Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(1): 1190-1194
Received: 16-11-2020
Accepted: 18-12-2020

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Effect of bioagent and seed coating on yield of soybean (*Glycine max* (L.) Merrill.)

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Abstract
A field experiment entitled "Effect of bioagent and seed coating on yield and seed quality parameters in soybean (Glycine max L.)MIRRIL.) was conducted during *kharif* 2019 at experimental field of Department of Agriculture Botany, Vasantrao Naik Marathwada Agriculture University, Parbhani. Seed of soybean var. MAUS 162 were coated with polymer in combination with different bioagents and maintained untreated seed (control). After seed treatment, the seed were sown in the field with three replication and seven treatment adopting randomized block design in order to find out the effect of seed treatments on various growth and yield parameters. Plant height, number of branches, leaf area. leaf area index, plant total dry weight, chlorophyll content, number of pods, number of seed, seed yield per hectare and harvest index were significantly superior in treatment $T_{7:}$ T_2+ Biomix@6ml followed by T_4 T_2+ *Rhizobium japonicum* @6ml than all other seed coating treatments over the control in the soybean var MAUS -162.

Keywords: Soybean, seed coating, bio-agents, polymer and seed yield

Introduction
Soybean (*Glycine max* L.) is the wonder crop of the 20th Century, which is commonly referred as 'miracle crop 'golden bean' or gold from soil which belonging to family Leguminosae, sub family Papilionaceae and the genus *Glycine* L. It is supposed to have originated in China and was introduced to India in 1968 (Bragg cv.) from USA (Nagata, 1970). It is basically a pulse crop and gained the importance as an oil seed crop. Soybean has the unique significance on this age of energy crisis and has a vital role in agriculture, enterprise and export change of India. The 30% of global vegetable oil and 60% of vegetable protein is derived from soybean. Due to high protein content, soybean is known as `poor man's meat'. Recently the area under soybean in our country is increasing year after year due to certain advantages like short duration crop, less pest and disease attack but productivity is not considerably increased and has remained almost stagnant for the past several years. Seed coating a effective technique to seed enhancement, in particular for large seeded agronomic and horticultural plants and its major benefit is that the seed enhancement material is placed directly on to the seed. The film components consist of mixture of polymer, plasticizer and colorants that are commercially available as ready to apply as liquids (Ni, 1997). Polymer coating acts as a temperature switch and protective coating by regulating intake of water by seed coat, until the soil has warmed to a predetermined temperature. In recent years, use of bioagent was also found very effective in controlling diseases (Cook and Baker,1983). In view of the above circumstances, the present investigation was undertaken to study the effect of bioagent and seed coating on yield parameters in soybean.

Material and Methods
A field experiment entitled "Effect of bioagent and seed coating on yield and seed quality parameters in soybean (Glycine max L.) MIRRIL.) was conducted during *kharif* 2019 at experimental field of Department of Agriculture Botany, Vasantrao Naik Marathwada Agriculture University, Parbhani. The experiment was laid out in randomized block design with three replication and seven treatments. The seed were coated with polymer in combination with different bioagents and maintained untreated seed (control). The seed treatments are$T_{1:}$Untreated seed, T_2:Polymer coating@ 3ml/kg,T_3: T_2+*Tricoderma viride* @ 5 ml, T_4: T_2+ *Rhizobium japonicum* @6ml, T_5: T_2+ Phosphorus solubilizing bacteria@6ml, T_6:T_2+ Potash Solubilizing bacteria@6ml, $T_{7:}$ T_2+ Biomix@6ml. Seed of soybean var. MAUS 162 were coated with polymer in combination with different bioagents and maintained untreated seed (control). The data were collected on various characters. The plant height was measured from the base of shoot to the last opened leaf in centimeter(cm) at various stages of crop growth.

Total number of branches per plant were counted from selected plant. Leaf area of selected leaves is determined by using leaf area meter. The leaf area index was measured by the method proposed by Watson (1952) is an appropriate measure of crop growth. It is dimension less ratio and calculated by following formula.

$$LAI = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Ground area per plant (cm}^2\text{)}}$$

Number of seeds per pod and number of pods per plant were taken in five randomly selected plants and averaged to get the results. Plant total dry weight was recorded in gram from the base of shoot to the last opened leaf for five selected and tagged plants from each plot and average was worked out. Plants were oven dried at a temperature of 65 °C before taking plant total dry weight. The chlorophyll reading of leaf was measured by using an instrument SPAD. Number of seeds per pod and number of pods per plant were taken in five randomly selected plants and averaged to get the results. Yield of five selected plants from each plot in each replication was recorded and averaged to get seed yield per plot. Yield obtained per plot was computed and extrapolated to get yield per hectare. A random sample of 100 seeds from each replication in all treatments were counted, weighed and expressed in grams for calculating 100 seed weight. Harvest index in different treatments was worked out by following formula given by Donald (1962)

$$HI\ (\%) = \frac{\text{Economic or grain yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

Result and Discussion:

Plant height (cm)

Plant height is an important morphological parameter and is a major component of the yield. Data on plant height was recorded at 30, 60 and 90 of crop growth stages.Plant height at different crop growth stages is presented in the table 1 which shows that all the seed coating treatments have significant effect on plant height over control. The treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (22.33) followed by treatment T_4:T_2+ *Rhizobium japonicum*@6ml/kg of seed (20.00) was recorded significantly higher plant height over other treatments and minimum in T_1 control (17.80). Whereas, at 60 days after sowing, the data shows that the treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (46.20) was recorded higher plant height over other treatments and T_1 – control(40.80). At 90 days. the data regarding plant height showed that the treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (50.40) was recorded higher plant height as compared to other treatments and T_1 – control (43.40).

Number of branches per plant

Number of branches is an important yield contributing parameter. Number of branches at different crop growth stages is presented in the table 1 which revealed that all the seed coating treatments have significant effect on number of branches per plant over control at all stages of crop growth. The treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (3.06) followed by treatment T_4:T_2+ *Rhizobium japonicum*@6ml/kg of seed (2.93) was recorded significantly higher number of branches over other treatments and minimum in T_1 control (1.80). Whereas, at 60 days after sowing, the data shows that the treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (6.40) was recorded higher number of branches over other treatments and T_1 – control(4.84). At 90 days. the data regarding number of branches per plant showed that the treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (7.09) was recorded higher number of branches as compared to other treatments and T_1 – control (5.06). Plant branches is major morphological character which contributes to yield. If branches are more than photosynthetic energy is diverted towards reproductive parts rather than vegetative parts and produces more number of pods which positively reflects in yield. Seed coating have differential promotive effect on height of plant.

Plant total dry weight (gm)

The plant total dry weight is an important factor which has direct and positive effect on seed yield per plant, biological yield, harvest index and production per unit area. Data on plant total dry weight was presented in table 1. All the seed coating seed coating treatment have significant effect on total dry weight.The treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (3.57) followed by treatment T_4:T_2+ *Rhizobium japonicum*@6ml/kg of seed (3.53) was recorded significantly higher plant total dry weight over other treatments and minimum in T_1 control(3.16).Whereas, at 60 days after sowing, the data shows that the treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (11.76) was recorded higher plant total dry weight over other treatments followed by T_4:T_2+ *Rhizobium japonicum*@6ml/kg of seed (11.50) and T_1 – control(10.00). At 90 days. the data regarding plant total dry weight showed that the treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (16.56) was recorded plant total dry weight as compared to other treatments followed by T_4:T_2+ *Rhizobium japonicum*@6ml/kg of seed (15.70) and T_1– control(15.03).The data on plant total dry matter recorded at different time intervals would give the picture in quantitative forms as regard accumulation and partitioning of the total dry matter among the plant’s parts throughout the growth period of crop. As there were no reproductive parts during early phases of crop growth.

Leaf area (cm^2)

Leaf area is an important morphological parameter and is a major component of the yield. Leaf area at different crop growth stages is presented in the table 2 which shows that all the seed coating treatment treatments have significant effect on leaf area over control. Leaf area increased up to 75 DAS, therefore it decreased due to profuse leaf shedding. At 45 days the treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (38.53) followed by treatment T_4:T_2+ *Rhizobium japonicum*@6ml/kg of seed (35.46) was recorded significantly superior to increase mean leaf area per plant over other treatments and minimum in T_1 control(28.76).Whereas, at 75 days after sowing, the data shows that the treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (46.46) followed by treatment T_4:T_2+ *Rhizobium japonicum*@6ml/kg of seed(46.23) was recorded to increase leaf area per plant over other treatments and T_1 – control(37.80). Leaf area is a major morphological character which determines the rate of photosynthesis. If leaf area is more than more surface area is available for absorption of photosynthetically active radiations and amount of chlorophyll also increase which positively reflects in source sink relationship and yield.

Leaf area index

Leaf area index at different crop growth stages is presented in the table 2 which shows that all the seed coating treatment treatments have significant effect on leaf area index over control. The treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (4.27) significantly superior over all the treatment to increase mean leaf area index per plant at 45 days after sowing followed by treatment T_4:T_2+ *Rhizobium japonicum*@6ml/kg of seed (3.93) and minimum in T_1 control(3.19).Whereas, at 75 days after sowing, the data shows that the treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (5.15) was recorded to increase leaf area per plant over other treatments followed by treatment T_4:T_2+ *Rhizobium japonicum*@6ml/kg (5.13) and T_1 – control(4.19).

Chlorophyll content

Data pertaining to chlorophyll content at 45 and 75 DAS of crop growth stage was recorded and presented in table 2 and was found to be significant. At 45 days, higher chlorophyll content was recorded in the treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (45.04) followed by treatment T_4:T_2+ *Rhizobium japonicum*@6ml/kg of seed (44.48) and minimum in T_1 control (40.73). Whereas, at 75 days after sowing, the data shows that the treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (50.00) followed by treatment T_4:T_2+ *Rhizobium japonicum*@6ml/kg of seed(49.13) was recorded to higher chlorophyll content over other treatments and T_1 – control(44.68). Photosynthetic activity in crop plants depends upon chlorophyll content. Chlorophyll have been rightly designated as "pigment of life" because of their control role in living system responsible for harvesting sunlight and transforming its energy into biochemical energy essential for life on earth.In the present investigation,it was observed that bioagent seed treatment had profound effect on chlorophyll content.

Number of pods per plant

Number of pods per plant recorded at harvest is presented in the table 3 and found to be significant. A significant variation in number of pods per plant among the different seed treatments was observed. All the seed coating treatments produced more number of pods per plants than control (26.60 pods). Thus, it can be concluded that seed coating likely to contribute for increasing the seed yield. Among the treatments, $T_{7:}$ T_2+ Biomix@6ml/Kg of seed recorded significantly high number of pods per plant (34.66) followed by T_4:T_2+ *Rhizobium japonicum*@6ml/kg of seed (33.46) over T_1 – control (26.60). Number of pods per plant was high in seed treatments with bioagents as compared with untreated seeds. The increase in number of pods may be due to medium plant height, maximum leaf area, maximum plant dry weight, the more number of branches per plant, decreased flower drop and increased pod setting, nutrient mobilization and nutrient uptake.

Number of seed per pod

The number of seed per pod is an important factor which has direct effect on seed yield per plant. Number of seed per pods recorded at harvest was presented in the table 3 and found to be significant. All the treatments recorded significantly higher number of seed per pod over control. Among the treatments, treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed recorded highest number of seed per pod (2.66) as compare to rest of the treatment followed by $T_{4:}$ T_2+*Rhizobium japonicum*@6 ml/kg of seed (2.60) and T_1 – control (2.13). Soybean pods contain maximum three seeds per pod, however due to physiological factor and source sink relationship all pods do not contain three seeds.

Test weight (g)

Test weight in gram is presented in the table 3 which was found to be significant. Hundred seed weight significantly differed in seed treatments All the different seed coating treatments have the significant difference in terms of test weight. Higher test weight was recorded by treatment T7-T_2+ Biomix@6ml/Kg of seed (12.53 g) as compared to other treatments followed by treatment T_4-*Rhizobium japonicum* @6ml/kg of seed (12.36) Lowest test weight was recorded by control (10.66). If the test weight is more than seed yield also more with bold seed size. The increase in seed weight in treated seeds may be due to the inhibition of activity of pathogen resulted in more dry matter production and availability of photosynthates for sink which ultimately resulted in more seed weight. Similar findings were observed by Tripathi and Singh (1991), Anuja et al., (2000), Taywede et al., (2002) and Rezende *et al*., (2003).

Seed yield per plot (kg)

Statistical data on seed yield per plant is presented in table 3. It revealed that there is a significant difference in seed yield per plot with respect to seed coating with bioagent. All the different seed coating treatments have the significant difference in terms of seed yield per plot. Higher seed yield per plot was recorded by treatment T7- T_2+ Biomix@6ml/Kg of seed (5.20 kg), followed by treatment T4- T_2+ *Rhizobium japonicum*@6ml/kg of seed (5.03) and treatment T3-T_2+*Trichoderma viride*@5ml /Kg of seed (4.86 Kg) Lowest seed yield per plot was recorded by control (4.06kg). The seeds coated with polymer alone was also found effective in increasing the seed yield and recorded more seed yield per plot (4.40 kg) over untreated seeds (4.06kg).

Seed yield per ha (qt / ha)

Seed yield per ha in quintal is presented in the table 3 which was found to be significant. All the different seed coating treatments have the significant difference in terms of seed yield per hectare. Data ranges from 18.82 (T1) to 26.3o (T7) for seed yield per ha. Higher seed yield per plant was recorded by treatment $T_{7:}$ T_2+ Biomix@6ml/Kg of seed (26.30 qt) which may be due to an increase in number of grains per pods, number of pods per plant,100 seed weight and higher portioning towards reproductive organs followed by treatment T_4: T_2+ *Rhizobium japonicum*@6ml/kg (24.63) and treatment T_3: T_2+*Trichoderma viride*@5ml /Kg of seed (23.19 qt). Lowest seed yield per ha was recorded by control (18.82 qt).

Harvest Index

Harvest index indicated the yielding efficiency of crop to produce grain yield. Data on harvest index was record and presented in table no 3 Analysis of data on Harvest index (%) is presented in the table 8. The data indicate that the difference among the treatments were significant over control. Among the treatment, T_7 (T_2+ Biomix@6ml/Kg of seed) 45.94 found significantly superior over all treatments to increase mean harvest index followed by treatment T_4: (*Rhizobium japonicum*@6ml/kg of seed 45.01 and control 40.69.

Table 1: Effect of seed coating on plant height (cm), No. of branches per plant and plant total dry weight

Treatments	Plant height (cm)			Number of branches per plant			Plant total dry weight		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1: Untreated seed	17.80	40.80	43.40	1.80	4.84	5.06	3.16	10.00	15.03
T_2: Polycot @ 3ml/Kg of seed	17.33	41.53	47.06	2.03	5.01	5.30	3.30	10.27	15.30
T_3:T_2+*Trichoderma viride*@5gm/Kg of seed	19.53	44.40	47.00	2.82	5.86	6.70	3.43	11.46	15.60
T_4:T_2+*Rhizobium japonicum*@6ml/kg of seed	20.00	45.33	49.46	2.93	5.91	6.82	3.53	11.50	15.70
T_5:T_2+Phosphorussolubilizingbacteria @6ml/kg	19.13	43.53	46.66	2.70	5.30	6.42	3.40	10.70	15.43
T_6: T_2+ Potash solubilizing bacteria @6ml/of seed	18.53	43.26	46.20	2.40	5.06	6.66	3.39	10.50	14.96
T_7: T_3+ Biomix@6ml/Kg of seed	22.33	46.20	50.40	3.06	6.40	7.09	3.57	11.76	16.56
SE±	0.68	0.77	1.26	0.06	0.10	0.08	0.04	0.07	0.06
CD@5%	2.12	2.39	3.93	0.19	0.32	0.25	0.12	0.23	0.19

Table 2: Effect of seed coating on leaf area (cm^2), Leaf area index, Chlorophyll content.

Treatment	Leaf area (cm^2)		Leaf area index		Chlorophyll content	
	45DAS	75DAS	45DAS	75DAS	45DAS	75 DAS
T_1: Untreated seed	28.76	37.80	3.19	4.19	40.73	44.68
T_2: Polycot @ 3ml/Kg of seed	32.00	40.86	3.55	4.53	41.53	45.69
T_3:T_2+*Trichoderma viride*@5gm/Kg of seed	34.46	44.33	3.82	4.92	44.16	48.40
T_4:T_2+*Rhizobium japonicum*@6ml/kg of seed	35.46	46.23	3.93	5.13	44.48	49.13
T_5:T_2+Phosphorussolubilizingbacteria @6ml/kg	33.63	42.40	3.73	4.70	43.86	47.72
T_6: T_2+ Potash solubilizing bacteria @6ml/of seed	32.13	42.13	3.56	4.67	42.00	46.98
T_7: T_3+ Biomix@6ml/Kg of seed	38.53	46.46	4.27	5.15	45.04	50.00
SE±	0.88	0.85	0.09	0.09	0.64	0.78
CD@5%	2.76	2.65	0.30	0.29	2.06	2.45

Table 3: Effect of seed coating on No. of pods/plant,No. of seed /pod, Test weight, seed yield per plot(kg), Seed yield per ha(qt/ha) and Harvest index (%)

Treatments	No. of pods per plant	No of seed per pod	Test weight(g)	Seed yield per plot(kg)	Seed yield Per hectare (qt/ha)	Harvest Index
T_1: Untreated seed	26.60	2.13	10.66	4.06	18.82	40.69
T_2: Polycot @ 3ml/Kg of seed	28.86	2.26	11.33	4.40	19.87	41.91
T_3:T_2+*Trichoderma viride*@5ml/Kg of seed	32.26	2.53	12.23	4.86	23.19	44.37
T_4:T_2+*Rhizobium japonicum*@6ml/kg of seed	33.46	2.60	12.36	5.03	24.63	45.01
T_5: T_2+ Phosphorus solubilizing bacteria @6ml/kg	31.93	2.46	11.86	4.69	21.60	44.01
T_6: T_2+ Potash solubilizing bacteria @6ml/of seed)	30.67	2.33	12.16	4.46	20.67	43.07
T_7: T_2+ Biomix@6ml/Kg of seed	34.66	2.66	12.53	5.20	26.30	45.94
SE(m) ±	0.99	0.08	0.11	0.06	0.48	0.41
CD@5%	3.10	0.25	0.35	0.19	1.51	1.30

Conclusion

From the above result it is concluded that, soybean yield parameters *viz.*, Plant height, number of branches, plant total dry weight,chlorophyll content, leaf area, leaf area index, number of pods per plant,number of seed per pod, test weight, seed yield per plot,seed yield per hectare and harvest index were significantly increased due to seed coating with T_7 (T_2+ Biomix@6ml/Kg of seed) and T_4: (*Rhizobium japonicum*@6ml/kg of seed in soybean var MAUS -162.

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