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Research Article

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH, YIELD AND ECONOMICS OF BLACK GRAM (*Vigna mungo*) UNDER RAINFED CONDITION

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Abstract: A field experiment was conducted at Jabalpur to evaluate the effect of recommended dose of fertilizer (RDF) alone and in combination with two types of seaweed sap (K-sap from *Kappaphycus* and G-sap from *Gracilaria* sp.) on growth, yield and economics of black gram in sandy clay loam soil of Kymore plateau. The foliar spray of K-sap and G-sap at 2.5, 5.0, 7.5 and 10.0% v/v with 100% RDF and6.25% of K saps with 50% RDF were performed twice (at 20 and 50 Days after sowing). Results revealed that application of K-sap or G-sap at different concentrations along with RDF significantly enhanced the plant growth parameters and yield attributes. The highest grain and stover yield were recorded under application K-sap at 10.0% along with 100% RDF which gave 30.26 and 27.04% more grain and stover yield, respectively over control (water spray with 100% RDF). The gross monetary return and net monetary return were also maximum (Rs. 60928 ha^{-1} and Rs. 32629 ha^{-1}) under the 10.0% K-sap with 100% RDF followed by 7.5% K-sap with 100% RDF (Rs. 59915 ha^{-1} and Rs. 32450 ha^{-1}). The maximum B: C ratio (2.18) was evidenced under the application of 7.5% K-sap with 100% RDF and it was found more remunerative and profitable over the control.

Keywords: *Kappaphycus, Seaweed sap, Growth and yield improvement, Black gram*

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Introduction

The pulse 'Black gram' plays an important role in Indian diet, as it contains 20 to 25% of vegetable protein, 40 to 47% of starch along with ash, fats, carbohydrates and essential vitamins as well as supplement to cereal-based diet. Thus, it is cheaper source to overcome protein malnutrition among human beings. India is the largest producer and consumer of pulse in the world. About 70% of world's black gram production comes from India. In India, black gram occupies 5.4 million hectares area and contributes 5.6 million tonne production with an average productivity of 654 kg/ha [1]. However, there are numerous factors to affect the productivity of black gram in our country. In order to achieve the nutritional security, intensive agricultural practices need more fertilizers for higher yield. This affects soil and plants in due course and posing a greater threat to the sustainable agriculture. Hence, there is an urgent need to application of fertilizers in conjunction with the organic measures in a precise way.

Seaweeds are marine algae and comprise one of the commercially important marine renewable resources. Seaweed extracts are marketed as liquid fertilizers and bio-stimulants since they contain amino acids, vitamins, growth promoting substances like cytokinins, auxin, gibberellins and abscisic acid [2], macronutrients such as Ca, K and P and micronutrients like Fe, Cu, Zn, B, Mn, Co and Mo [3]. These extracts stimulate the growth and yield of plants, develop tolerance to environmental stress, increase nutrient uptake from soil and enhance antioxidant properties, finally enhance the yield potential of crop plants (pulses, cereals, vegetables, flowers, and fruits) without impairing the soil health [4,5]. Therefore, use of seaweeds as fertilizers has allowed for substitution in place of conventional synthetic fertilizer, especially in rainfed crop. Integrate nutrient management plays a key role in increasing the productivity of crops and sustained management of soil fertility.

Some studies also revealed that seaweed saps are successful in enhancing productivity of crops when applied along with chemical fertilizer or organic manure [6]. So far there is no report on integrated use of seaweed sap application along with chemical fertilizer on black gram under rainfed condition for kymore plateau Satpura Hills of India. Keeping above facts in view, the present investigation is undertaken to study the "Effect of integrated nutrient management on growth, yield and economic of black gram under rainfed condition.

Materials and Methods

The field experiment was conducted during the *kharif* season of 2012 at Product testing Unit Agronomy, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, and Madhya Pradesh, India. The soil of the site was sandy clay loam with pH 7.17, electrical conductivity 0.31 ds/m, organic carbon 0.63%, available nitrogen 283 kg ha^{-1}, available P_2O_5 17.6 kg ha^{-1} and available K_2O 301 kg ha^{-1}. The climate of the region is characterized as typically sub-humid and tropical. The experimental site is located at 23°11' North latitude, 79°58' East longitude and altitude is 411.78 m above mean sea level. The experiment comprised ten treatments (*viz*., T1 - 2.5% K-sap + 100% RDF (Recommended dose of chemical fertilizers - 20 kg N, 50 kg P_2O_5, 20 kg K_2O ha^{-1}), T2- 5.0 % K-sap + 100% RDF, T3 - 7.5% K-sap + 100% RDF, T4 - 10.0% K-sap + 100% RDF, T5 - 2.5% G-sap + 100% RDF, T6 - 5.0% G-sap + 100% RDF, T7 - 7.5% G-sap + 100% RDF, T8 - 10.0% G-sap + 100% RDF, T9 – water spray + 100% RDF, T10 - 6.25% K-sap + 50% RDF) were tested in a randomized block design with three replication. Black gram variety LBG-20 was sown on 17th July 2012 and harvested on 11th October 2012. The twice foliar application of K-sap of *Kappaphycus alvarezii* and G-sap of *Gracilaria edulis* with total spray volume of 550 l ha^{-1} were made in each application at 25 and 50 days after sowing (DAS).

Table-1 *Effect of integrated nutrient management on growth, yield attributes and yields of black gram*

Treatments	Plant height (cm)	Number of branches plant^{-1}	Leaf area index	Chlorophyll index (g m^{-2})	Pods plant^{-1}	Grains pod^{-1}	Seed Yield (q ha^{-1})	Stover yield (q ha^{-1})
T1	28.39	2.73	4.16	43.61	18.45	5.73	12.07	46.30
T2	29.03	2.80	4.54	44.34	20.56	6.27	13.12	47.41
T3	32.18	3.33	5.26	49.05	23.20	6.87	14.48	50.20
T4	33.69	3.43	5.65	50.20	24.09	7.00	14.72	51.54
T5	28.15	2.73	4.02	40.65	18.90	5.60	11.99	43.02
T6	28.60	2.80	4.42	44.12	19.92	6.00	12.84	45.57
T7	31.59	2.93	4.74	47.65	20.50	6.73	13.38	47.55
T8	32.10	3.13	5.15	47.82	21.32	6.80	13.42	48.29
T9	26.19	2.53	3.51	38.46	17.32	5.33	11.30	40.57
T10	27.35	2.67	3.75	40.55	18.29	5.40	11.96	41.58
Sem+=	0.51	0.08	0.15	0.44	0.48	0.11	0.39	0.50
CD at 5%	1.53	0.24	0.45	1.32	1.42	0.33	1.17	1.49

[T1 - 2.5% K-sap + 100% RDF, T2- 5.0 % K-sap + 100% RDF, T3 - 7.5% K-sap + 100% RDF, T4 - 10.0% K-sap + 100% RDF, T5 - 2.5% G-sap + 100% RDF, T6 - 5.0% G-sap + 100% RDF, T7 - 7.5% G-sap + 100% RDF, T8 - 10.0% G-sap + 100% RDF, T9 – water spray + 100% RDF, T10 - 6.25% K-sap + 50% RDF]

Table-2 Effect of integrated nutrient management on economics of black gram

Treatments	Gross monetary returns (Rs ha^{-1})	Total cost of cultivation (Rs ha^{-1})	Net monetary returns (Rs ha^{-1})	B: C Ratio
T1	50119	25798	24321	1.94
T2	54376	26632	27744	2.04
T3	59915	27465	32450	2.18
T4	60928	28299	32629	2.15
T5	49694	25798	23896	1.93
T6	53170	26632	26538	2.00
T7	55435	27465	27970	2.02
T8	55612	28299	27313	1.97
T9	46809	24965	21844	1.87
T10	49425	26203	23222	1.89

[T1 - 2.5% K-sap + 100% RDF, T2- 5.0 % K-sap + 100% RDF, T3 - 7.5% K-sap + 100% RDF, T4 - 10.0% K-sap + 100% RDF, T5 - 2.5% G-sap + 100% RDF, T6 - 5.0% G-sap + 100% RDF, T7 - 7.5% G-sap + 100% RDF, T8 - 10.0% G-sap + 100% RDF, T9 – water spray + 100% RDF, T10 - 6.25% K-sap + 50% RDF]

The recommended dose of fertilizer (RDF) for black gram was 20, 50, 20 kg N, P_2O_5, K_2O ha^{-1}, respectively and all fertilizers were applied as basal.

The observations on Plant height (cm), Number of branches plant-1, leaf area index (LAI) and Chlorophyll concentration (g m^{-2}) were made at 45 DAS through random sampling. LAI was calculated by the ratio of leaf area to the area of ground cover [7]. The chlorophyll concentration (g m^{-2}) of leaves was determined by chlorophyll content metre.

Cost of cultivation for each treatment was calculated by taking in prevailing price of inputs. Similarly, gross monetary returns (GMR) were computed on the basis of existing market price of the produce (both grain and stover) as the gross monetary returns per hectare under different treatments. The net monetary returns per hectare under each treatment were found out by deducting the cost of cultivation of a particular treatment from the gross monetary return of that same treatment. Benefit cost ratio was computed by ratio of Gross monetary return (Rs/ha) to Cost of cultivation (Rs/ha). The prevailing market price of black gram seed and stover was Rs. 4000 and 40 quintle-1, respectively. Common cost of cultivation was Rs. 22375 ha^{-1}. Rate of *Kappaphycus* or *Gracilaria* sap and 100% RDF were Rs. 30 L-1 and Rs. 1990, respectively. Data obtained on various observations were tabulated and then subjected to using analysis of variance (ANOVA) following randomized block design [8]. Differences were considered significant at 5% level of probability.

Results and Discussion

Effect on growth parameters of black gram

Foliar application of both seaweed saps along with RDF exhibited an enhanced effect on plant growth parameters (*viz*., plant height, branches plant-1, leaf area index and chlorophyll index) in comparison to water spray with 100% RDF [Table-1]. In general, gradual increase in growth parameters were observed with increasing the concentration of seaweed saps. Data recorded at 45 DAS shown that the application of 10.0% K-sap with 100% RDF registered appreciably taller plant (33.69cm), a greater number of branches plant-1 (3.43), maximum value of leaf area index (5.65) and more chlorophyll content (50.20 g m^{-2}) over the rest of all treatments except 7.5% K-sap with 100% RDF. However, the difference in growth attributes between 7.5 and 10% K-sap or G-sap with 100% RDF as well as between 6.25% K-sap with 50% RDF and water spray with 100% RDF were not marked. This increase in all growth parameter with higher concentration of saps applied might be due to more availability of plant nutrient and growth promoting hormones (*viz*., Auxins, Cytokinins, Gibberellins), which ultimately resulted in the higher values of the growth parameters [9,10]. Increased chlorophyll content might be due to the presence of high amount of Mg [11].

Effect on yield attributes and yields of black gram

The yield contributing parameters (pods plant-1 and grains pod-1) were maximum under the application of 10.0% K-sap with 100%RDF [Table-1]. However, these yield attributes were significantly higher under 10% K-sap or G-sap with 100% RDF over rest of treatment but statistically similar to 7.5% K-sap or G-sap with 100% RDF. The probable reason of this increase might be ascribed to greater accumulation of carbohydrates, protein and their translocation to the reproductive organs which in turn, maximized the yield parameters [12,13].

Among all the treatments, 10% K-sap with 100% RDF produced significantly higher number pods plant-1 (24.12) and grains pod-1 (7.00) as well as grain and stover yield (14.30 q ha^{-1} and 44.69q ha^{-1}, respectively). However, it was statistically similar to application of 7.5% K-sap with 100% RDF. Increase in the yields under these treatments could be owing to enhancement of yield components. This is in conformity with result obtained for Phaseolus aureus [13], Phaseolus radiata [14,15] and Phaseolus mungo [16]. Another studies suggested that the presence of micro- elements and plant growth regulators, especially cytokinins in *Kappaphycus* and *Gracilaria* extracts could be the reason for this yield enhancement [17,18].

Economic analysis

The economic assessment (*viz*., cost of cultivation, gross monetary return, net monetary return and benefit cost ratio) is essential to evaluate the effect of particular treatment for its practical utility to the growers. The data [Table-2] revealed that the maximum cost of cultivation (Rs. 28229 ha^{-1}) noticed under the application of 10.0% K-sap or G-sap with 100% RDF was attributed to higher dose of K-sap or G-sap, while the application of water spray with 100% RDF needed minimum investment of Rs. 24965 ha^{-1} due to no inclusion of cost of seaweed sap.

Among the different treatments, the gross monetary return and net monetary return were maximum (Rs. 60928 ha^{-1} and Rs. 32629 ha^{-1}) under the 10.0% K-sap with 100% RDF followed by 7.5% K-sap with 100% RDF (Rs. 59915 ha^{-1} and Rs. 32450 ha^{-1}). However, these were remarkably minimum (Rs. 46809 ha^{-1} and Rs. 21844 ha^{-1}) under the water spray with 100% RDF. These variations in the gross monetary return and net monetary return were owing to difference in grain and stover yields of crop. As regard the B: C ratio, it was observed maximum (2.18) under the application of 7.5% K-sap with 100% RDF. This was due to more reduction in cost of seaweed sap under this as compared to the highest concentration (10.0%) of K-sap with 100% RDF but it was statically similar to that of treatment in terms of yield. Hence, application of 7.5% K-sap with 100% RDF was found more remunerative over 100% RDF only.

Conclusion

This study concluded that use of eco-friendly seaweed liquid extracts with RDF are effective to attaining better growth and yield of black gram over conventional method. The practice of twice foliar application of 7.5% of K-sap at 25 and 50 DAS with 100% RDF may be recommended to earn more profit from a unit area, time and investment of black gram cultivation under rainfed condition.

Application of research: Integrated use of seaweed sap with RDF is efficient nutrient management practice for farmers to get sustainable crop production under rainfed condition.

Research Category: Integrated nutrient management

Abbreviations: RDF: Recommended dose of fertilizer
DAS: Days after sowing
LAI: leaf area index
GMR: Gross monetary returns
NMR: Net monetary returns
B:C ratio: Benefit cost ratio

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Cultivar / Variety / Breed name: Black gram (*Vigna mungo*)

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
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