Augmenting Productivity of Major Crops through Seed Polymer Coating with Micronutrients and Foliar Spray

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***Abstract*—Laboratory and field experiments were conducted to study the effect of seed polymer coating with various micronutrients either alone or in combination and foliar spray on growth, yield and yield attributing characters of cotton, pigeon pea, chickpea and groundnut. In the laboratory experiment, polymer dosage @ 8ml, 6ml, 6ml and 4ml per kg of seeds in cotton pigeon pea, chickpea and groundnut, respectively recorded significantly higher germination and seedling vigour index compared to control and other treatments. In field experiment, irrespective of crops, seed coating with polymer along with micronutrients and two foliar sprays during flowering at an interval of 10 days increased the yield to the extent of 16.7% in cotton, 19.9% in pigeon pea, 16.1% in chickpea and 13.8% in groundnut over control.**

***Index Terms*—seed, micronutrient, polymer and crops**

I. Introduction

Seed is the pivot of agriculture; careful farming envisages and enforces first and foremost attention on seed. “Care with the seed joy with harvest” is the popular adage which enlightens about the importance of seed.

Seed polymer coating is the sophisticated process of applying precise amount of active ingredients along with a liquid polymer directly on to the seed surface without obscuring its shape, size and weight. This polymer forms a flexible film that adheres and protects the active ingredients, preventing the dusting off and loss of active ingredients during handling. This technology helps in precise and uniform application of fungicides, insecticides, bioagents, micronutrients, colours and other additives [1].

Micronutrients play an important role in increasing the yield levels of pulses, oilseed and legumes through their direct effects on the plant itself and through symbiotic nitrogen fixation process. Micronutrients are required in relatively smaller quantities for plant growth, they are as important as macronutrients. Micronutrients often act as cofactors in enzyme systems and participate in redox reactions, in addition to having several other vital functions in plants. Most importantly, micronutrients are involved in the key physiological processes of photosynthesis and respiration and their deficiency can impede these vital physiological processes thus limiting yield gain in many crops. It is estimated that, the extent of micro nutrient deficiency in the Indian soils are 47% Zn, 35% B, 15% MO, 13% Fe, 4% Mn and 2% Cu. While, in Karnataka state it is 78% Zn, 39% Fe, 32% B and 5% Cu.

In crop plants, micronutrients may be applied to the soil, foliar sprayed or added as seed treatments. 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; but high cost has restricted its wider adaption, particularly by resource-poor farmers. Moreover, foliar application occurs at later growth stages when crop stands are already established. Seed treatment is a better option from an economical perspective as less micronutrient is needed, it is easy to apply and seedling growth is improved. Keeping all these backdrops in mind, the study was undertaken to know the influence of seed coating with synthetic polymers and micronutrient on augmenting the productivity of major crops like cotton, pigeon pea, chickpea and groundnut.

II. Material and Methods

A. Seed Material

The fresh and untreated seeds of chickpea cv. JG-11, pigeon pea cv. TS 3R and ground nut cv. K-9 were obtained from Seed Unit, UAS Raichur. Whereas, *Bt*-cotton hybrid seeds (Jaadu) were procured from Kaveri Seeds Pvt. Ltd. Hyderabad, Andhra Pradesh state.

B. Standardization of Seed Coating Polymer

The cleaned and graded seeds were coated with polymer as per treatment (control, polymer @ 2, 4, 6, 8 and 10ml kg^{-1} seeds) after diluting with 45 ml distilled water in a rotary seed coating machine available in the Department of Seed Science and Technology. Subsequently the seeds were air dried to bring back to original moisture content and then used for germination test and recording of other observations.

C. Seed Coating with Polymer and Micronutrients

Firstly, the micronutrients were weighed separately depending on the percentage fixed. Then, the

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combinations of micronutrients and polymer were mixed homogeneously to ensure the entire ingredients are fully blended.

After that, the seeds were coated with different micronutrients viz., $ZnSO_4$, Boron and Potassium molybdate along with polymer @ 6 ml per kg^{-1}seeds in pigeon pea, $FeSO_4$, $MgSO_4$, $MnSO_4$ along with polymer @ 8ml perkg^{-1} in cotton, $ZnSO_4$, Boron, Ammonium Molybdate and $FeSO_4$ with 6 ml polymer per kg^{-1} seeds in chickpea and $ZnSO_4$, Boron, Ammonium molybdate, FeSO4 and $CaSO_4$ with 4 ml polymer per kg^{-1} seeds in groundnut. The coated seeds were properly dried under shade. The seeds of all the four crops were sown 4-5cm deep within the soil and later the seeds were covered manually. Soon after sowing, the experimental plots were irrigated lightly to ensure uniform germination and optimum plant stand. The experiment was laid out in Randomized Block Design (RBD) with three replications and consists of 17 treatments in cotton and chickpea. Whereas, 16 and 23 treatments for pigeonpea and groundnut, respectively.

D. *Foliar Application*

Two foliar sprays of micronutrients *viz.*, $ZnSO_4$ (0.5%)+ $FeSO_4$ (0.5%) + $MgSO_4$ (1%) + $MgSO_4$ (0.5%) in cotton and zinc sulphate (0.5%) + Potassium molybdate (0.1%) + borax (0.2%) in pigeon pea were given during flowering stage (75 and 85 DAS) at an interval of 10 days. The micronutrient mixture of $ZnSO_4$ (0.5%)+ Boron (0.2%)+ Ammonium molybdate (0.1%) + $FeSO_4$ (0.5%) in chickpea and Zinc sulphate (0.5%) + Borax (0.2%) + Ammonium molybdate (0.1%) + Ferrous sulphate (0.5%) + Calcium sulphate (0.5%) in groundnut were given at an interval of 10 days during flowering stage (50 and 60 DAS).

E. *Collection of Experimental Data*

The biometric observations on growth parameters were recorded at three stages of the plant growth *viz.*, vegetative, flowering and harvesting stage. For recording various parameters, five plants at random from net plot area were selected and tagged in each plot for taking observations on growth and yield parameters.

III. Results and Discussion

A. *Standardization of Seed Coating Polymer for Cotton, Pigeon Pea, Chickpea and Groundnut*

Seed polymerisation is a method wherein, uniform layer of polymer is applied over seeds without significantly increasing seed size or weight. The plasticizer polymer forms a flexible film that adheres and protects the fungicides, micronutrients, preventing dusting off and loss of fungicide during handling. The film is readily water soluble (hydrophilic) so as not to impede the seed germination. The more precise and uniform application of fungicides, insecticides, micronutrients, colours and other additives can be accomplished by seed coating. Seed coating or polymerisation is one of the most economical approaches for improving seed performance.

Polymer dosage @ 8ml and 6ml per kg of seeds in cotton and chickpea respectively recorded significantly higher germination (87.00 and 96.40 respectively) and seedling vigour index (2613 and 2761 respectively) compared to control and other treatments (Table I).

TABLE I. Standardization of Polymer Dosage for Seed Coating in Cotton and Chickpea

Treatments	Cotton		Chickpea	
	G (%)	SVI	G (%)	SVI
T_1	82.25	2108	92.45	2213
T_2	82.75	2162	93.18	2289
T_3	82.75	2297	94.45	2320
T_4	84.00	2383	96.40	2761
T_5	87.00	2613	96.50	2830
T_6	86.75	2686	96.75	2957
Mean	84.25	2375	94.75	2562
SEm±	0.39	32	0.13	68
CD @ 1%	1.17	97	0.40	202

Similarly for pigeon pea and ground nut polymer dosage @ 6ml and 4ml respectively recorded significantly higher germination (94.10 and 77.00%, respectively) and seedling vigour index (2435 and 1725 respectively) compared to control and other treatments (Table II).

TABLE II. Standardization of Polymer Dosage for Seed Coating in Pigeon Pea and Groundnut

Treatments	Pigeon pea		Groundnut	
	G (%)	SVI	G (%)	SVI
T_1	91.00	1934	74.00	1326
T_2	92.08	2013	75.75	1400
T_3	92.25	2080	77.00	1725
T_4	94.10	2435	76.62	1562
T_5	94.60	2567	75.00	1371
T_6	94.38	2464	74.50	1374
Mean	93.07	2249	74.00	1459
SEm±	0.50	43	0.40	39.0
CD @ 1%	1.48	128	1.18	117

Legend for Table I and Table II:
G: Germination (%); SVI: Seedling vigour index
T_1: control; T_2: Polymer @ 2ml kg^{-1} seed, T_3: Polymer @ 4ml kg^{-1} seed, T_4: Polymer @ 6ml kg^{-1} seed, T_5: Polymer @ 8ml kg^{-1} seed and T_6: Polymer @ 10ml kg^{-1} seed.

The increase in germination percentage might be due to hydrophilic nature of the polymer that has increased imbibition rate which led to faster activation of cells resulting in the enhancement of mitochondrial activity leading to the formation of more high energy compounds and vital biomolecules, which are made available during the early phase of germination with reduced imbibitional damage by regulating the water uptake. These results are in accordance with the findings of [2], [3].

B. *Effect of Seed Polymerisation with Micronutrients and Foliar Spray on Growth and Yield of Cotton, Pigeon Pea, Chickpea and Groundnut*

Micronutrients play a vital role in production of quality seeds, besides increasing the productivity. Crop productivity is a function of genetic potentiality of crop, variety, soil productivity and environmental conditions. The physiological and biochemical activities taking place in the plant body is largely determined by enzymatic activities. These enzymatic activities are mainly governed by the availability of micronutrients. Among the various micronutrients that are required for proper plant growth and development Zinc, Boron, Molybdenum and Iron play most important role particularly in legume crops.

C. Cotton

Among the treatments, seed polymer coating (8ml/kg) with the combination of micronutrients namely, $ZnSO_4$ + $FeSO_4$ + $MgSO_4$ + $MnSO_4$ each @ 4g per kg of seed along with two foliar sprays (0.5% + 0.5% + 1% + 0.5%, respectively in EDTA form except MgSO4) at an interval of ten days during flowering stage (65 & 75 DAS) recorded significantly higher leaf area index (4.550), chlorophyll content (45.20), number of bolls per plant (41.57), seed cotton yield (29.03 q/ha) and lint yield (10.49 q/ha) compared to all other treatments and control (3.483, 38.9, 36.83, 24.77 q & 9.12 q, respectively for the above parameters) (Fig. 1). The per cent increase in seed cotton yield was to the tune of 16.7 over control. This might be due to the combined effect of micronutrients which act as main component of some antioxidant enzymes which are involved in the protection of chloroplasts from free radicals [4], [5] and thereby increase the chlorophyll content which had stimulatory effect in photosynthesis [6] due to which the canopy established in a better way and ultimately lead to more LAI [7]. Higher LAI and chlorophyll content increased the uptake of carbon dioxide leading to higher production of carbohydrates and in turn accumulation of these carbohydrates in seed (sink) resulted in increased seed index, which further might have increased the cotton yield [8]. Our results are confirmatory with the findings of [9], [10].

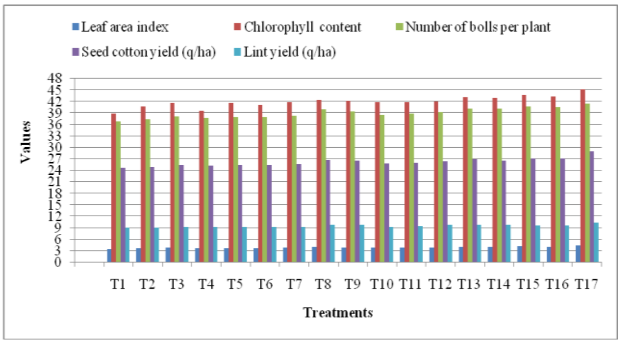

Figure 1. Effect of seed polymerization with micronutrients on growth and yield of cotton

Legend:
T_1: Control; T_2: Only polymer (8ml); T_3: ZnSO4 @ 4g per kg of seed; T_4: FeSO4 @ 4g per kg of seed; T_5: MgSO4 @ 4g per kg of seed; T_6: MnSO4 @ 4g per kg of seed; T_7: (T_3+T_4); T_8: (T_3+T_5); T_9: (T_3+T_6); T_9: (T_4+T_5); T_{11}: (T_4+T_6); T_{12}: (T_5+T_6); T_{13}: (T_3+T_4+T_5); T_{14}: (T_3+T_4+T_6); T_{15}: (T_3+T_5+T_6); T_{16}: (T_4+T_5+T_6); T_{17}: (T_3+T_4+T_5+T_6).

D. Chickpea

Seed polymer coating (6ml/kg) with the combination of micronutrients namely, $ZnSO_4$ + Boron + Ammonium molybdate + $FeSO_4$ each at 2g per kg of seed with two foliar sprays (0.5% + 0.2% + 0.1% + 0.5%, respectively, except $ZnSO_4$ 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 (1.890), more number of effective nodules per plant (25.5), pod yield (24.10 q/ha) and seed yield (22.30 q/ha) compared to all other treatments and control (0.804, 18.2, 21.80 q/ha and 19.13 q/ha, respectively) (Fig. 2) and noticed 16.1 % increase in seed yield over control.

Higher values in this treatment 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 grow robustly and establish the canopy resulting in larger leaf area index [11] and which are required by *rhizobia* for atmospheric nitrogen fixation in legumes and are considered as an important constituents of nitrate reductase, nitrogenase and is required for both synthesis and activity of enzymes [12]. More the number of effective nodules more will be the nitrogen fixation in plant roots which ultimately increases the vegetative growth and yield due to higher source to sink ratio in chickpea [13].

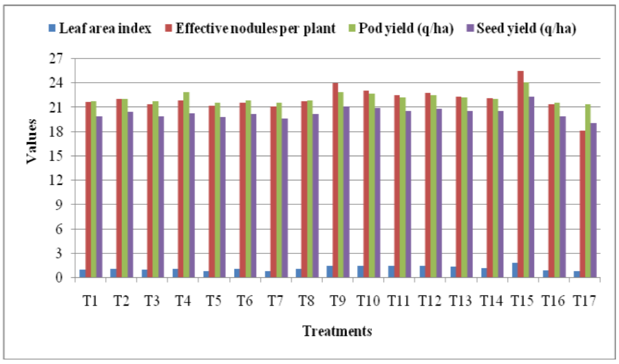

Figure 2. Effect of seed polymerization with micronutrients on growth and yield of chickpea

Legend:
T_1: ZnSO4 @ 2g per kg of seed; T_2: ZnSO4 @ 4g per kg of seed; T_3: Boron @ 2g per kg of seed T_4: Boron @ 4g per kg of seed; T_5: Ammonium molybdate @ 2g per kg of seed; T_6: Ammonium molybdate @ 4g per kg of seed; T_7: FeSO4 @ 2g per kg of seed; T_8: FeSO4 @ 4g per 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.

E. Pigeon Pea

Seed polymer coating (6ml $kg^{-1}$of seed) with potassium molybdate + ZnSO4 + 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 recorded significantly higher leaf area index (2.91), more number of effective nodules per plant (10.15) and seed yield (16.30 q/ha) compared to all other treatments and control (1.80, 6.52 and 13.86 q/ha, respectively for the above parameters) (Fig. 3).

The per cent increase in seed yield was to the tune of 19.9 over control. The increase in seed yield as a result of seed polymer coating with micronutrients and foliar spray might be attributed to the role played by micronutrients in activating dehydrogenase and other enzymes. These micronutrients are also necessary for the biosynthesis of IAA, the growth regulator, which is essential for normal enlargement of cells [14] and also significant increase in effective nodules per plant due to the combined effect of micronutrients in particular zinc and potassium molybdate, as Mo being essential for N fixation, which has ensured better N supply to the crop [15].

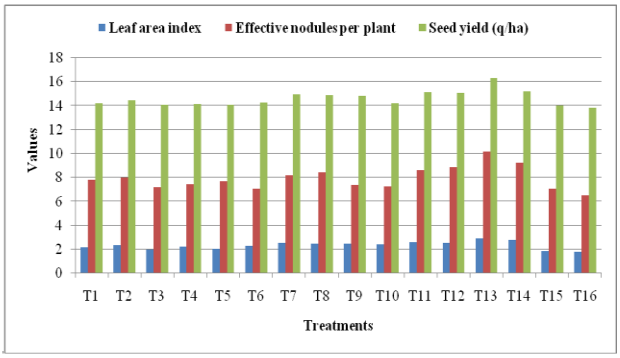

Figure 3. Effect of seed polymerization with micronutrients on growth and yield of pigeon pea

Legend:
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: (T_1+T_3); T_8: (T_2+T_4); T_9: (T_3+T_5); T_{10}: (T_4+T_6); T_{11}: (T_1+T_5); T_{12}: (T_2+T_6); T_{13}: (T_1+T_3+T_5); T_{14}: (T_2+T_4+T_6); T_{15}: Only polymer; T_{16}: Absolute control.

F. Groundnut

All the growth and yield attributing parameters differed significantly due to seed treatment with micronutrients and polymer. The seed polymer coating with different micronutrients (Zinc sulphate + Borax + Ferrous sulphate + Ammonium molybdate + calcium sulphate each @ 2g per kg seed) and two foliar spray Zinc sulphate (0.5%) + Borax (0.2%) + Ammonium molybdate (0.1%) + ferrous sulphate (0.5 %) + Calcium sulphate (0.5%) at interval of 10 days during flowering stage (50 and 60 DAS) recorded significantly higher leaf area index (1.50), chlorophyll content (38.3) pod yield per ha (16.29 q), and seed yield per ha (8.89) compared to other treatments and control (Fig. 4). The per cent increase in seed yield was to the tune of 13.8 over control. The increase in LAI in this treatment might be due to higher rate of availability of nutrients wherein made the plants to absorb more available nutrients, grow robust, establish the canopy and in turn increase photosynthetic activity, translocation of photosynthates and accumulation of more food reserves in seed as evident with higher test weight and yield parameters [16].

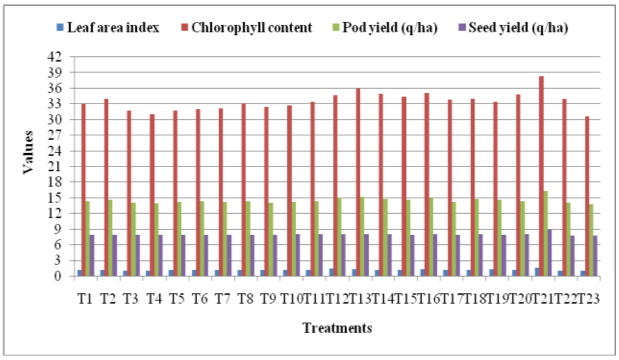

Figure 4. Effect of seed polymerization with micronutrients on growth and yield of groundnut

Legend:
T_1: $ZnSO_4$ @ 2g per kg of seed; T_2: $ZnSO_4$ @ 4g per kg of seed; T_3: Boron @ 2g per kg of seed; T_4: Boron @ 4g per kg of seed; T_5: Ammonium molybdate @ 2g per kg of seed; T_6: Ammonium molybdate @ 4g per kg of seed; T_7: $FeSO_4$ @ 2g per kg of seed; T_8: $FeSO_4$ @ 4g per kg of seed; T_9: $CaSO_4$ @ 2g per kg of seed; T_{10}: $CaSO_4$ @ 4g per kg of seed; T_{11}: $ZnSO_4$+Boron each @ 2g per kg of seed (T_1+T_3); T_{12}: (T_1+T_5); T_{13}: (T_1+T_7); T_{14}: (T_1+T_9); T_{15}: (T_3+T_5); T_{16}: (T_3+T_7); T_{17}: (T_3+T_9); T_{18}: (T_5+T_7); T_{19}: (T_5+T_9); T_{20}: (T_7+T_9); T_{21}: (T_1+T_3+T_5+T_7+T_9); T_{22}: Only polymer; T_{23}: Absolute control.

IV. Conclusion

From the results discussed above, it is concluded that seeds coating with polymer + micronutrients helps in increasing productivity of cotton, pigeon pea, chickpea and groundnut with minimum expenditure and maximum returns per unit area.

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