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Enhanced yield and nutritional quality in green gram (*Phaseolus radiata* L) treated with seaweed (*Kappaphycus alvarezii*) extract

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This study presents foliar application effect of *Kappaphycus alvarezii* (5-15%) extract on yield and seed quality of green gram at flowering stage. Application of *K. alvarezii* (conc. 10.0%) significantly increased seed yield (30.11%) compared to control, due to increase in yield of pods, weight of pods as well as seed yield per plant and 100 seed weight. This treatment also improved nutritional quality of seed as follows: protein, 19.43; carbohydrate, 5.17; P, 3.61; and Mo, 52.63%.

Keywords: Green gram, Hormones, Liquid seaweed extract, Nutritional quality, Yield

Introduction

Organic farming is proving as a remedy to cure ills of modern chemical agriculture[1]. Organic fertilizers have contributed for deposition of residues, improving physical and chemical properties of soil[2]. Organic matter improves physical properties of soil[3,4] (porosity, structure and water-holding capacity). Therefore, application of organic fertilizer has received great attention[5]. Nutrient management through organic resources is very much essential for various crops[6]. Among organic sources as supplemental fertilizer, seaweed extract has been used[7]. More than 15 million tonnes (MT) of seaweed products are used annually as nutrient supplements and biostimulants in agriculture and horticultural crop production[8]. Application of seaweed extracts enhances seed germination and seedling vigour[9-11]. Commercial extracts of *Ascophyllum nodosum* improved root and shoot growth of *Arabidopsis thaliana*[12]. Seaweed extracts have increased crop yield, delay of fruit senescence, improved overall plant vigour, improved yield quantity and quality, and improve ability to withstand adverse environmental conditions[13]. Seaweed extract as organic biostimulant has proved beneficial in horticulture[14]. Significant increase in crop yield due to foliar application of seaweed extracts has been reported[15-18]. Seaweed (*Kappaphycus alvarezii*) extract has been found rich in nutrients including plant growth regulators[16] (IAA, kinetin, zeatine and gibberellins). Seaweeds contain plant growth regulators[19-22] (auxins and cytokinins), which showed positive responses in different crops[23]. Green gram or mung bean (*Vigna radiata* L.) is the third most food legumes grown and consumed in India3[24] and is a good source of carbohydrates, proteins and minerals and its protein quality is similar to or better than other legumes[25-26] (chickpea, black gram, peas, pigeonpea etc.).

This study presents application of *K. alvarezii* as a foliar spray to green gram to determine improvement in yield and nutritional quality of seeds.

Materials and Methods

A pot experiment was conducted during Kharif season of 2005-2006 in CSMCRI premises, Bhavnagar. A mixture of red soil, black soil and farm yard manure (2:1:1) was used to fill pots in order to maintain substratum uniformity. Certified seeds were sorted out for uniform size and colour and used for sowing. Finally, only one seedling was allowed to grow in each pot. A foliar application of *K. alvarezii* extract (5.0, 10.0, and 15.0%) was given at flowering stage. Control plants were sprayed with water. For proper adherence, extract was mixed with surfactant.

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Table 1—Effect of *K. alvarezii* extract on yield and yield attributing characters of green gram var. K-851

Treatment	No. of pods per plant	Wt. of pods per plant, g	No. of seeds per pod	Seed yield per plant, g	100 seed wt, g
Control	27.67	18.53	9.50	13.65	4.72
5.00%	31.83	22.21	9.57	15.94	4.49
10.00%	36.33	24.12	9.87	17.76	4.83
15.00%	34.83	23.50	9.73	17.24	4.56
CD at 5%	4.321	4.075	0.204	2.889	0.169

Table 2—Effect of *K. alvarezii* extract on carbohydrates, nitrogen and protein content in seeds of green gram var. K-851

Treatment	Carbohydrate, %	Total N, %	Crude protein, %
Control	58.950± 2.079	2.900± 0.100	18.220± 0.900
5.0%	60.515± 2.008	2.950± 0.150	18.445± 0.945
10.0%	61.995± 2.037	3.105± 0.165	19.430± 0.510
15.0%	60.350± 1.472	2.910± 0.147	18.187± 0.919

Pods were collected from each plant at maturity; seeds were separated and weighed. Length of pod was measured and seeds were counted from each pod. Seeds were oven dried at 70°C to get constant weight and ground to pass through a 0.5 mm sieve for biochemical analysis. Carbohydrate was extracted[27] and determined using spectrophotometer[28]. Protein content was estimated by multiplying N content with 6.25, while N content was determined following semi-micro Kjeldahl method[29] after plant tissue was oxidized and decomposed by sulphuric acid with digestion mixture (K_2SO_4:$CuSO_4$ = 5:1). P was determined by vanadomolybdate yellow method spectrophotometrically, Na and K by flame photometer[30] and minerals (Ca, Mg, Fe, Zn, Mn, Cu, and Mo) by inductively coupled plasma–optical emission spectroscopy (ICP-OES) after wet digestion with HNO_3-$HClO_4$ (10:4) di-acid mixture[31]. All determinations were performed in triplicate and data represented on dry weight basis as mean values ± standard deviations.

Results and Discussion

Yield and Yield Attributes

Foliar application of *K. alvarezii* extract (10.0%) gave increase in yield over control to the extent of 30.11%, which was maximum and significant increase, as compared to increase in the yield by 16.78 and 26.30% for plants treated with 5.0 and 15.0% respectively (Table 1). Increase in yield was mainly due to increase in number of pods as well as weight of pods per plant and number of seeds per pod. This is in conformity with results reported for *Phaseolus aureus*[32]. Increase in yield of several crops like *Capsicum annuum*[18], black gram[33] and canola plants (*Brassica napus*) [34] is reported with foliar application of seaweed extract. Kelpak significantly increased yield of tepary bean (*P. acutifolius* Gray) growing at all concentrations of nutrient supply by increasing bean weight rather than bean number[35]. Application of seaweed extract has increased cholorophyll content of *P. vulgaris*[36] and tomatoes[37,38].

Nutritional Quality of Seeds

Foliar application of extract of a brown alga, *Sargassum wightii* Greville, improved yield and fruit quality of *Zizyphus mauritiana* Lamk[39]. In present study, foliar application of *K. alvarezii* extract not only increased seed yield but also improved nutritional quality of seeds. Compared to control, carbohydrate content had increased by 5.17% while protein by 7.07% with foliar application of 10. 0% *K. alvarezii* extract (Table 2). Minerals content in seed in all concentrations were higher compared to control plant (Table 3). This is in conformity with result obtained for okra and wheat[15,16]. Application of seaweed extract increased N content of beans[35], sugar content of sugarbeet and orange[40,41] and lipid and protein in vegetable

Table 3—Effect of *K. alvarezii* extract on macro and micro nutrients content (mg/100g) in seeds of green gram var.K-851

Treatment	Na	K	P	Ca	Mg	Fe	Zn	Mn	Cu	Mo
Control	24.000 ±2.933	1725.000 ±52.202	415.000 ±15.000	112.600 ±9.312	150.200 ±8.661	5.080 ±0.121	3.280 ±0.080	1.387 ±0.060	0.573 ±0.017	0.247 ±0.017
5.0%	26.67 ±2.031	1793.000 ±64.784	420.000 ±17.231	124.400 ±10.800	157.000 ±12.000	5.420 ±0.197	3.320 ±0.125	1.587 ±0.040	0.673 ±0.025	0.337 ±0.016
10.0%	32.000 ±2.000	1920.000 ±57.663	430.000 ±15.000	131.400 ±10.800	178.600 ±12.421	5.900 ±0.249	3.340 ±0.182	1.897 ±0.096	0.693 ±0.018	0.377 ±0.023
15.0%	28.000 ±2.646	1730.000 ±40.000	425.000 ±32.787	123.200 ±5.892	168.000 ±11.000	5.240 ±0.209	3.160 ±0.195	1.467 ±0.063	0.633 ±0.018	0.357 ±0.027

plants when grown in lower percentages of seaweed compost prepared from *Codium iyengarii* borg[42]. Beneficial effects of seaweed extract may be due to presence of some growth promoting substances[43] (IAA, IBA, Gibberellins, cytokinins, micronutrients, vitamins and amino acids).

Conclusions

Foliar application of *K. alvarezii* extract increased yield and improved nutrition of green gram, due to presence of microelements and plant growth regulators, especially cytokinin.

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