016) in transplanted pigeonpea by foliar application of pulse magic @ 10 g l^{-1}. Thakur *et al*. (2017) noticed that the significantly higher number of pods with the foliar application of pulse magic @ 10 g l^{-1} in blackgram, as a result increased yield. Rajabi *et al*. (2013) recorded that the foliar application of 1.2 mM SA in chickpea increased the maximum number of pods per plant as compared with control. Ramesh (2004) reported that seed hardening with $CaCl_2$ @ 2 % increased seed yield per plant in chickpea. Manjunath and Dhanoji (2011) obtained significantly higher seed yield by seed hardening with $CaCl_2$ @ 2 % as compare to control in chickpea. Marimuthu and Surendran (2015) in blackgram found that application of NPK+ foliar spray of diammonium phosphate @ 2 % + foliar spray of pulse wonder at 50 % flowering resulted in higher seed yield. Ali and Mahmoud (2013) reported that application of SA @ 150 ppm produced the higher seed yield over control in mung bean. It can be inferred from the above discussion that growth and yield characters are significant from the point of higher productivity in cowpea.

Through the investigation it can be concluded that a single spray of pulse magic @ 8 g l^{-1} at 50 per cent flowering stage is found to be more effective to enhance the productivity especially in dryland. This might be due to maintaining higher leaf area index, crop growth rate, net assimilation rate, increased sink strength and finally higher yield.

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