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Influence of seed polymer coating with micronutrients and foliar spray on seed yield of chickpea (*Cicer arietinum* L.)

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ABSTRACT
A field experiment was conducted at the Department of Seed Science and Technology, College of Agriculture, University of Agricultural Sciences, Raichur to study the influence of seed polymer coating with micronutrients and foliar spray on seed yield of chickpea. The experiment consisted of seventeen different seed polymer coating and foliar spray treatments with various combinations of $ZnSO_4$, boron, ammonium molybdate, $FeSO_4$ including control. Among the different treatments imposed, seed polymer coating (@ 6 ml/kg) of chickpea seeds with the combination of $ZnSO_4$ + Boron + Ammonium molybdate + $FeSO_4$ (each @ 2 g/kg) of seed along with two foliar sprays (0.5 % + 0.2 % + 0.1 % + 0.5 %, respectively, $ZnSO_4$ and $FeSO_4$ in EDTA form) at an interval of 10 days during flowering stage (50 and 60 DAS) recorded significantly higher leaf area index, chlorophyll content, plant height, effective root nodules plant^{-1}, pods plant^{-1}, seed yield compared to all other treatments and control.

Key words: Chickpea, Leaf area index, Micronutrients, Polymer coating, Root nodules, Seed yield.

INTRODUCTION

Pulse crops play an important role in human diet as they are the main source of proteins compared to other protein sources like meat and meat products. Among the pulses, chickpea (*Cicer arietinum* L.) commonly known as bengal gram is a major *rabi* pulse crop, which is highly nutritious grain legume and one of the cheapest sources of energy and protein as it contains 60-65 per cent carbohydrates, 6 per cent fat and 12 to 31 per cent higher protein than any other pulse crop.

The continuous use of micronutrient free high nitrogen and phosphorous fertilizers in the intensive cropping system with diminishing use of organic manures has resulted in the depletion of micronutrients cations from the soil reserves. Owing to this, the productivity of many crops has reduced substantially over the years. It has been estimated that, the extent of micronutrient deficiency in the Indian soils are 47, 35, 15, 13, 4 and 2 % for zinc, boron, molybdenum, iron, manganese and copper, respectively (Anonymous, 2011). The micronutrients are required in relatively smaller quantities for plant growth and are as important as macronutrients and often act as co-factors in enzyme activity and participate in redox reactions, in addition to having several other vital functions in plants (Mengel *et al.*, 2001). Mmicronutrients play an important role in increasing the yield of pulses, oilseed and legumes through their direct effects on the plant and through symbiotic nitrogen fixation process.

Among the different micronutrients, zinc, boron, ferrous sulphate and ammonium molybdate play a very important role in chickpea. Zinc plays an important role in nucleic acid and protein synthesis and helps in utilization of phosphorus and nitrogen in seed formation and development. Ferrous sulphate is a constituent of chlorophyll biosynthesis that regulates respiration, photosynthesis, reduction of nitrates and sulphates and also activates several enzymes involved in respiration (Kaleeswari *et al.*, 2013). While, boron plays an important role in flower retention, pollen tube growth, seed formation and seed setting and mainly involved in translocation of metabolites from source to sink (Tanaka and Fujiwar, 2008). Whereas, molybdenum in legumes, helps root nodule to fix atmospheric nitrogen (Campo *et al.,* 2000).

These micronutrients may be supplied to the plants through soil application, foliar spray or seed treatment. Micronutrient application through seed treatment improves the stand establishment, advances phenological events, increases yield and micronutrient contents in grain in most of the crops. In many cases, micronutrient application through seed treatment performed better or similar to other application methods (Singh *et al.,* 2003). Being an easy and cost effective method, seed treatment by polymer coating offer an attractive option for resource-poor farmers through its pronounced effect during the early stage of seedling establishment (Johnson *et al.,* 2005). Keeping in view the above facts, the present investigation was carried out with an objective to study the influence of seed polymerization

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with micronutrients and foliar spray on growth and seed yield of chickpea.

MATERIALS AND METHODS

A field experiment was conducted in the Main Agricultural Research Station, University of Agricultural Sciences, Raichur during *rabi* 2014 in a randomised block design to study the influence of seed polymer coating with micronutrients and foliar spray on growth, physiology and seed yield of chickpea cultivar JG-11. The experiment consisted of seventeen different treatments *viz.,* T_1: $ZnSO_4$ (2 g/kg of seed), T_2: $ZnSO_4$ (4 g/kg of seed), T_3: Boron (2 g/ kg of seed), T_4: Boron (4 g/kg of seed), T_5: Ammonium molybdate (2 g/kg of seed), T_6: Ammonium molybdate (4 g/ kg of seed), T_7: $FeSO_4$ (2 g/kg of seed), T_8: $FeSO_4$ (4 g/kg of seed), T_9: $T_1 + T_3$, T_{10}: $T_1 + T_5$, T_{11}: $T_1 + T_7$, T_{12}: $T_3 + T_5$, T_{13}: $T_3 + T_7$, T_{14}: $T_5 + T_7$, T_{15}: $T_1 + T_3 + T_5 + T_7$, T_{16}: Only polymer, T_{17}: Absolute control. The micronutrients were applied to the seed either individually or in combination as per the above treatments by using 6 ml polymer (Disco Agro DC Red L-603 procured from Incotec Pvt. Ltd. Ahmedabad, Gujarat) dissolved in 45 ml water per kg of seed in a rotary seed coating machine. The coated seeds were properly dried in shade and sown in three replications with randomised block design with spacing of 30 x 10 cm. In addition to these treatments, two foliar sprays at an interval of 10 days during flowering stage (50 and 60 DAS) were given either individually or in combination as per the treatments (0.5 % + 0.2 % + 0.1% + 0.5 %, respectively, $ZnSO_4$ and $FeSO_4$ in EDTA form).

The observations on plant height, primary and secondary branches plant^{-1}, leaf area index, chlorophyll content, stomatal conductance and resistance, number of nodules plant^{-1}, number of pods plant^{-1}, hundred seed weight, seed yield plant^{-1} and hectare^{-1} were recorded. The leaf area index (LAI) was measured with an AccuPAR 80 ceptometer (Decagon Devices, Inc., Pullman, WA, USA), chlorophyll content was measured by using SPAD meter, Leaf stomatal conductance and resistance was measured by using leaf porometer (SC-1 porometer, Decagon Devices, Pullman, WA, USA). The statistical analysis was done as per the procedure described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Seed coating with polymer, micronutrients and foliar spray had significant influence on plant growth, physiological parameters, yield attributing characters and yield of chickpea.

Among the different treatments, T_{15} ($ZnSO_4$ + boron + ammonium molybdate + $FeSO_4$ (each @ 2 g/kg of seed) along with two foliar sprays with zinc sulphate (0.5 %) in EDTA form + borax (0.2 %) + ammonium molybdate (0.1 %) and ferrous sulphate (0.5 %) in EDTA form at an interval of ten days during flowering) recorded significantly higher plant height (30.1, 46.8 and 48.7 cm) at 30, 60 and 75 DAS, respectively (Table 1) as compared to all other treatments and control (23.2, 40.5 and 44.2 cm, respectively). The same treatment also recorded significantly higher number of primary (9.2) and secondary (33.8) branches per plant at harvest (Table 1) compared to control (8.5 and 30.2, respectively). This might be due to the involvement of micronutrients in root and shoot elongation through cell enlargement and cell division that might have enhanced the plant growth through development of vigorous and stronger root system thereby enabling the plant to derive available soil moisture and nutrients and hence resulted in increased plant height and branches per plant. Similar results were reported by Vijaya and Ponnuswamy (1998) in black gram with $ZnSO_4$ (0.2 %) + $MnSO_4$ (0.2 %) + Na_2MO_4 (0.1 %) per kg of seed, Srimathi *et al.* (2007) in green gram due to combined hardening with $MnSO_4$ (100 ppm) and *Prosopis* leaf extract (1 %) + pelleting with DAP (40 g) + $MnSO_4$ (100 mg) + $FeSO_4$ (100 mg) + ammonium molybdate (250 mg)/kg of seed and Gupta and Sahu (2012) in chickpea who recorded 25.3 per cent increase in grain yield due to combined application of RDF + $FeSo_4$(10 kg/ha)+ Borax (10 kg/ha) + $ZnSo_4$(25 kg/ha) + ammonium molybdate (1 kg/ha).

Leaf area index one of the most important and commonly used indices to analyze the growth of any crop plant depends on the per cent expansion of crop canopy to utilize the sunlight for photosynthesis. In the present investigation significantly higher leaf area index (0.546, 4.114, and 1.890 µmol m^{-1}s^{-1}) was recorded by T_{15} (Table 1) compared to all other treatments and control (0.265, 2.071 and 0.804 µmol m^{-1}s^{-1}) at 30, 60 and 75 DAS, respectively. This might be due to the combined effect of micronutrients which might have made the plant to absorb more available nutrients required for its growth and establish the canopy resulting in larger leaf area index. Similar results were reported by Mahakulkar *et al.* (1991) in peanut with the application 10 kg B + 20 kg S per hectare, Tripathy *et al.* (1999) in soybean with soil application of Zn (25 kg/ha) + B (10 kg/ha) and Mo (1.5 kg/ha) and Ramesh and Thirumuragan (2001) in soybean due to application of Ammonium molybdate (250 mg/kg of seed) + ferrous sulphate (500 mg/kg of seed).

Similarly T_{15} also recorded significantly higher chlorophyll content (59.7, 61.9 and 59.6 SPAD values) (Table 1), higher stomatal conductance (593.1, 514.6 and 398.8 M mol/m^{2}s) (Table 1) and lower stomatal resistance (1.3, 1.6 and 2.5 m^{2}s/mol) (Table 1) compared to control which recorded lower chlorophyll content (39.0, 48.4 and 33.2 SPAD value), lower stomatal conductance (297.4, 296.0 and 203.4 M mol/m^{2}s) and higher stomatal resistance (3.7, 4.6 and 5.8 m^{2}s/mol) respectively at 30, 60 and 75 DAS. This might be due to the combined effect of micronutrients which act as main component of some antioxidants enzymes

Table 1: Influence of seed polymer coating with micronutrients and foliar spray on growth and physiological parameters of chickpea

Treatments *	Plant height (cm)			Branches		Leaf area index ($\mu mol\ m^{-1}s^{-1}$)			Chlorophyll content (SPAD values)			Stomatal conductance ($M\ mol/m^2s$)			Stomatal resistance (m^2s/mol)		
	30 DAS	60 DAS	75 DAS	Primary	Secondary	30 DAS	60 DAS	75 DAS	30 DAS	60 DAS	75 DAS	30 DAS	60 DAS	75 DAS	30 DAS	60 DAS	75 DAS
T_1	24.9	42.6	45.9	8.6	30.7	0.379	2.539	1.037	44.4	52.6	38.3	396.5	333.0	248.6	3.1	3.7	4.6
T_2	25.5	43.0	46.1	8.7	31.0	0.400	2.737	1.142	48.8	54.3	42.6	444.7	377.7	274.0	2.7	3.0	4.1
T_3	24.8	42.5	45.5	8.6	30.7	0.377	2.455	1.015	43.5	51.7	37.7	393.8	330.4	245.3	3.1	3.7	5.0
T_4	25.4	42.9	46.1	8.7	30.9	0.399	2.736	1.107	48.4	53.8	42.5	444.5	368.6	258.5	2.9	3.3	4.1
T_5	24.7	41.8	44.8	8.6	30.5	0.340	2.299	0.835	42.5	51.6	36.6	346.4	313.9	208.7	3.2	3.9	5.1
T_6	25.1	42.9	46.1	8.6	30.9	0.399	2.703	1.104	45.9	53.6	39.5	427.4	339.5	258.0	3.0	3.3	4.4
T_7	24.6	41.4	44.7	8.6	30.5	0.288	2.213	0.807	40.1	48.9	34.3	343.0	312.1	205.1	3.5	4.1	5.7
T_8	25.0	42.9	46.0	8.6	30.8	0.399	2.621	1.073	44.9	53.0	38.4	404.4	334.4	250.2	3.0	3.6	4.4
T_9	26.1	44.6	46.9	8.8	32.3	0.449	3.755	1.533	51.6	56.6	45.7	468.1	417.8	346.8	2.2	2.4	2.9
T_{10}	25.9	44.1	46.8	8.8	32.0	0.433	3.481	1.501	51.0	56.6	44.5	463.3	415.7	343.2	2.4	2.8	3.4
T_{11}	25.6	43.2	46.6	8.7	31.4	0.423	2.871	1.449	49.8	55.0	43.6	457.9	406.5	319.9	2.5	2.8	3.5
T_{12}	25.8	43.7	46.6	8.8	31.7	0.428	3.396	1.483	50.7	55.9	44.5	459.9	408.1	325.0	2.5	2.8	3.5
T_{13}	25.5	43.1	46.1	8.7	31.3	0.417	2.811	1.408	48.3	54.9	42.5	453.4	403.5	296.7	2.6	2.8	3.7
T_{14}	25.5	43.0	46.1	8.7	31.1	0.405	2.775	1.217	48.6	54.5	42.9	452.3	399.7	277.1	2.8	2.9	3.8
T_{15}	30.1	46.8	48.7	9.2	33.8	0.546	4.114	1.890	59.7	61.9	53.4	593.1	514.6	398.8	1.3	1.6	2.5
T_{16}	24.8	42.2	45.3	8.6	30.5	0.374	2.354	0.973	42.9	51.7	36.7	383.0	325.8	227.0	3.2	3.7	5.1
T_{17}	23.2	40.5	44.2	8.5	30.2	0.265	2.071	0.804	39.0	48.4	33.2	297.4	296.0	203.4	3.7	4.6	5.8
Mean	25.4	43.0	46.0	8.7	31.2	0.395	2.820	1.199	47.1	53.8	41.0	425.2	370.4	275.7	2.8	3.2	4.2
S.Em.±	0.4	0.7	0.6	0.1	0.6	0.031	0.111	0.108	2.8	1.7	1.2	37.2	27.8	16.2	0.3	0.4	0.3
CD @ 5 %	1.3	1.9	1.7	0.3	1.7	0.090	0.321	0.311	8.0	4.9	3.5	107.1	80.0	46.8	0.8	1.0	0.9

Legend: T_1: $ZnSO_4$ (2 g/kg of seed), T_2: $ZnSO_4$ (4 g/kg of seed), T_3: Boron (2 g/kg of seed), T_4: Boron (4 g/kg of seed), T_5: Ammonium molybdate (2 g/kg of seed), T_6: Ammonium molybdate (4 g/kg of seed), T_7: $FeSO_4$ (2 g/kg of seed), T_8: $FeSO_4$ (4 g/kg of seed), T_9: $T_1 + T_3$, T_{10}: $T_1 + T_5$, T_{11}: $T_1 + T_7$, T_{12}: $T_3 + T_5$, T_{13}: $T_3 + T_7$, T_{14}: $T_5 + T_7$, T_{15}: $T_1 + T_3 + T_5 + T_7$, T_{16}: Only polymer, T_{17}: Absolute control.

* includes foliar spray as mentioned in material & methods.

involved in protection of chloroplasts from free radicals and also due to the action of iron which act as precursor of chlorophyll (Marschner,1995; Barker and Pilbeam, 2007) there by increased the chlorophyll content which further might have increased the photosynthetic activity with higher intake of carbon dioxide due to higher stomatal conductance and reduced the stomatal resistance. Similar results were reported by John *et al.* (2005) in maize with micronutrient mixture (0.1 % of zinc, manganese and iron, and 0.5 % copper, boron and molybdenum/kg of seed).

Treatments imposed with micronutrients through seed polymer coating and foliar spray (T_{15}) have shown highly significant difference with respect to total number of nodules and effective root nodule/plant (55.0 and 25.5, respectively) at 60 days after sowing compared to all other treatments and control (45.5 and 18.2, respectively) (Table 2 and Figure 1). Increase in total and effective nodules/plant due to application of micronutrients might be due to the enhanced activity of Rhizobium due to supplementation of micronutrients *viz.*, Mo and Fe which are very essiential for nitrogenese enzyme activity for biological nitrogen fixation by N_2-fixing bacteria. Similarly, Zn and B are also essential for various enzymatic reactions (Campo *et al.,* 2000, Gupta and Sahu, 2012). More the number of effective nodules more will be the nitrogen fixation in plant roots which ultimately improved the growth and yield of crop plants. Similar results were reported by Balachander *et al.* (2003) in black gram with foliar application of molybdenum (50 ppm), cobalt 50 ppm, borax (0.2%), iron (0.2%) and Geeta Goudar *et al.* (2008) in soybean with combination of Zn + Mo and Zn + Fe + Mo each @ 75 ppm through seed treatment.

The number of pods plant^{-1} is a major yield attributing character contributing towards final seed yield. In the present investigation among the different treatments T_{15} recorded significantly higher number of pods (94.5) plant^{-1} compared to all other treatments (Table 2) and control (84.4). This increase in number of pods plant^{-1} might be due to higher number of primary and secondary branches plant^{-1} and also due to higher values for various physiological parameters registered by this treatment. Similar observations were made by Vijaya and Ponnuswamy (1998) in black gram with combined application of $ZnSO_4$ (0.2 %) + $MnSO_4$ (0.2 %) + Na_2MO_4 (0.1 %)/kg of seed and Dixit and Elamathi (2007) in green gram due to foliar application of DAP (2 %) + NAA (40 ppm) + B (0.2 %) + Mo (0.05 %). Significantly higher hundred seed weight of 25.9 g was recorded by T_{15} as compared to all other treatments and control (23.6 g) (Table 2). This increase in hundred seed weight might be due to role of micronutrients (boron) in pollen germination, seed development, cell division, translocation of sugar and starch from source to sink (Masuthi *et al.,* 2009).

All the seed polymer coating and foliar spray treatments with various combinations of $ZnSO_4$, boron,

Table 2: Influence of seed polymer coating with micronutrients and foliar spray on root nodules, seed yield and its attributing Characters

Treatments*	Root nodules per plant (60 DAS)		No. of pods per plant	100 seed weight (g)	Seed yield (g/plant)	Seed yield (q/ha)	% increase per ha over control
	Total	Effective					
T_1	48.2	21.7	85.9	24.5	24.07	19.96	4.3
T_2	49.1	22.1	86.5	25.1	24.74	20.47	7.0
T_3	47.6	21.4	85.6	24.5	24.00	19.89	4.0
T_4	48.8	21.9	86.4	25.1	24.72	20.26	5.9
T_5	47.1	21.2	85.2	23.8	23.33	19.80	3.5
T_6	48.6	21.6	86.2	24.8	24.39	20.21	5.6
T_7	46.8	21.1	85.2	23.6	23.09	19.60	2.5
T_8	48.4	21.8	86.0	24.5	24.12	20.22	5.7
T_9	51.3	24.0	90.3	25.8	26.33	21.13	10.5
T_{10}	51.3	23.1	89.4	25.8	26.10	20.98	9.7
T_{11}	50.0	22.5	87.7	25.5	25.41	20.58	7.6
T_{12}	50.6	22.8	88.6	25.7	25.79	20.88	9.1
T_{13}	49.5	22.3	87.3	25.4	25.23	20.60	7.7
T_{14}	49.3	22.2	85.9	25.3	25.01	20.59	7.6
T_{15}	55.0	25.5	94.5	25.9	28.90	22.30	16.6
T_{16}	47.5	21.4	85.2	24.2	23.61	19.90	4.0
T_{17}	45.5	18.2	84.4	23.6	22.89	19.13	-
Mean	49.1	22.2	87.1	24.9	24.81	20.38	7.0
S.Em.±	0.8	0.4	1.0	0.1	0.77	0.39	
CD @ 5 %	2.4	1.1	3.0	0.4	2.21	1.12	

Legend: T_1: $ZnSO_4$ (2 g/kg of seed), T_2: $ZnSO_4$ (4 g/kg of seed), T_3: Boron (2 g/kg of seed), T_4: Boron (4 g/kg of seed), T_5: Ammonium molybdate (2 g/kg of seed), T_6: Ammonium molybdate (4 g/kg of seed), T_7: $FeSO_4$ (2 g/kg of seed), T_8: $FeSO_4$ (4 g/kg of seed), T_9: $T_1 + T_3$, T_{10}: $T_1 + T_5$, T_{11}: $T_1 + T_7$, T_{12}: $T_3 + T_5$, T_{13}: $T_3 + T_7$, T_{14}: $T_5 + T_7$, T_{15}: $T_1 + T_3 + T_5 + T_7$, T_{16}: Only polymer, T_{17}: Absolute control. * includes foliar spray as mentioned in material & methods.

Fig 1: Root nodules per plant at 60 days after sowing

ammonium molybdate, $FeSO_4$ resulted in improvement in seed yield. However, the treatment T_{15} recorded significantly higher seed yield (28.9 g/plant and 22.30 q/ha) compared to all other treatments (Table 2) and control (22.89 g/plant and 19.13 q/ha). There was an overall increase of 16.6 per cent seed yield/hectare over control due to combined seed polymer coating with all the micronutrients and foliar spray. This might be due to involvement of micronutrients in biosynthesis of plant harmones and also component of various enzymes which play an important role in nucleic acid and protein synthesis (Kaleeswari *et al*., 2013) and in turn enhanced seed vigour resulting in better seedling establishment which lead to increased plant height, ultimately the leaf canopy leading to increased leaf area index. Due to higher leaf area index there might have been increased photosynthetic activity with the help of higher chlorophyll content and with enhanced stomatal conductance wherein, the uptake of carbon dioxide might be more leading to higher production of carbohydrates and thereby translocation of these metabolites to root nodules. Due to enhancement of root nodules nitrogen assimilation might be higher thereby lead to increased number of branches which might be due to translocation of metabolites and carbohydrates from photo synthetically active leaf from branches to the developing pod and in turn accumulation of these carbohydrates in seed resulted in increased test weight, which finally increased the seed yield/hectare. In addition to this the micronutrients also help in utilization of phosphorus and nitrogen in flower retention, pollen tube development, seed formation and seed setting through the translocation of metabolites from source to sink (Tanaka and Fujiwar, 2008) thereby increased the seed yield. Similar results were reported by Awad *et al.* (1994) in groundnut with soil application of Zn + Mn + Fe + Cu + B, Geetha *et al.* (1996) in groundnut with application of Mo+ Zn at 8 g per kg seed, Poongothai and Chitdeshwari (2003) in black gram with soil application of 5 kg Zn + 1.5 kg B + 0.5 kg Mo + 40 kgs ha^{-1}.

CONCLUSION

Seed polymer coating (6 ml/kg) of chickpea seeds along with $ZnSO_4$ + boron + ammonium molybdate + $FeSO_4$ each at 2 g per kg of seed with two foliar sprays (0.5 % + 0.2 % + 0.1% + 0.5 %, respectively, $ZnSO_4$ and $FeSO_4$ in EDTA form) at an interval of ten days during flowering stage (50 and 60 DAS) resulted in better growth, improved physiological and yield attributing characters and ultimately recorded higher seed yield.

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