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Effect of seaweed sap (*Kappaphycus alvarezii*) and micronutrients on growth and yield of moong bean (*Vigna radiata* L.)

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Abstract
The field experiment was conducted at Crop Research Farm (CRF), Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) during *Zaid* season 2023 on moong bean crop. The treatment consisted of 2 levels of Seaweed Sap (*Kappaphycus alvarezii*) (5% and 7.5%), and 4 levels soil application of micronutrients, Boron (1.5 and 3.0 kg/ha) and Molybdenum (0.75 and 1.5 kg/ha) and control. The experiment was lay out in Randomized Block Design (RBD) with 9 treatments and replicated thrice. Application of Seaweed sap (*Kappaphycus alvarezii*) 7.5% and Soil application of B 3.0 kg/ha produced growth parameters like higher plant height (43.35 cm), number of nodules/plant (31.89), number of branches/plant (6.14), plant dry weight (18.57 g) and yield attributes like maximum pods/plant (30.58), maximum seeds/pod (8.35), test weight (37.76 g), seed yield (1248.85 kg/ha) and Stover yield (2304.97 kg/ha).Treatment combination with Seaweed sap (*Kappaphycus alvarezii*) 7.5% and Soil application of B 3.0 kg/ha highest gross return (₹.122958/ha), net return (₹.82481/ha) and benefit cost ratio (2.04) when compared to other treatment.

Keywords: Boron, economics, growth, molybdenum, moong bean, seaweed sap, yield

Introduction
Moong bean (*Vigna radiata* L.) is the third most important pulse crop grown in India next only to gram and pigeon pea. It is a favorable pulse crop since it will thrive better in all seasons as sole and intercrop or fallow crop. In India, moong bean is cultivated in arid and semi-arid region. It is also called as Mung, Mungo or golden gram (Movalia *et al*., 2018) [7]. Pulses are an important source of energy and protein, essential amino acids, dietary fibres, minerals, and vitamins, and play a significant role in addressing global nutritional security. They positively impact soil properties, resource utilization, biological nitrogen fixation (BNF), N economy, and production sustainability. pulses positively impact dietary energy, soil and human health, and nutritional, environmental, and economic security (Kumar *et al*., 2023) [4]. India is the major producer of moong bean in the world accounts 65% of world acreage and 54% of the total production, during 2020-21, moong bean is grown in about 30.37 lakh ha with the total production of 2.64 million tonnes with a productivity of 888 kg/ha and contributing 10% to the total pulse production. Some of the states like Rajasthan (19.23 lakh/ha), Karnataka, (4.23 lakh/ha), Maharashtra (4.03 lakh/ha) Madhya Pradesh (2.10 lakh/ha), Odisha (1.69 lakh/ha), Telangana (0.73 lakh/ha) and Uttar Pradesh (0.30 lakh/ha) are the major producers of moong bean in India (MoA&FW, 2022) [6].
Seaweed sap is a rich source of many macro- as well as micronutrients and it contains plant growth regulators like cytokinin, gibberellin and auxin (Layek *et al*., 2018) [5]. Further improvement of crop growth and yield would be achieved by supplying the essential nutrients to the plants at critical growth phases from non-soil sources such as foliar spraying (Alshaal and El-Ramady, 2017) [1]. Seaweed sap is generally applied as foliar spray at critical growth stages of different crops along with chemical fertilizer (Pramanick *et al*., 2013) [10].
Micronutrients play an important role in increasing yield of pulses and oilseed legumes through their effects on the plant itself and on the nitrogen fixing symbiotic process (Movalia *et al*.,

2018) [7]. In plant metabolism, Boron is associated with activity of various enzymes, cell division, transportation of carbohydrate and uptake of calcium and potassium. The deficiency of boron in the soil deteriorates the soil quality as well as production of crops (Jana and Nayak, 2006) [2].

Molybdenum, being a constituent of nitrate reductase and nitrogenase enzymes, is associated with ammonia reduction and nitrogen fixation (Paricha *et al.*, 1983) [8]. Molybdenum oxyanion has strong adsorption binding, but the strength of this binding decreases as the pH of soil increases. Thus, molybdenum becomes deficient in lower pH and available at higher soil pH (Patra and Bhattacharya, 2009) [9].

2. Materials and Methods

This experiment was laid out during the *zaid* season of 2023 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The crop research farm is situated at 250 39" 42" N latitude, 810 67" 56" E longitude and at an altitude of 98 m above mean sea level. The experiment was laid out in Randomized Block Design and comprised of seaweed sap (*Kappaphycus alvarezii*) and micronutrients i.e Boron and Molybdenum with nine treatments and each was replicated thrice. The recommended dose of Nitrogen (20 kg/ha), Phosphorus (40 kg/ha) and Potassium (20 kg/ha) and seaweed sap, Boron and Molybdenum were applied as per the treatments. Data recorded on different aspects of crop, viz., growth, yield attributes were subjected to statistically analysis by analysis of variance method and economic data analysis mathematical method. (Gomez and Gomez, 1976) [11] and economic data analysis mathematical method.

Results and Discussion

Growth parameters

Plant dry weight

At 60 DAS, significantly and higher plant dry weight (18.57 g/ plant) was recorded in treatment 6 [Seaweed sap (*Kappaphycus alvarezii*) 7.5% + B 3.0 kg/ha]. However, treatment 8 [Seaweed sap (*Kappaphycus alvarezii*) 7.5% + Mo 1.5 kg/ha], were found to be statistically at par with treatment 6 [Seaweed sap (*Kappaphycus alvarezii*) 7.5% + B 3.0 kg/ha]. Significant and maximum plant dry weight was observed with the application of Boron @ 3.0 kg/ha due to increase in general, boron affects cell division, and nitrogen uptake from the soil may have accelerated plant growth as measured by plant dry weight. Similar results were also reported by Krishna *et al.*, (2022) [3].

Number of pods/plants

The significantly and maximum number of pods/plants (30.58) was recorded in treatment 6 [Seaweed sap (*Kappaphycus alvarezii*) 7.5% + B 3.0 kg/ha]. However, treatment 8 [Seaweed sap (*Kappaphycus alvarezii*) 7.5% + Mo 1.5 kg/ha], treatment 7 [Seaweed sap (*Kappaphycus alvarezii*) 7.5% + Mo 0.75 kg/ha], treatment 5 [Seaweed sap (*Kappaphycus alvarezii*) 7.5% + B 1.5 kg/ha] were found to be statistically at par with treatment 6 [Seaweed sap (*Kappaphycus alvarezii*) 7.5% + B 3.0 kg/ha]. Significant and maximum number of pods/ plants was observed with the application of Boron 3.0 kg/ha might be due to one of boron's beneficial effects may be its crucial function in plant metabolism and the creation of nucleic acids. Similar results were also reported by Krishna *et al.*, (2022) [3].

Test weight

At harvest, highest test weight (37.76 g) was recorded in treatment 6 [Seaweed sap (*Kappaphycus alvarezii*) 7.5% + B 3.0 kg/ha], through there was no significant difference among the treatment. Significant and maximum test weight was observed with the application of Boron @ 3.0 kg/ha might be due to increase in this characteristic by foliar spray may be attributed to the sprayed boron's role in early stages of starch utilization, chlorophyll production, enzyme activation, membrane integrity, and stomatal balancing, which led to a rise in assimilate accumulation and heavier grains. Similar results were also reported by Krishna *et al.*, (2022) [3].

Seed yield (kg/ha)

The significantly and maximum seed yield (1248.85 kg/ha) was recorded in treatment 6 [Seaweed sap (*Kappaphycus alvarezii*) 7.5% + B 3.0 kg/ha]. However, treatment 5 [Seaweed sap (*Kappaphycus alvarezii*) 7.5% + B 1.5 kg/ha] were found to be statistically at par with treatment 6 [Seaweed sap (*Kappaphycus alvarezii*) 7.5% + B 3.0 kg/ha]. Significant and maximum seed yield was observed with the application of Boron @ 3.0 kg/ha might be due to because boron is involved in many physiological processes of plants, including chlorophyll production, stomatal control, and starch utilization, which improve seed yield, it is essential for boosting seed yield. In addition to being essential for many physiological processes and plant growth, nutrition is also important for boosting Working with different crops other researchers have also reported increased yield of different crops reported by (Patra and Bhattacharya, 2009) [9].

B:C Ratio

B:C ratio of growing moong bean as influenced by seaweed sap spray (*Kappaphycus alvarezii*) and micronutrients has been exhibited. Highest Benefit cost ratio (2.04) was recorded in treatment 6 [Seaweed sap (*Kappaphycus alvarezii*) 7.5% + B 3.0 kg/ha] as compared to other treatments.

Table 1: Effect of seaweed sap and micronutrients on growth, yield attributes and yield of moong bean

Treatment combinations	Plant dry weight (60DAS)	No. of pods /plant	Test weight (g)	Seed yield (kg/ha)	B:C ratio
Seaweed sap (*Kappaphycus alvarezii*) 5% + B 1.5 kg/ha	13.18	25.62	34.18	994.99	1.35
Seaweed sap (*Kappaphycus alvarezii*) 5% + B 3.0 kg/ha	13.71	26.20	34.98	1012.11	1.27
Seaweed sap (*Kappaphycus alvarezii*) 5% + Mo 0.75 kg/ha	13.08	25.97	33.78	994.77	1.23
Seaweed sap (*Kappaphycus alvarezii*) 5% + Mo 1.5kg/ha	13.27	26.41	34.59	931.80	1.38
Seaweed sap (*Kappaphycus alvarezii*) 7.5%+ B 1.5 kg/ha	16.13	28.30	37.47	1174.81	1.44
Seaweed sap (*Kappaphycus alvarezii*) 7.5% + B 3.0 kg/ha	18.57	30.58	37.76	1248.85	1.30
Seaweed sap (*Kappaphycus alvarezii*) 7.5% + Mo 0.75 kg/ha	16.05	27.67	36.32	1018.27	1.67
Seaweed sap (*Kappaphycus alvarezii*) 7.5% + Mo 1.5 kg/ha	16.28	28.81	37.67	1004.14	1.90
N-P- K: 20-40-20 kg/ha (Control)	11.07	23.16	33.29	883.72	1.62
F- Test	S	S	NS	S	-
S.Em(±)	0.79	1.33	1.88	48.50	-
CD (p=0.05)	2.36	3.99	-	145.41	-

Conclusion

Based on the above findings it can be concluded that application of 3.0 kg/ha B along with 7.5% seaweed sap (*Kappaphycus alvarezii*) treatment combination of 6 recorded highest plant height, dry weight, no. of pods/plant, test weight, seed yield and benefit cost ratio in moong bean.

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