Effect of seed treatment of boron, cobalt and molybdenum on growth parameter, grain yield and seed quality in soybean (*Glycine max* L.) under Inceptisol.

Abstract

A field study was conducted to know the "Effect of seed treatment of boron, cobalt and molybdenum on growth parameter, grain yield and seed quality in soybean (*Glycine max* L.) under Inceptisol'" during *kharif*, during 2022-23 at experimental farm, department of Soil Science and Agricultural chemistry, College of Agriculture, Badnapur. The experiment was laid out in Randomized Block Design (RBD) with 8 treatments which were replicated thrice.The treatments comprises (T_1) Absolute control, (T_2) RDF, (T_3) RDF + Boron @ 2 gm kg^{-1} seed, (T_4) RDF + Cobalt @ 1.5 gm kg^{-1} seed, (T_5) RDF + Ammonium molybdate 1 gm kg^{-1} seed , (T_6) RDF + Boron @ 2 gm kg^{-1} seed + Cobalt @ 1.5 gm kg^{-1} seed, (T_7) RDF + Cobalt @ 1.5 gm kg^{-1} seed + Ammonium molybdate @ 1 gm kg^{-1} seed, (T_8) RDF + Boron @ 2 gm kg^{-1} seed + Cobalt @ 1.5 gm kg^{-1} + Ammonium molybdate @ 1 gm kg^{-1} seed .To achieve the objectives the observations were recorded at various growth stages of soybean *kharif*, during 2022-23. The result indicates that, treatment (T_8) receving RDF + Boron @ 2 gm kg^{-1} seed + Cobalt @ 1.5 gm kg^{-1} seed + Ammonium molybdate @ 1 gm kg^{-1}seed was found effective due to advantages effect on morpho-physiological growth, yield and yield attributing characters likeplant height, nodulation, fresh weight of nodules, no. of root nodules, root length, number of pods $plant^{-1}$of soybean grain yield, Stover yield of soybean.In grain quality the results revealed that test weight, protein content percentage were significantly influenced with the application of treatment T_8.On the other hand, in all the cases the lower response was found from the control treatment.

Keywords:Seed treatment, boron, cobalt and Ammonium molybdate, soybean yield, quality

Introduction

Soybean (*Glycinemax* L.) is known as Manchurian bean or Wonder crop which belongs to family leguminaceae.Soybean seed consist of 20-22 percent oil and 40-42 percent protein and other nutrients like calcium, iron and glycine (Devi *etal*.2014).Soybean is easily processed into a variety of goods, including soy cheese, soy milk, soy protein, soy yoghurt, and soybean oil and soy nuts, among others. Additionally, soy is used to produce soy molasses, soy paint, and soy ink. It might support India's rural food processing sector, which has the potential to transform the country's economy by improving soil and human health. Madhya Pradesh and Maharashtra states are the major producers of soybean accounting for 87 percent of acre and 82 percent of the production.

In soybean boron (B) is a crucial micronutrient having functions in nitrogen fixation, tissue growth, reproduction and photosynthate translocation (Bolanos *et al*.,1996; Davidson, 2014). The creation of cell walls, cell division, root elongation and the control of plant hormones are all boron-related processes in plants. For pollen to germinate and the pollen tube to grow, borax is necessary.Boron has role in pollination, fruit setting, seed setting and the movement of nutrients like sugar and phosphorus, among other things, boron is a micronutrient of particular significance. Lack of boron has a negative impact on flowering and fruit setting, which lowers soybean production and quality. Boron shortage typically results in stunted growth, the leaves may twist and shrivel and have a tendency to thicken. In plants with low levels of B, seed viability is poor.

Cobalt is essential to plants entire growth processes. Cobalt is a helpful element for higher plants and it directly affects plant metabolism. Because it is crucial for the bacteria that fix nitrogen in root nodules, cobalt is necessary for leguminous plants (Witte *et al*., 2002). Cobalt is required for the development of the stem, the lengthening of the coleoptiles and the expansion of the leaf lamina, component required for a plant to mature and for the production of healthy buds.Cobalt is a transition metal and a crucial part of many enzymes and coenzymes.

Soybean needs molybdenum in a minute amount i.e. only 0.5 parts per million of molybdenum. The nitrate reduction mechanism, which transforms nitrate molecules into amino form, requires molybdenum in plants. This is a crucial first step in the synthesis of proteins, which are essential for plant growth. When Molybdenum applied to nitrogen-deficient soil, a cofactor for the enzyme nitrate reductase, which is involved in nitrogen assimilation, encourages nitrogen fixation and nodule formation, especially for legumes, increasing yield.Molybdenum serves as a structural component, a catalyst and is a direct participant in redox processes in these enzymes.

Material and Methods

The field experiment was conducted during *kharif*, during 2022-23 at experimental farm, department of Soil Science and Agricultural chemistry, College of Agriculture, Badnapur. to study the "Effect of seed treatment of boron, cobalt and molybdenum on growth parameter, grain yield and seed quality in soybean (*Glycine max* L.) under Inceptisol' After completion of preparatory tillage operations, the experimental units were laid out as per plan.The experiment was laid out in randomized block design (RBD) with eight (8) treatments.The layout consists of 24 experimental plots in three replications.The treatments comprises (T_1) Absolute control, (T_2) RDF, (T_3) RDF + Boron @ 2 gm kg^{-1} seed, (T_4) RDF + Cobalt @ 1.5 gm kg^{-1} seed, (T_5) RDF + Ammonium molybdate 1 gm kg^{-1} seed , (T_6) RDF + Boron @ 2 gm kg^{-1} seed + Cobalt @ 1.5 gm kg^{-1} seed, (T_7) RDF + Cobalt @ 1.5 gm kg^{-1} seed + Ammonium molybdate @ 1 gm kg^{-1} seed, (T_8) RDF + Boron @ 2 gm kg^{-1} seed + Cobalt @ 1.5 gm kg^{-1} + Ammonium molybdate @ 1 gm kg^{-1} seed .

Soybean seed variety MAUS-18 was sown on 08 July 2022 by dibbling method as per randomly replicated plot having size 4.5 X 5 m^2 and 3.60 and 3.30 m^2 in gross and net plot respectively, maintained row to row spacing 45 cm and plant to plant 5 cm and using a seed rate of 75 kg ha^{-1}. All the plots were fertilized with recommended dose of NPKS (30:60:30:20 kg ha^{-1}) whole quantity of fertilizers was applied as a basal dose and micronutrients seed treatment done at the time of sowing. After sowing, seed was covered with soil. Sowing depth was kept almost 5 cm. and other agronomic practices were carried out uniformly according to the recommendations in all the treatments.The crop was harvested at maturity stage on 26 October, 2022 The observation recorded viz. Fresh weight of nodules (mg), No. of root nodules, Root length (cm)at flowering, and plant height, at harvest stage The yield attributing parameters viz., no. of pods per plant seed yield(kg ha^{-1}), Stover yield (kg ha^{-1}), were recorded at harvest stage. Quality parameter like protein, and test weight value were recorded. The data collected from the above observation were analysed statistically by the procedure prescribed by Panse and Sukhatme (1967). The findings of the present study as well as relevant discussion have been presented under following heads.

Result and Discussion

Fresh weight of nodules (mg)

The fresh weight of nodules $plant^{-1}$ of soybean was recorded at flowering stage and presented in table no.1.Significantly maximum fresh weight of nodule was observed in seed treatment (T_8) RDF+ Boron @ 2 gm kg^{-1} seed+ Cobalt @ 1.5 gm kg^{-1} seed + Ammonium molybadte @ 1 gm kg^{-1} seed (395.50 mg), which was found statistically at par with treatment T_7, T_6,T_5,,T_4, T_3 over treatment (T_1) absolute control and at par with each other. Treatment (T_2) RDF (370.53 mg) was significant over treatment (T_1) absolute control.However, the treatment (T_1) absolute control recorded lowest fresh weight of nodules (359.10 mg) plant^{-1}.

Development of root system provides higher number of nodules formed by *Rhizobium* bacteria. Cobalt helps in vitamin B_{12} formation which is essential for nitrogen fixation by the *Rhizobium*. Boron regulates carbohydrate metabolism and is necessary for translocation of sugar from leaves to root nodule. It is also required for carbohydrate and protein synthesis. Molybdenum is required for nitrogen fixation by *Rhizobium* activity of nitrogenase and nitrogen fixation controlled by it.

The results are in accordance with the finding of Pattanayak*et al*. (2000) who reported that use of cobalt as a seed treatment @ 0.008 mg g^{-1} seed and molybdenum at 0.08 mg g^{-1} seed in green gram shows significant increase in nodule weight and leghaemoglobin in green gram.

No. of root nodules at flowering stage

The effect of seed treatment of boron, cobalt and ammonium molybadte on the number of nodules of soybean was recorded at flowering stage. The data is presented in table no 1 and. At the time of flowering maximum number of root nodules plant^{-1} were observed in treatment (T_8) RDF + Boron @ 2 gm kg^{-1} seed + Cobalt @ 1.5 gm kg-1 seed + Ammonium molybadte @ 1 gm kg^{-1}seed (47.26) which was at par with T_7 (44.33), T_6 (44) , T_5 (42.83) ,T_4 (42.00), (T_3) (39.83) and (T_2) (37.67) were significant over treatment (T_1) absolute control and at par with each other. However, treatment (T_1) absolute control recorded lowest number of root nodules (30.17) plant^{-1}. Application of molybdenum and cobalt helps in spreading root system which gives more sites for rhizobia infection and increases their proliferation in rhizosphere, which helps in forming more effective root nodules.

Similar findings were also made by Gad *et al*. (2013) on number of root nodules was increased in groundnut by application of molybdenum. Obtained results also confirmed with the findings of Singh *et al*. (2010) highest number of nodules at flowering and pod filling (47.80) were recorded with application of cobalt 2 mg kg^{-1} seed and ammonium molybdate 1 mg kg^{-1} seed. The findings of the present study are also similar to findings of Rao *et al*. (1999).

Root length at flowering (cm)

The influence of seed treatment of boron, cobalt and Ammonium molybdate on root length (cm) was measured at flowering stage of soybean. The data presented in table no. 1 and. The treatment (T_8) RDF+ Boron @ 2 gm kg^{-1}seed + Cobalt @ 1.5

gm kg^{-1} seed + Ammonium molybdate@ 1 gm kg^{-1} seed significantly influence the root length (35.00cm) and was found superior over the rest of the treatments and it was at par with T_7 (33.86 cm), T_6 (33.00 cm), T_5 (32.83 cm), T_4 (32). T_3 (29.17) and T_2 (28.03 cm) were significant over treatment (T_1) absolute control and at par with each other. However, treatment (T_1) absolute control recorded lowest root length (22.33). Application of molybdenum and cobalt helps in spreading root system which gives more sites for rhizobia infection and increases their proliferation in rhizosphere, which helps in forming more effective root nodules and also increases root length.

According to Kandil *et al.*(2013) application of cobalt @ 12 mg kg^{-1} seed significantly increased in root length (27.9 cm) of soybean.

Table No. 1 Effect of seed treatment of boron, cobalt and molybdenum on fresh weight of nodules (mg), No. of root nodules, Root length(cm) at flowering stage,plant height, No. of pods per plant at harvest (cm) in soybean.

Treatments	**Fresh weight of nodules (mg)**	**No.of root nodules**	**Root length (cm)**	**Plant height (cm)**	**No. of pods per plant**
T_1 : Absolute control	359.10	30.17	22.33	32.33	41.00
T_2 :RDF	370.53	37.67	28.03	41.88	51.10
T_3 :RDF+ Boron @ 2gm kg^{-1} seed	375.83	39.83	29.17	42.10	61.17
T_4 : RDF+ Cobalt @ 1.5gm kg^{-1} seed	381.83	42.00	32.00	43.57	56.20
T_5 :RDF + Ammonium molybdate@ 1gm kg^{-1} seed	387.50	42.83	32.83	45.17	63.10
T_6 : RDF+ Boron @ 2gm kg^{-1} seed+ Cobalt @ 1.5 gm kg^{-1} seed	390.76	44.00	33.00	45.33	65.30
T_7 :RDF+ Cobalt @ 1.5 gm kg^{-1} seed + Ammonium molybdate @ 1gm kg^{-1} seed	392.50	44.33	33.86	48.16	67.20
T_8 :RDF+ Boron @ 2 gm kg^{-1}seed + Cobalt @ 1.5 gmkg^{-1}seed + Ammonium molybdate @ 1 gm kg^{-1} seed	395.50	47.26	35.00	51.33	69.10
SE(m) ±	**2.77**	**1.85**	**1.58**	**2.40**	**2.97**
CD at 5%	**8.40**	**5.62**	**4.81**	**9.48**	**9.01**

Plant height (cm)

The plant height of soybean was recorded at harvest stage of crop. The observations recorded under different treatment are presented in table no. 1 Significant variation were observed on plant height of soybean with all the treatments over absolute control (T_1). The plant height was statistically significant and highest in treatment (T_8) RDF + Boron @ 2 gm Kg^{-1} seed + Cobalt @1.5 gm kg^{-1}seed + Ammonium molybdate @ 1 gm kg^{-1} seed at harvest stage of crop (51.33 cm) which was statistically at par with all other treatments except treatment (T_1) absolute control. However, Treatment (T_1) absolute control which had recorded the lowest plant height (32.33 cm) among all the treatments.

The increase in plant height might be due to increase in nodulation, biological nitrogen fixation, chlorophyll content and photosynthesis that result in better growth of plant due to seed treatment of boron, cobalt and molybdenum.

Tahir *et al.* (2011) recorded highest plant height at harvest (66.40) in soybean with application of Mo @ 4 gm kg^{-1} seed and *rhizobium*. The increase in the plant height due to application of boron, molybdenum might be due to their crucial role as a promoter of cell division and act in the induction and development of meristematic tissues. The results confirm the finding of devi *et al*. (2014).

No. of pods per plant

The effect of seed treatment of boron, cobalt and Ammonium molybdateon number of pods $plant^{-1}$ of soybean was recorded and presented in table no.1 Significantly higher number of pods were recorded in treatment (T_8) RDF + Boron @ 2 gm kg^{-1} seed + Cobalt @ 1.5 gm kg^{-1} seed + Ammonium molybdate@ 1gm kg^{-1} seed (69.10), which was found statistically at par with treatment T_7 (67.20),T_6(65.30),T_5 (63.10), T_4 (56.20), T_3 (61.17). T_2 (51.10) was significant over treatment (T_1) absolute control.However, Treatment (T_1) absolute controlrecorded the lowest number of pods (41.00) $plant^{-1}$. The improvement in the pod bearing capacity of soybean could be possibly becauseof increase in photosynthesis, better vegetative and reproductive growth of crop with an application of boron and molybdenum along with RDF. This resultare in accordance with Adkine*et al*. (2011) who observed that application of boron, molybdenum along with RDF produces maximum number of pods per $plant^{-1}$.

Seed yield (kg ha^{-1})

The effect of seed treatment boron, cobalt and molybdenum on seed yield (kg ha^{-1}) was recorded and presented in table no.2. The seed yield was found significantly maximum in treatment (T_8) RDF + Boron @ 2 gm kg^{-1} seed + Cobalt @ 1.5 gm kg^{-1} seed + Ammonium molybdate @ 1 gm kg^{-1} seed (2110 kg ha^{-1}). It was superior treatment amongst all. While it was found at par with treatment (T_7) RDF + Cobalt @ 1.5 gm kg^{-1} seed + Ammonium molybdate @ 1 gm kg^{-1} seed (2067 kg ha^{-1}), treatment (T_6) RDF + Boron @ 2 gm kg^{-1} seed + Cobalt @ 1.5 gm kg^{-1} seed (1992 kg ha^{-1}) and treatment (T_5) RDF + Ammonium molybdate @ 1 gm kg^{-1} seed (1914 kg ha^{-1}). Treatment (T_4) RDF + Cobalt @ 1.5 gm kg^{-1} seed (1772 kg ha^{-1}), treatment (T_3) RDF + Boron @ 2 gm kg^{-1} seed (1844 kg ha^{-1}) and treatment (T_2) RDF (1700 kg ha^{-1}) were significant over treatment (T_1) absolute control and at par with each other. However, significantly lowest grain yield (kg ha^{-1}) was observed in treatment (T_1) absolute control (1350 kg ha^{-1}).

The seed treatment of boron, cobalt and molybdenum with RDF was found to be beneficial for maintaining the fertility of soil as well as subsequently increasing the productivity potential of soybean which has been revealed by increasing the grain and straw yield. Boron plays an important role to transfer the nutrients from leaves to reproductive organs, increases pollination and seed development.

This results are in accordance with Rahman *et al.* (2014) who noted that seed treatment with Boron @ 2 gm kg^{-1} seed and Molybdenum @ 1 gm kg^{-1} seed along with RDF gives higher seed yield (1109.61 kg^{-1} ha) in seed production of chickpea.

Stover yield (kg ha$^{-1)}$

The data regarding the stover yield (kg ha^{-1}) of soybean interpreted in table no.2 significant variations were observed in the stover yield due to application of different treatments. Statistically significantstover yield was found in treatment (T_8) RDF + Boron @ 2 gm kg^{-1} seed + Cobalt @ 1.5 gm kg^{-1} seed + Ammonium molybdate@ 1 gm kg^{-1} seed (3102 kg ha^{-1}) which was found statistically at par with treatment T_7 (3061 kg ha^{-1}),T_6 (2929 kg ha^{-1}),T_5 (2814 kg ha^{-1}),T_4(2605), T_3(2711 kg),T_2(2500 kg ha^{-1}) were significant over treatment (T_1) absolute control. The lowest stover yield was found in treatment (T_1) absolute control (1951 kg ha^{-1}). Boron and molybdenum might have stimulated the process of photosynthesis and carbohydrate metabolites in source and later translocated to the newly formed sinks which ultimately increases the grain and straw yield.

This result confirms the findings of Dozet*et al.*(2016) who noted significantly highest seed yield (2.31 t ha^{-1}) and straw yield (3.05 t ha^{-1}) with an application of cobalt and molybdenum.

Table No. 2 Effect of seed treatment of boron, cobalt and molybdenum on Seed yield(kg ha^{-1}),Stover yield(kg ha^{-1})Test weight (g)Protein content (%)at harvest (cm) in soybean.

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Test weight (g)	Protein content (%)
T_1 : Absolute control	1350	1951	10.23	37.00
T_2 :RDF	1700	2500	12.36	39.00
T_3 :RDF+ Boron @ 2gm kg^{-1} seed	1844	2711	12.67	39.50
T_4 : RDF+ Cobalt @ 1.5gm kg^{-1} seed	1772	2605	12.43	39.50
T_5 :RDF + Ammonium molybdate@ 1gm kg^{-1} seed	1914	2814	13.00	40.00
T_6 : RDF+ Boron @ 2gm kg^{-1} seed+ Cobalt @ 1.5 gm kg^{-1} seed	1992	2929	13.60	40.00
T_7 :RDF+ Cobalt @ 1.5 gm kg^{-1} seed + Ammonium molybdate @ 1gm kg^{-1} seed	2067	3061	13.76	40.20
T_8 :RDF+ Boron @ 2 gm kg^{-1}seed + Cobalt @ 1.5 gmkg^{-1}seed + Ammonium molybdate @ 1 gm kg^{-1} seed	13.80	2110	3102	40.50
SE(m) ±	**0.65**	**72.26**	**71.68**	**0.40**
CD at 5%	**2.00**	**219.20**	**217.43**	**1.23**

Test weight (g)

The effect of seed treatment of boron, cobalt and molybdenum test weight of soybean was presented in table no.2. Significantly highest test weight was found in treatment (T_8) RDF + Boron @ 2 gm kg^{-1} seed + Cobalt @ 1.5 gm kg^{-1} seed + Ammonium molybdate@ 1 gm kg^{-1} seed (13.80 g) which was found at par with all other treatments except treatment (T_2) RDF (12.36 g) which was significant over treatment (T_1) absolute control. However, treatment (T_1) absolute control (10.23 g) recorded lowest test weight among all treatments. The increase in test weight of soybean might be due to their role as a micronutrient for plant growth. These elements contribute to improved plant development, leading to higher grain filling and consequently, increased test weight of soybean. Similar result were obtained by

Shirpurkar*et al.*(2005) who noted significant increase in test weight of soybean (13.70 g) with application of boron and molybdenum.

Protein content (%)

The effect of seed treatment of boron, cobalt and molybdenum on protein content in soybean is presented in table no.2. Significantly higher protein content was recorded in treatment (T_8) RDF + Boron @ 2 gm kg^{-1} seed + Cobalt @ 1.5 gm kg^{-1} seed+ Ammonium molybdate@1 gm kg^{-1} seed (40.50 %) which was found statistically at par with all the except treatment (T_2) RDF (39 %) which was superior over treatment (T_1) absolute control. However, treatment (T_1) absolute controlrecorded lowest protein content (37 %) among all the treatments. Protein content of seed is essentially a manifestation of N content. The increase in nitrogen content might be due to seed treatment of cobalt and molybdenum. Molybdenum stimulates nitrogen fixation in legumes and reduction of nitrate associated with the higher protein content.

Similar results in soybean grain protein (37.66 %) were obtained by Dozet*et al*. (2016) with application of nitrogen fertilization, cobalt and molybdenum. The best quality seed and protein production (690 kg ga^{-1}) were obtained with combined application of boron and cobalt by Stolyrov (2000).

Conclusion

It can be inferred and concluded that soybean performed the best with seed treatment (T_8) Boron @ 2 gm kg^{-1} seed + Cobalt @ 1.5 gm kg^{-1} seed + Ammonium molybdate @ 1 gm kg^{-1}seed kg^{1}seed with recommended dose of NPKS (30:60:30:20 kg ha-1) to soybean improved growth attributes, yield attributes and quality. So, seed treatment is an attractive and easy alternative in supplying themicronutrient requirement to crops in time.

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