Original Research Article

Effectiveness of Micronutrients and Seed coating polymer application on seed yield and yield attributing parameters of pigeonpea (*Cajanus cajan* L.)

ABSTRACT

Aims: to study the Effectiveness of Micronutrients and Seed coating polymer application on seed yield and yield attributing parameters of pigeonpea (*Cajanus cajan* L.)

Place of Study: Field experiment was conducted during *kharif* 2014 at Main Agricultural Research Station, College of Agriculture, University of Agricultural Sciences, Raichur.

Methodology: The different micronutrients *viz.,* Potassium molybdate (2 or 4 ml per kg of seed), $ZnSO_4$ (2, 4 ml per kg of seed) and boron (2, 4 ml per kg of seed) as per the treatment either individually or in combination were coated with polymer at the rate of 6 ml per kg of seed using rotary seed coating machine, such coated seeds were properly dried under shade. after imposition of treatments, the seeds before sowing were treated with *Rhizobium* and *Trichoderma harizianum* culture. In addition, two foliar sprays as per the treatments either individually or in combination at an interval of 10 days during flowering stage (75 and 85 DAS) were given [Potassium molybdate (0.1 %), (Zinc sulphate (0.5 %) in EDTA form, Borax (0.2 %)]. Various observations on seed yield and yield attributing parameters were recorded, analysed statistically to study the effectiveness of Micronutrients and Seed coating polymer application on seed yield and yield attributing parameters of pigeonpea (*Cajanus cajan* L.).

Results: Seed coating polymer (@ 6 ml/kg) of pigeonpea seeds with the combination of potassium molybdate + $ZnSO_4$ + boron (each @ 2g / kg) of seed along with two foliar sprays of potassium molybdate (0.1 %) + zinc sulphate (0.5 %) in EDTA form + borax (0.2 %) at an interval of 10 days during flowering stage (75 and 85 DAS) recorded significantly maximum number of pods per plant (193.0), maximum number of seeds per pod (3.67), higher seed yield per plant (62.80 g) and finally, highest seed yield (16.30 q) per hectare as compared to control.

Conclusion: Micronutrients (*viz.,* Potassium molybdate, $ZnSO_{4,}$ boron) and seed coating polymer at optimum doses can stimulate the physiological functions, resulting in early germination, improved seedling vigour with better stand establishment lead to increased productivity of pigeonpea. Hence, It could be advocated for better establishment of seedlings and higher seed yield.

Keywords: [Micronutrient, Pigeonpea, Seed coating polymer, Seed yield }

1. INTRODUCTION

Pigeonpea (*Cajanus cajan*) is a deep rooted hardy crop grown either as sole crop or intercrop in combination with variety of crops. Initial slow growth habits, wider row spacing and long maturity period of pigeonpea make it ideal as a component crop with most of the cereal or millets, pulses, oilseed and vegetables in rainfed uplands. Its deep root systems help tap plant nutrients from deeper layers allowing the base food crop to feed at top layers of the soil. The pigeonpea based intercropping systems give greater relative yield advantage under stress and can provide useful buffer against low yields. Pigeonpea is one of the important pulse crops of India and 91 per cent of the world's pigeonpea is produced in India. The productivity of pigeonpea in India (799 kg ha-1) is far below the average productivity of world (848 kg ha-1) as per the reports of Ministry of Agriculture (Anon., 2010). In Karnataka, pigeonpea occupies an area of 0.66 million hectares with an average productivity of 555 kg per hectare (Anon., 2013). Pigeonpea is grown in almost all the states and larger portion of the area is in the states like Maharashtra, Uttar Pradesh, Madhya Pradesh, Karnataka and Gujarat. Andhra Pradesh and Tamil Nadu together occupy 87.89 per cent of area and contribute 86.10 per cent to the total production. Pigeonpea is cultivated for grain purpose as *dhal* which is a major source of protein for poor farmers. It has three times protein as compared to cereals. Tender green seeds are used as vegetable, crushed seeds are used as animal feed, green leaves as fodder, stem is used as fuel wood and to thatch huts, for basket making and fencing and also used to culture the lac insects. It is also often used as a live fence around small farms. It is grown across the mountain slopes to reduce soil erosion. The low yield of pigeonpea is mainly attributed to their cultivation on poor soils with inadequate and imbalanced nutrient application without the application of macronutrients and micronutrients like boron, zinc and iron.

Seed coating (polymerization) is a technique wherein any substance applied to the seed does not obscure or change its shape. The film is readily water soluble (hydrophilic) so as not to impede seed germination [3]. In this method small quantity of chemicals or micronutrients are needed as compared to soil application or foliar spray. Seed polymerization is one of the most economical approaches for improving seed performance. Film coating helps to smoothen the seed surface which improves ability of flow and helps in mechanized planting [3]. The improvements in crop establishment, growth and yield due to coating or pelleting have been reported in several agricultural, horticultural and tree crops [3-4].

The use of micronutrients in pulses production is one of the ways to boost up the productivity (Gowda et al., 2013). Zinc plays an important role in formation of chlorophyll and growth hormones and is associated with the uptake of water (Mousavi et al., 2013). Boron plays an important role in calcium metabolism, its uptake and efficient use, which is the important constituent of cell wall (Naghii and Samman, 1993). Molybdenum plays the key role in process of atmospheric nitrogen fixation besides role in enzyme systems (Weisany et al., 2013). The yield and yield attributing characters are directly related to the productivity and hence the micronutrients like zinc, boron and molybdenum are important in the production of legume crops.

Pigeonpea is an important pulse crop of rainfed agriculture and a principal source of protein in the Indian diet. Rainfed soils are generally degraded with poor native fertility [5]. Mineral nutrient deficiencies limit nitrogen fixation by the legume-rhizobium symbiosis, resulting in low legume yields. Nutrient limitations to legume production result from deficiencies of not only major nutrients but also micronutrients such as molybdenum (Mo), zinc (Zn), boron (B) and iron (Fe) [6]. Inadequate nodulation of pigeonpea can be associated with low plant available Mo. Increase in flower numbers, pod set improvement, and reduction in days to flowering are influenced by Mo [7]. Application of micronutrients along with recommended doses of fertilizers (RDF) to pigeonpea is essential for higher yield under rainfed conditions.The micronutrients may be supplied to the plants through soil application, foliar spray or applied to seed through seed treatment (Farooq et al., 2012). Although the required amount of micronutrients can be supplied by any of these methods, foliar sprays have been more effective in yield improvement and grain enrichment (Arif et al., 2016). Application of micronutrients through foliar spray is taken up at later growth stages when crop stands are already established (Farooq et al., 2012). Hence, an alternative acceptable method of supplying micronutrients during the early stage of seedling establishment is the need of the hour.

Very little work has been carried out regarding the response of pigeonpea to the application of seed coating polymer and foliar spray with micronutrients. Hence, the present investigation entitled "Effectiveness of Micronutrients and Seed coating polymer application on seed yield and yield attributing parameters of pigeonpea (*Cajanus cajan* L.) was undertaken.

2. MATERIAL AND METHODS

The experiment was conducted during *kharif* 2014 at Main Agricultural Research Station, College of Agriculture, University of Agricultural Sciences, Raichur, India. Geographically, the station is situated in the North-Eastern dry zone (Zone- 2) of Karnataka State at 16° 15' North latitude and 77° 20' East longitude and at an altitude of 389 meter above mean sea level (Table 1.). The soil of the experimental site was deep black, clay in nature and 8.3 pH (Table 2.). The experiment consisted of 16 different treatments *viz.,* T_1: Potassium molybdate @ 2g per kg of seed, T_2: Potassium molybdate @ 4g per kg of seed, T_3: ZnSO4 @ 2g per kg of seed, T_4: ZnSO4 @ 4g per kg of seed, T_5: Boron @ 2g per kg of seed, T_6: Boron @ 4g per kg of seed, T_7: Potassium molybdate + ZnSO4 (each @ 2g / kg of seed), T_8: Potassium molybdate + ZnSO4 (each @ 4g / kg of seed), T_9: ZnSO4 + Boron (each @ 2g / kg of seed), T_{10}: ZnSO4 + Boron (each @ 4g / kg of seed), T_{11}: Potassium molybdate + Boron (each @ 2g / kg of seed), T_{12}: Potassium molybdate + Boron (each @ 4g / kg of seed), T_{13}: Potassium molybdate + ZnSO4 + Boron (each @ 2g / kg of seed), T_{14}: Potassium molybdate + ZnSO4 + Boron (each @ 4g / kg of seed), T_{15}: Only polymer and T_{16}: Absolute control laid out in randomized block design with three replications.

Table 1. Monthly meteorological data for the experimental year 2014-2015 and mean of the last 81 years (1932-2013) at Meteorological Observatory, Main Agricultural Research Station, University of Agricultural Sciences, Raichur

Month	Rainfall (mm)		Temperature (°C) Mean maximum		Temperature (°C) Mean minimum		Relative humidity (%)	
	1932-2013	2014-15	1932-2013	2014-15	1932-2013	2014-15	1932-2013	2014-15
April	70.70	19.40	39.9	39.32	22.6	24.77	77.00	40.17
May	71.50	93.00	39.7	39.08	22.5	24.68	80.00	47.76
June	182.70	48.40	35.3	37.76	22.3	24.68	82.00	52.60
July	62.50	123.10	33.4	33.74	20.5	23.08	79.00	68.24

August	21.20	372.90	32.9	32.70	19.1	22.71	79.00	71.00
September	4.00	102.70	32.2	31.01	16.2	22.48	76.00	75.37
October	1.20	50.60	31.5	31.99	16.8	21.32	77.00	66.39
November	1.10	12.00	31.3	30.90	18.5	17.50	62.00	62.57
December	44.30	1.80	30.5	29.41	22.6	15.11	56.00	64.45
January	12.95	10.00	31.3	30.25	24.4	17.23	53.00	58.84
February	42.90	0.00	32.5	32.65	25.3	18.29	60.00	57.21
March	113.80	24.90	36.5	35.25	23.3	21.81	79.00	50.66
Total	**628.85**	**875.30**	**-**		**-**		**-**	

The seeds of pigeonpea variety TS 3R were sown with a spacing of 90 cm between rows and 30 cm between plants with the plot size was 9.0 x 4.8 m^2. The fresh seeds of pigeonpea

Table 2. Physical and chemical properties of the soil in experimental site

Properties	**Value obtained**	**Method adopted**
I. Physical properties		
1. Particle size analysis		International Pipette method (Piper, 1966, Jena et al., 2013)
Sand (%)	20.18	
Silt (%)	23.02	
Clay (%)	56.80	
Texture	Clay	
2. Bulk density (Mg m^{-3})	1.28	Core Sampler method (Dastane, 1967)
II. Chemical properties		
Soil reaction (pH)	8.30	Potentionmeter (Jackson, 1967)
Electrical conductivity (dS m^{-1})	0.25	Conductivity bridge (Jackson, 1967)
Organic carbon (%)	0.60	Wet Oxidation method (Jackson, 1967)
Available nitrogen (kg ha^{-1})	218.00	Alkaline permanganate method (Subbaiah and Asija, 1956)
Available phosphorus (kg ha^{-1})	32.00	Olsen's method (Jackson, 1967)
Available potassium (kg ha^{-1})	180.67	Flame photometry method (Jackson, 1967)

were treated with different micronutrients as per above treatments through seed coating polymer at the rate of 6 ml per kg of seed which was standardized from laboratory experiment using rotary seed coating machine and the coated seeds were properly dried under shade (Fig. 1). In addition to seed coating polymer, two foliar sprays of micronutrients *viz.,* zinc sulphate (0.5%), potassium molybdate (0.1%) in EDTA form and borax (0.2%) in non EDTA form were given during flowering stage (75 and 85 DAYS) at an interval of 10 days either individually or in combination as per the treatments.

Figure 1. Pigeonpea seeds coated with polymer and micronutrients

The various observations *viz.,* number of pods per plant, number of seeds per pod, seed yield per plant and seed yield per hectare were recorded. The research data was statistically analysed by adopting the procedure prescribed by Panse and Sukhatme [8].

3. RESULTS AND DISCUSSION

Though micronutrients are required in small amounts but play a key role in biochemical activities in plant. Seed coating polymer with micronutrients and foliar spray significantly influenced the seed yield and yield attributing parameters (Table 3). The number of pods per plant is a major yield attributing component contributing to the final seed yield. In the present investigation among the different treatments of seed coating polymer with micronutrients and foliar spray, the treatment T_{13} [Potassium molybdate + $ZnSO_4$ +boron (each @ 2g / kg seed)] along with two foliar sprays of potassium molybdate (0.1%) + zinc sulphate (0.5%) in EDTA form + borax (0.2%) recorded significantly maximum number of pods per plant (193.0). Whereas, minimum number of pods (169.0) per plant was recorded in the control. This increase in number of pods per plant might be due to higher number of primary and secondary branches per plant and also due to higher values for various physiological growth parameters registered by this treatment. Similar results were reported by Dixit and Elamathi [9] in cowpea due to seed fortification and pelleting with the combination of $ZnSO_4$ (0.2%) + $MnSO_4$ (0.2%) + Na_2MO_4 (0.1%) per kg seeds. John et al. [10] also reported the same in green gram due to foliar application of DAP (2%) + NAA (40 ppm) + B (0.2 %) + Mo (0.05 %). As a result of stimulated physiological functions due to imposed treatments and foliar spray the number of seeds per pod was also differed significantly. However, T_{13} recorded maximum number of seeds per pod (3.40) as compared to control (2.93) i.e.T_{16}.

Seed coating polymer with micronutrients and foliar spray significantly influenced the seed yield per plant and seed yield per hectare. The treatment T_{13} [Potassium molybdate + $ZnSO_4$ + boron (each @ 2g / kg seed)] along with two foliar sprays of potassium molybdate (0.1%) + zinc sulphate (0.5%) in EDTA form + borax (0.2%) produced higher seed yield per plant (62.80 g) and seed yield per hectare (16.30 q) which were found to be superior over all the treatments. Whereas, the lowest seed yield per plant (53.20 g) and seed yield per hectare (13.86 q/ha) was recorded in the control (T_{16}). Polymer present in the coating material might have also helped in higher rate of water uptake in turn resulted in the early germination with more seedling vigour and better stand establishment, which might have ultimately led to better growth, plant stand and productivity of pigeonpea and increase in plant height, number of pods per plant and test weight as a consequent of improvement in root growth and nodulation. The reason for the increased yield might also be due to the increased photosynthetic efficiency through stabilization of chlorophyll, higher production of

Table 3. Influence of seed coating polymer and micronutrients with foliar spray on seed yield and yield attributing parameters of pigeonpea

Treatment	No. of pods/plant	No. of seeds/pod	Seed yield (g)/plant	Seed yield (q)/ha
T_1	179.0	3.10	54.88	14.20
T_2	183.0	3.21	57.50	14.46
T_3	174.2	2.98	53.60	14.10
T_4	181.0	3.16	56.12	14.15
T_5	174.3	3.00	54.00	14.10
T_6	181.7	3.10	56.33	14.30
T_7	186.0	3.26	59.05	14.95
T_8	185.0	3.22	58.80	14.92
T_9	184.3	3.18	57.93	14.86
T_{10}	184.0	3.21	57.50	14.20
T_{11}	187.2	3.32	59.60	15.17
T_{12}	187.6	3.30	59.40	15.06
T_{13}	193.0	3.67	62.80	16.30
T_{14}	188.0	3.32	60.08	15.20
T_{15}	173.0	2.97	53.42	14.03
T_{16}	169.0	2.93	53.20	13.86
Mean	**181.9**	**3.17**	**57.14**	**14.62**
S.Em.±	0.96	0.04	0.64	0.14
CD (P = 0.05)	2.77	0.13	1.84	0.40

photosynthesis resulting in increased translocation of nutrients from the source to sink in the treated plants. The increase in seed yield due to combined application of zinc, boron and potassium molybdenum might be attributed to the complementary effect of these nutrients with each other and along with standard dosage of polymer ultimately, resulting in the higher growth and seed yield. Similar findings were observed by [11] where they observed beneficial effects of micronutrients (zinc, manganese, iron, copper, boron and molybdenum) and polymer together in getting better yield in maize. As Mo being essential for Nitrogen fixation, which has ensured better Nitrogen supply to the crop while Zn being an activation of several enzyme systems might have improved physiological functions of the plant [12] and conversion of flower to pod which resulted in better growth and yield of the crop. These results are in accordance with the findings of [13] in groundnut who observed similar increase in the yield due to seed treatment with Zn+Mo at the rate of 8 g per kg of seed. Similarly, boron is directly linked with the process of pollen producing capacity of anther, viability of pollen grains, pollen germination and pollen tube growth and fertilization [14]. [15] also reported significant increase in seed yield and its attributes when seeds were pelleted with boron alone, Zinc + Boron + arappu leaf powder. [16] observed that combined application of both boron and molybdenum were superior to their single application in chickpea. In the same line [17] also noticed increased yield of soybean due to combined application of Zn, B and Mo at 2 kg, 1.0 kg and 0.5 kg respectively with *Bradyrhizobium* biofertilizer.

However, from the present study it is clear that there was a significant increase in the yield and yield attributing characters due to seed coating polymer with micronutrients i.e. zinc, boron and potassium molybdate sole or in combination but the sole treatment of polymer at the rate of 6 ml per kg was found to be similar with T_{16} (control) in terms of number of seeds per pod, seed yield per plant and per hectare. These results are in conformity with the findings of [18] in pigeonpea where they recorded statistically similar values for plant height, number of primary and secondary branches, number of pods per plant, pod weight per plant, seed yield per plant and seed yield per hectare with seed treatment of polymer at the rate of 5 ml per kg of seed as compared to control. Hence, in general it is important to note that the polymer is more effective when used in combination with micronutrients, biofertilizers and fungicides than sole. Similar findings were reported by [19] in sunflower and [11].

4. CONCLUSION

Seed coating polymer and micronutrients with foliar spray in combination resulted in better seed yield and yield attributing parameters. Seed coating polymer (6 ml per kg of seed) with the combination of micronutrients namely, potassium molybdate + $ZnSO_4$ + boron each at 2g per kg of seed with two foliar sprays (0.1 % + 0.5 % + 0.2 % respectively, potassium molybdate and $ZnSO_4$ in EDTA form) at an interval of 10 days during flowering stage (75 and 85 DAS) can be recommended as the optimum dose for pigeonpea cultivation during *kharif* season.

Acknowledgement:

We thankfully acknowledge the contribution of the reviewers.

REFERENCES

1. Anonymous, 2010, All India area, production and yield of total pulses. 2010-11. *Ministry of Agriculture, Govt. of India. Retrieved from* www.indiastat.com
2. Farooq, M., Wahid, A., & Siddique, K. H. (2012). Micronutrient application through seed treatments: a review. *Journal of soil science and plant nutrition*, *12*(1), 125-142.
3. Punithavathi M. Seed hardening and pelleting studies in ragi Cv. Co-13. M. Sc (Agri.) Thesis, Tamil Nadu Agric. Univ. Coimbatore (India); 1997.
4. Malla Reddy M, Padmaja B, Malathi S and Jalapathi Rao L. Effects of micronutrients on growth and yield of pigeonpea. Journal of SAT Agricultural Research 5(1). 2016;14:1-6.
5. Bhuiyan MAH, Khanam D and Ali MY. Chickpea root nodulation and yield as affected by micronutrient application and rhizobium inoculation. International Chickpea and Pigeonpea Newsletter 1999;6:28–29.

6. Prasad M, Pillai A, Faber G, Field S and Dowling T Prasad M, Pillai A, Faber G, Field S and Dowling T. Molybdenum response of pigeonpea on Ferruginous Latosols in Fiji. International Chickpea and Pigeonpea Newsletter. 1998; 5:55–56.

7. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. ICAR-New Delhi (India).1985;167-174.

8. Ponnuswamy AS, Vijaya J. Effect of seed fortification and pelleting on crop growth and yield in cowpea. Madras Agric. J. 1997; 84(7): 395-431.

9. Pradeep Mohan Dixit and Elamathi, S. Effect of foliar application of DAP, micronutrients and NAA on growth and yield of green gram (*Vigna radiata* L.). *Legume Res., 2007;* 30(4): 305-307.

10. Sherin Susan John, Bharati, Natesan P, Raja K, Seed film coating technology for maximizing the growth and productivity of maize. Karnataka. J. Agric. Sci. 2005;18(2):349-356.

11. Duyingqiong, Q., Liao Xingrong, He Jianghua, Hiang Zhoyao and Zhou Xiaohong. Effect of B and Mo on the growth, development and yield of peanut. *Plant nutri. fert. Sci,* 2002;8(2): 233-35.

12. Geetha, K. N., Shankar, A. G. and Shivashankar, K. Effect of Mo, Zn and Ca on productivity of groundnut. *J. Oilseeds Res., 1995;*13(2): 167 – 172.

13. Sharma, A., Nakul, H. T., Jelgeri, B. R. and Ashok Surwenshi. Effect of micronutrients on growth, yield and yield components in pigeonpea (*Cajanus cajan* (L.) Millsp.). *Res. J. Agric. Sci*., 2010;1(2): 142- 144.

14. Masuthi DA, Vyakaranahal BS, Deshpande VK. Influence of pelleting with micronutrients and botanical on growth, seed yield and quality of vegetable cowpea. Karnataka J. Agric. Sci. 2009; 22: 898-900.

15. Dinesh Chandra R, Effect of biofertilizer, zinc, boron and molybdenum on nodulation, growth and yield of soybean. M. Sc. (Agri.) Thesis, Bangladesh Agricu. Univ. Mymensingh (Bangladesh):2014.

16. Shil, N.C., Noor, S. and Hossain, M.A. Effect of boron and molybdenum on the yield of chickpea. *J. Agric. Rural dev.,* 2007;5(1-2): 17-24.

17. Vinodkumar SB, Vyakarnahal BS, Dhananjaya P, Yegappa Hipparagi, Asha AM, Effect of seed polymer coating on field performance and quality of pigeonpea (*Cajanus cajan* L.). Environ. Eco. 2013;31(1):43-46.

18. Shakuntala N. M., Vyakaranahal B. S., Shankergoud, I., Deshpande, V. K., Pujari, B. T., and Nadaf , H. L., 2010, Effect of seed polymer coating on growth and yield of sunflower hybrid -RSFH-130*. Karnataka J. Agric. Sci.,* 23(5): 708-711*.*

19. Gowda, C. L., Samineni, S., Gaur, P. M., & Saxena, K. B. (2013). Enhancing the productivity and production of pulses in India.

20. Mousavi, S. R. Mohammad Galavi, M. Rezaei, M. 2012.The interaction of zinc with other elements in plants: a review. Intl J Agri Crop Sci. Vol., 4 (24), 1881-1884.

21. Naghii MR, Samman S. The role of boron in nutrition and metabolism. Prog Food Nutr Sci. 1993 Oct-Dec;17(4):331-49.

22. Weisany, W., Raei, Y., & Allahverdipoor, K. H. (2013). Role of some of mineral nutrients in biological nitrogen fixation. *Bulletin of Environment, Pharmacology and Life Sciences*, *2*(4), 77-84.

23. Arif, M., Chohan, M. A., Ali, S., Gul, R., & Khan, S. (2006). Response of wheat to foliar application of nutrients. *Journal of Agricultural and Biological Science*, *1*(4), 30-34.

24. Jena, R.K. Jagadeeswaran, R. Sivasamy, R. Analogy of Soil Parameters in Particle Size Analysis through Laser Diffraction Techniques. Indian Journal Of Hill Farming 26(2):78- 83.

25. S. J. Jankowski and Freiser, H. Flame Photometric Methods of Determining the Potassium Tetraphenylborate. *Analytical Chemistry* **1961** *33* (6), 773-775.