Effect of seaweed extracts on the growth, yield and nutrient uptake of black gram (Vigna mungo L.) in the red and lateritic belt of West Bengal

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Abstract
A field experiment was conducted at the Agricultural farm of Visva-Bharati University, Birbhum, West Bengal during Pre-kharif (Summar) season of 2012, to study the effect of foliar spray of seaweed extracts (prepared from Kappaphycus alvarezii & Gracilaria crassa) on the growth and productivity of black gram. The foliar spray was applied thrice at different concentrations (0, 5.0, 7.5, 10.0 and 15.0% v/v) of seaweed extracts. Foliar applications of seaweed extracts significantly enhanced the growth and yield attributes. The highest grain yield was recorded with applications of 15% Kappaphycus + recommended dose of fertilizer which at par with 15% Gracilaria extracts + RDF resulting in an enhanced by 51 and 44% grain yield, respectively compared to the water applied plots. The highest straw yield was also achieved with the application of 15% seaweed extracts. The nutrient uptake (N, P and K) which influenced due to the application was also with seaweed extract.

Keywords: Seaweed extracts, Kappaphycus (K), Gracilaria (G), recommended dose of fertilizer, black gram

Introduction
Seaweeds are one of the important marine living resources which are renewable. Several species of green, brown and red algae are used as manure in coastal areas throughout the world. They are rich in potassium but poor in nitrogen and phosphorus. Seaweed concentrates are beneficial effects on plants as they contain growth promoting hormones (IAA, IBA and Cytokinins) and different trace elements, vitamins and amino acids (Khan et al. 2009) [4]. A wide range of beneficial effects have been reported from the use of liquid seaweed extracts, including increased crop yields, increased uptake of inorganic constituents from the soil, more resistance to stress conditions. Seaweed species were reported to be potential sources of fertilizer. Integrated use of sea weed liquid fertilizer in combination with the chemical fertilizer and their proper management for better growth and yield is very essential. Keeping, these facts in perspective, the present investigation were taken up. Sea weeds are marine algae, saltwater dwelling, and simple organisms that fall into the rather. A positive effect of several species of algae on the growth, development and, consequently yields of field crops have been proved so far. Seaweed liquid extract could serve as an alternative bio-fertilizer as is eco-friendly, and substantial economic with environmental benefits. So the main objective of this study is to evaluate the application of different concentrations of seaweed extracts in enhancing the growth, yield and nutrient uptake of black gram (Vigna mungo L.) grown in fields, in the red lateritic belt.

Materials and methods
A field experiment was conducted during pre-kharif season of 2012 at the agricultural farm, Palli Siksha Bhavana, Visva-Bharati, Sriniketan, Birbhum, West Bengal. The farm is situated at 23°39’ N latitude and 87°42’ E longitude with an average altitude of 58.90 m above mean sea level (MSL) under sub-humid, semi arid region of West Bengal. The soil of the experimental site was sandy loam in texture with pH 5.76, organic carbon 0.39%, available nitrogen 146.20 kg/ha, available phosphorus 31.1 kg/ha and available potassium 139.1 kg/ha.
The experiment comprised of 13 treatments and the treatments were distributed in randomized block design with three replications. The details of the treatments are: T1 - 100% RDF + Water, T2 - 5% K + 100% RDF, T3 - 7.5% K + 100% RDF, T4 - 10% K + 100% RDF, T5 - 15% K + 100% RDF, T6 - 5% G + 100% RDF, T7 - 7.5% G + 100% RDF, T8 - 10% G + 100% RDF, T9 - 15% G + 100% RDF, T10 - 7.5% K + 75% RDF, T11 - 7.5% G + 75% RDF, T12 - 7.5% K + 50% RDF and T13 - 7.5% G + 50% RDF (K = Kappaphycus, G = Gracilaria and RDF = Recommended Dose of Fertilizer). Three sprays of Kappaphycus and Gracilaria extract were applied one at the seedling stage [20 days after sowing (DAS)] second at the pre-flowering stage (40 DAS) and third at the pod development stage (60 DAS). The recommended dose of fertilizer (RDF) for black gram @ 20:40:40 kg ha\(^{-1}\) N, P\(_2\)O\(_5\) and K\(_2\)O, were applied as basal. Data of plant samples were taken through random sampling at 40 DAS and 60 DAS to measure plant height, dry matter accumulation, crop growth rate (CGR) and leaf area index (LAI). Data on yield attributes were taken randomly before harvesting. At maturity, black gram seeds and stick samples were collected from each plot, oven dried at 70°C to constant weight and ground to pass through a 0.5 mm sieve for chemical analysis. Data were analyzed using analysis of variance (ANOVA) following randomized block design (Gomez and Gomez, 1984). Differences were considered significant at 5% level of probability.

**Result and discussion**

**Growth attribute**

| Treatment          | Plant height (c.m) | Dry matter accumulation (g m\(^{-2}\)) | Crop growth rate (CGR (g m\(^{-2}\) day\(^{-1}\)) | Leaf area index (LAI) |
|--------------------|--------------------|----------------------------------------|-----------------------------------------------|----------------------|
|                    | 20DAS 40DAS 60DAS | 20DAS 40DAS 60DAS                      | 20-40DAS 40-60DAS                              | 20DAS 40DAS 60DAS    |
| T1                 | 14.3 36.5 44.8    | 21.1 143.5 316.4                       | 6.12 8.65                                    | 0.89 2.85 3.22      |
| T2                 | 14.4 38.9 46.2    | 21.1 150.3 331.3                       | 6.46 9.05                                    | 0.86 3.07 3.38      |
| T3                 | 14.3 40.6 46.9    | 20.9 156.3 340.5                       | 6.77 9.21                                    | 0.88 3.14 3.52      |
| T4                 | 14.2 44.3 49.1    | 21.2 173.6 361.7                       | 7.62 9.40                                    | 0.84 3.60 3.76      |
| T5                 | 14.2 46.0 52.9    | 21.1 191.8 391.7                       | 8.53 9.99                                    | 0.86 3.86 4.04      |
| T6                 | 14.6 38.3 45.5    | 21.2 146.3 321.9                       | 6.26 8.78                                    | 0.79 3.05 3.34      |
| T7                 | 14.2 40.3 47.2    | 20.9 154.2 334.7                       | 6.67 8.86                                    | 0.82 3.12 3.47      |
| T8                 | 14.3 43.1 49.1    | 20.8 172.2 355.1                       | 7.57 9.15                                    | 0.91 3.58 3.60      |
| T9                 | 14.4 45.2 50.8    | 21.1 185.7 379.1                       | 8.23 9.67                                    | 0.81 3.74 3.92      |
| T10                | 14.1 39.1 46.7    | 20.5 155.6 337.7                       | 6.66 9.21                                    | 0.76 3.12 3.43      |
| T11                | 14.1 38.7 46.4    | 20.4 152.2 334.3                       | 6.59 9.11                                    | 0.71 3.04 3.38      |
| T12                | 13.5 38.0 45.5    | 20.5 145.4 327.2                       | 6.26 9.09                                    | 0.67 3.01 3.29      |
| T13                | 13.63 37.87 45.13 | 20.27 144.49 322.18                     | 6.21 8.88                                    | 0.64 2.93 3.25      |
| SE.m (±)           | 0.44 1.82 1.63    | 0.53 6.57 14.28                       | 0.28 0.23                                    | 0.03 0.13 0.16      |
| CD at 5%           | 5.3 4.76         | N.S 19.18 41.7                        | 0.83 0.67                                    | 0.1 0.38 0.47       |

DAS= Days After Sowing, CGR=Crop Growth Rate, LAI=Leaf Area Index.

**Yield attributes and Yields**

The use of seaweed extract increased all the yield attributes measured for black gram (Table 2). The maximum numbers of branches per plant, pods per plant, seeds/pod and test weight were observed under the treatment T13 (folicar application of 15% Kappaphycus extract along with 100% RDF) which was closely followed by 15% Gracilaria extract + 100% RDF (T6), T4 (10% Kappaphycus extract +100% RDF), T8 (10% Gracilaria extract + 100% RDF). The maximum increase in seed yield over water to the extent of 51% and this treatment was followed by the treatments T9 (15%Gracilaria extract + 100% RDF), T1 (10% Kappaphycus extract +100% RDF), T8 (10% Gracilaria extract + 100% RDF), T5 (7.5% Kappaphycus extract + 100% RDF) and T1 (7.5%Gracilaria extract +100%RDF) recording 44.03, 39.79, 32.84, 28.87 and 25.03 % yield increase, respectively over water applied plots. Strover yield was observed highest at T3 (15% Kappaphycus + 100% RDF) which was Statistically at par with T9 (15% Gracilaria extract + 100% RDF). High value of LAI was recorded with T5 (15% Kappaphycus extract + 100% RDF) for all the observations. Higher growth attributes of black gram occurred probably due to, presence of growth promoting hormones (IAA and IBA, Cytokinins) trace elements (Fe, Cu, Zn, Co, Mo, Mn, and Ni), vitamins and amino acids (Ferreira and Lourens, 2002) [2]. Similar results were reported on soybean (Rathore et al., 2009) [9], cowpea (Lakshmi and Sundaramoorthy, 2010) [3], green gram (Pramanick et al, 2012) [8] and sesame (Shankar et al., 2015) [10].

Foliar application of different sea weed liquid fertilizer along with 100% RDF increased growth attributes of black gram significantly over water applied plot (Table 1). In general, a gradual increase in plant growth attributes was observed with increasing seaweed extract application. The result of the experiment indicated that plant height and dry matter accumulation of Black gram at 20 DAS had no significant effect while 40 DAS and 60 DAS were significantly influenced by the different levels. Because first spraying should be done at 20 DAS. The increasing trend in plant height, dry matter accumulation, crop growth rate (CGR) and leaf area index (LAI) was noticed with the advancement levels of growth of the crop up to 60 DAS. Maximum plant height and dry matter accumulation was recorded with 15% Kappaphycus extract + 100% RDF (T5) and was statistically at par with 15% Gracilaria extract + 100% RDF (T6) treated plot regarding all the observations taken at different DAS. In case of CGR during 20-40 DAS and 40-60 DAS, the best result was recorded with the treatment T5 (15% Kappaphycus + 100% RDF) which was closely followed by T9 (15% Gracilaria extract + 100% RDF).
amino acids. Similar kind of results were reported on (Bai et al., 2008; Pramanick et al., 2012 and Shankar et al., 2015)\(^2\). are reported with the foliar application of seaweed extract.

Table 2: Effect of treatments on yield components, seed and stover yield of green gram.

| Treatment | No of branches plant\(^1\) | No of pods plant\(^1\) | No of seed pod\(^1\) | Test weight (g) | Seed yield (kg ha\(^{-1}\)) | Stover yield (kg ha\(^{-1}\)) | Harvest index (%) |
|-----------|-----------------------------|------------------------|---------------------|----------------|--------------------------|-----------------------|-----------------|
| T\(_1\)   | 6.01                        | 21.40                  | 5.65                | 32.93          | 1148                     | 3478                  | 22.39           |
| T\(_2\)   | 6.86                        | 26.64                  | 6.31                | 34.43          | 1297                     | 3642                  | 25.03           |
| T\(_3\)   | 7.17                        | 33.92                  | 6.66                | 36.67          | 1481                     | 4092                  | 26.60           |
| T\(_4\)   | 7.84                        | 37.61                  | 6.81                | 36.87          | 1607                     | 4717                  | 25.75           |
| T\(_5\)   | 8.17                        | 52.34                  | 7.15                | 36.97          | 1733                     | 5016                  | 27.68           |
| T\(_6\)   | 8.65                        | 25.68                  | 6.18                | 34.47          | 1263                     | 3642                  | 26.03           |
| T\(_7\)   | 7.02                        | 31.60                  | 6.51                | 36.54          | 1435                     | 3919                  | 26.19           |
| T\(_8\)   | 7.34                        | 33.74                  | 6.71                | 36.74          | 1525                     | 4297                  | 27.29           |
| T\(_9\)   | 8.01                        | 47.10                  | 6.96                | 36.92          | 1653                     | 4464                  | 27.94           |
| T\(_10\)  | 7.01                        | 30.97                  | 6.40                | 35.24          | 1401                     | 3990                  | 26.00           |
| T\(_11\)  | 7.00                        | 28.71                  | 6.33                | 35.11          | 1343                     | 3863                  | 23.97           |
| T\(_12\)  | 6.83                        | 24.14                  | 5.91                | 33.97          | 1251                     | 3618                  | 24.14           |
| T\(_13\)  | 6.34                        | 23.45                  | 5.70                | 33.50          | 1228                     | 3564                  | 23.30           |
| SE.m(±)   | 0.29                        | 1.20                   | 0.24                | 0.89           | 59.91                    | 494.78                | 0.91            |
| CD at 5%  | 0.85                        | 3.51                   | 0.71                | 2.60           | 174.89                   | 7.30                  | 2.65            |

Nutrients content and uptake

The use of the seaweed extracts significantly increased N, P and K uptake by grains at higher concentrations (10% and above) and reached maximum at 15% seaweed extract compared with control (Table 3). The highest N and K uptake by grain was recorded with the treatment T\(_3\) (15% *Kappaphycus* extract + RDF) which was statistically at par with 15% *Gracilaria* extract + RDF (T\(_5\)), 10% *Kappaphycus* extract + RDF (T\(_4\)) and 10% *Gracilaria* extract + RDF (T\(_6\)). 15% *Kappaphycus* extract + RDF showed the maximum uptake of P by grain. In case of nutrient uptake by stover, 15% *Kappaphycus* extract + RDF was observed to be the best and it was closely followed by 15% *Gracilaria* extract + RDF and 10% *Kappaphycus* extract + RDF. Our results confirm those findings previously reported by Pramanick et al. (2012)\(^8\) in green gram noted an increased uptake of magnesium (mg), K and calcium (Ca) in lettuce with seaweed concentrate application. Mancuso et al. (2006)\(^6\) and Zodape et al. (2009)\(^1\) also observed.

Table 3: Effect of treatments on nutrient uptake by seed and stover of black gram.

| Treatment | Nutrient uptake by seed (kg ha\(^{-1}\)) | Nutrient uptake by stover (kg ha\(^{-1}\)) |
|-----------|----------------------------------------|-------------------------------------------|
|           | N | P | K | N | P | K |
| T\(_1\)   | 44.0 | 1.5 | 8.4 | 44.9 | 3.5 | 31.7 |
| T\(_2\)   | 33.0 | 2.1 | 10.6 | 52.8 | 4.7 | 39.0 |
| T\(_3\)   | 61.4 | 2.7 | 12.4 | 60.2 | 6.6 | 44.6 |
| T\(_4\)   | 67.0 | 3.1 | 14.3 | 70.3 | 8.0 | 52.4 |
| T\(_5\)   | 72.9 | 4.0 | 16.1 | 79.3 | 10.0 | 59.7 |
| T\(_6\)   | 51.2 | 2.0 | 10.0 | 49.2 | 5.1 | 38.2 |
| T\(_7\)   | 58.9 | 2.4 | 11.6 | 54.5 | 5.9 | 41.6 |
| T\(_8\)   | 63.3 | 3.2 | 13.3 | 62.7 | 7.3 | 48.6 |
| T\(_9\)   | 69.1 | 3.3 | 15.0 | 68.7 | 8.0 | 51.3 |
| T\(_10\)  | 54.4 | 2.7 | 11.1 | 57.1 | 6.0 | 41.9 |
| T\(_11\)  | 52.3 | 2.3 | 10.5 | 54.5 | 5.4 | 39.4 |
| T\(_12\)  | 48.5 | 2.0 | 9.4 | 49.6 | 4.7 | 35.5 |
| T\(_13\)  | 47.4 | 1.8 | 9.3 | 47.0 | 4.6 | 33.8 |
| SE.m(±)   | 2.31 | 0.11 | 0.46 | 2.85 | 0.28 | 1.82 |
| CD at 5%  | 6.75 | 0.31 | 1.35 | 8.32 | 0.83 | 5.31 |

Conclusion

Thus, it can be concluded that the seaweed extracts are effective in increasing the growth attributes, yield attributes and yield of black gram. The extracts also enhance nutrient content and uptake by this grain crop. Presence of microelements and plant growth regulators, especially cytokinins in *Kappaphycus* and *Gracilaria* extracts is responsible for the increased growth, yield and quality of black gram receiving by the foliar application of the different extracts.

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