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RESEARCH ARTICLE

GRAIN YIELD AND FUNCTIONAL PROPERTIES OF RED GRAM APPLIED WITH SEAWEED EXTRACT POWDER MANUFACTURED FROM *KAPPAPHYCUS ALVAREZII*

Kosalaraman Karthikeyan and *Munisamy Shanmugam

Research and Development Division, AquAgri Processing Private Limited, B5, SIPCOT Industrial Complex, Manamadurai – 630 606, Sivagangai District, Tamil Nadu, India

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ABSTRACT

The effect of seaweed extract powder (Aquasap powder) on germination and field trial on red gram was studied. Germination at 0.03% solution was very effective and recommended same concentration for seed treatment of red gram. Seaweed extract powder at 0.2% was applied in filed through foliar spray at the vegetative phase, pre-flowering stage and pod maturity phase of red gram and it found that it enhanced yield of net grain to 35.93%. However, no statistically significant differences in the functional properties of red gram ($p \geq 0.05$) between treated plants control plants were observed. Therefore, the application of eco-friendly seaweed based organic bio-stimulant is recommended for red gram farming for higher yield and better quality.

INTRODUCTION

Bio-stimulant substances extracted from marine algae are used as fertilizer to increase the quality and yield of plants. Seaweed extract is natural organic fertilizers which is highly effective nutrient and promotes maximum yield, quick germination of seeds and ability of resistance of many crops (Dewivedi *et al*., 2014). The seaweed extract is used as foliar nutrient which is one of such approaches as they are very effective to the crops (Pramanick *et al*., 2014). Many research studies have shown the advantageous effect of seaweed extract in stimulating the growth of plants and same has been reviewed by Khan *et al*. (2009). Kappaphycus alvarezii, a red seaweed which is one of major raw materials for high economic value product carrageenan, a thickening agen used in idustries. K. alvarezii extract contains macro-micro nutrients and growth promoting substances like auxin, cytokinin and gibberellins (Zodape *et al*., 2009, Prasad *et al*., 2010, Karthikeyan & Shanmugam, 2016). It was reported that extract of K. alvarezii increased 60.89% more yield in tomato and 20.94% higher crop yield in okra (Zodape *et al*., 2009; Zodape *et al*., 2008). Eswaran *et al*. (2005) has observed that the yield of brinjal with application of Eucheuma seaweed powder was 41.1%. Soybean when treated with 15% and 12.5% of extract of Kappaphycus yielded 57% and 46% more when compared to the control respectively with 15% more yield in straw (Rathore *et al*., 2009). Similar kind of result in onion (22.0%) with treatment of Eucheuma seaweed powder was reported by Eswaran *et al*., (2005).

***Corresponding author: Munisamy Shanmugam,**
Research and Development Division, AquAgri Processing Private Limited, B5, SIPCOT Industrial Complex, Manamadurai – 630 606, Sivagangai District, Tamil Nadu, India.

The maximum yield in tomato (Zodape *et al*., 2011) and banana had been reported when extract of K. alvarezii was applied through foliar application (Karthikeyan & Shanmugam, 2014). Red gram (pigeon pea, Tur or Arhar) is one of the important crops of rain fed agriculture in the semi-arid tropics and enriches soil through symbiotic nitrogen fixation. It is one of the important pulses in India and it contributes about 90% of total red gram production in world. In India, Maharashtra is the largest producer of red gram which produces nearly 35% of total production in the country, followed by Karnataka, Madhya Pradesh and Uttar Pradesh with 13% each. During 2013-2014, total production of red gram in India was 2.5 to 3.0 million metric tons produced from 3.5 to 4.0 million hectares (Internet). Mostly seaweed based biostimulant are available in the market are from brown algae species such as Ascophyllum nodusum, Sargassum etc., but the present investigation reports the efficacy of bio-stimulant of commercially manufactured seaweed extract powder (Aquasap powder: Brand name of AquAgri) from red seaweed of K. alvarezii on the germination, grain yield and functional properties of red gram.

MATERIALS AND METHODS

Seeds of red gram (Co 6) were obtained from Regional Pulses Research Station, Tamil Nadu Agriculture University, Coimbatore. Commercially manufactured powder of seaweed extract from K. alvarezii bio-stimulant Aquasap powder (Batch no: 09102013-13) was collected from AquAgri Processing Private Limited, Manamadurai, India. pH of Aquasap powder (1%) was measured using pH meter (Model: Eutech Instrument). Elements were analyzed by atomic absorption spectroscopy (Association of Analytical Communities 18th edition: 2005). PGRs such as auxin (Gorden and Paley, 1957), cytokinin (Syono and Torrey, 1975) and gibberellic acid (Holbrook *et al*., 1961) were estimated using colorometric methods.

Germination test

Seeds were soaked in 0.03% of Aquasap powder for one hour and 100 seeds with four sub replicates of 25 seeds each was carried out in germination paper at a germination room which was maintained at 25±1.5 C and RH 96±2 percent with diffuse light (10 hrs) during the day. The normal seedling was recorded on 7th day of the culture period and the percentage of germination was observed.

Root and shoot length

The shoot length was measured from the collar region to tip of the shoot and the root length was calculated from the collar region to tip of the primary root. The mean values were expressed in cm.

Fresh and dry weight

The uprooted plants were washed and they were blotted with blotting paper and weighed. Then they were dried in a hot air oven at 80^{o}C for 16 hrs and then dry weight was taken. The mean values were expressed in mg g-1.

Estimation of chlorophyll

500 mg of fresh material was taken and ground with 10 ml of 80% acetone. The homogenate was centrifuged at 3000 rpm for 15 min. The supernatant was stored and residue was re-extracted with 5 ml of 80% acetone. The extracts were mixed and taken absorbance at 645 nm and 663 nm in the UV-spectrophotometer (Arnon, 1949).

$$\text{Chlorophyll } a \text{ (mg/g.fr.wt.)} = \frac{(12.7 \times \Delta A663 - 2.69 \times \Delta A645)}{a \times 1000 \times W} \times V$$

$$\text{Chlorophyll } b \text{ (mg/g.fr.wt.)} = \frac{(22.9 \times \Delta A645 - 4.68 \times \Delta A663)}{a \times 1000 \times W} \times V$$

$$\text{Total Chlorophyll (mg/g.fr.wt.)} = \frac{(20.2 \times \Delta A645 - 8.02 \times \Delta A663)}{a \times 1000 \times W} \times V$$

ΔA = Absorbance at respective wavelength
V = Volume of extract (ml)

W = Fresh weight of the sample (g)

Estimation of carotenoid

Carotenoid content of germinated plantlets was determined by the method of Kirk and Allen (1965). The extract obtained for chlorophyll estimation was used for carotenoid estimation by measuring at 480 nm in UV-spectrophotometer.

Carotenoid (mg/g.fr.wt) = $\Delta A480 + (0.114 \times \Delta A663) - (0.638 \times \Delta A645)$
ΔA = Absorbance at respective wavelength

Field study

Experiment of red gram trial was conducted during March – October, 2012 in Agri R&D plot of AquAgri Processing Private Limited, Manamadurai at Sivagangai district, Tamil Nadu (Lat. 9˚42′55″N, Long. 79˚28′2″E). Farmyard was applied at 13 tonnes/ha ratio and ploughed 3 times and broke the soil finely with rotovator. The plot size was 25 m × 4 m and experiment was conducted in 32 plots. Seeds were soaked in 0.03% of Aquasap powder for one hour and sowed into the field. The plots were irrigated weekly intervals by flooding method. Red gram was treated with recommended dosage of 0.2% of Aquasap powder for 3 times through foliar application. First dosage was applied at the vegetative phase (25th days after sowing), second dosage during pre-flowering stage (3rd month after sowing) and final application was given at pod maturity phase (5th month after sowing). The crop was harvested when pod was fully matured and grains were collected by maual thrashing.

Seed weight (SW)

Weight of 100 seeds obtained from trial was determined as per AOAC (1984) and average seed weight was calculated.

Moisture content (MC)

The seeds were dried at 80˚C for 16 hrs then cooled in desiccators and moisture content was calculated as below:

$$\% \text{ of Moisture content} = \frac{W2-W3}{W2-W1} \times 100$$

Where, W1 = Weight of empty plate weight
W2 = Weight of Plate + Sample
W3 = Weight of Plate + Sample after oven dry

Ash content (AC)

5 g of sample was burn to ashes in the muffle furnace at 550˚C for 4 hours, then it was cooled in the desiccators and ash content was calculated as below:

$$\% \text{ Ash} = \frac{W2 - W1}{\text{Weight of sample}} \times 100$$

Where W1 = weight of empty crucible
W2 = weight of crucible + ash

Seed coat percentage (SCP)

50 seeds of seeds were weighed and soaked in 100 ml of water over night, removed the coat manually, dried in oven and both coat and seeds weights were taken.

Seed density (SD)

Hundred seeds were taken and transferred into 50 ml water in 100 ml measuring cylinder. The seeds were allowed to soak for 10 minutes and the volume of water displaced was recorded.

The density was calculated as below:

SD = Mass / Volume

Production of red gram flour (PRGF)

The seeds were soaked overnight in water at 1:5 (w/v) ratio and coats of seeds were removed manually and the dehulled seeds were dried in the oven at 30˚C for 48 hours and ground.

Bulk density (BD)

2 g of the flour samples was taken in calibrated measuring cylinder and tapped and the bulk density was determined as below:

BD = Mass / Volume

Swelling index (SI)

Height and level of the powder sample was noted when 1 g of the sample was weighed and dispersed into a test tube. 10 ml of distilled water was added and allowed to stand for 1 hr. The height was then recorded and the swelling index calculated as the ratio of the final height to the initial height.

$$SI = H2/ H1$$

Where SI = Swelling index
H1= Initial height
H2= Final height

Water absorption capacity (WAC)

0.4 g of sample was taken in a centrifuge tube (V1) and added 40 ml of distilled water into it and mixed well. The mixture was allowed to stand for 30 min at room temperature and centrifuged at 4500 rpm for 7 min. The supernatant was decanted and weight of the sample with centrifuge tube (V2) was noted.

$$WAC = \frac{V2 - V1}{\text{Weight of the sample (0.4g)}} \times 100$$

Oil absorption capacity (OAC)

This was same as WAC but a refined vegetable oil was used instead of water and the time allowed for absorption was 1hr at room temperature. The oil absorption capacity was determined as

$$OAC = \frac{V2 - V1}{\text{Weight of the sample (0.4g)}} \times 100$$

Gelation capacity (GC)

5 g of sample was weighed into a beaker with 20 ml of H_2O and heated to gelling point and the temperature at which it got gelled was measured using a thermometer.

Emulsion capacity (EC)

10 ml of distilled water was mixed with 1 g of sample and shaked for 30 seconds then 10 ml of refined oil was added into it and shaken continuously until the oil was properly mixed with the sample and left to stand for 30 min. The height of oil separated from the sample was noted and the emulsion capacity was expressed as shown below

$$EC = \frac{\text{Emulsion height} \times 100}{\text{Water height} \times 1}$$

Foaming capacity (FC)

1 g of sample was mixed with 10 ml of distilled water and blended for 5min. After 30 sec the height of foam was recovered. The foaming capacity was expressed as percentage of foam produced after whipping. It is calculated as:

$$FC = \frac{Va\text{-}Vb \times 100}{Vb \quad \times 1}$$

Where

Va = height after whipping
Vb = height before whipping

Wettabilit

When 1 g of the red gram flour was taken in 500 ml distilled water in 1000 ml beaker and time taken to disperse powder completely was noted and mean of triplicate was recorded as wettability. The data on biomass, pods weight and no. of pods per plant, seed weight, seed coat weight, seed germination, shoot length, root length, fresh weight, dry weight, chlorophyll a, chlorophyll b, total chlorophyll, carotenoids and functional properties of red gram were estimated.

Statistical analysis

Statistical analysis such as analysis of variance (ANOVA, SYSTAT version 7), correlation and regression was applied to analyze the data.

RESULTS

Physicochemical properties of seaweed extract powder

Physical properties and active ingredients profile of seaweed extract powder (Aquasap powder: Brand name of AquAgri) is given in Table 1.

Germination study

The seed germination ranged from 70.01% to 90.06% (ave. 79.73%) and 89.19% to 98.88% (ave. 96.56%) in control and treated plants respectively with 19.85% increase in treated one. Average shoots length in control and treated plants were 20.18 cm (18.18 cm to 23.63 cm) and 19.63 cm (17.61 cm to21.18 cm) respectively.

Table 1. Physico-chemical properties and active ingredient profile of bio-stimulant Aquasap powder from seaweed *K. alvarezii*

Physicochemical Parameters	Units	Results
Total organic matter	g/100g	8.31
Electrical conductivity (1% solution)	mS	4.63
pH (1% solution)	-	7.90
Moisture content	ml/100g	1.90
Total ash	g/100g	89.64
Bulk density	g/cc	0.76
Macro nutrients		
Nitrogen (N)	g/100g	0.54
Phosphorous (P)	g/100g	0.03
Potassium (K)	g/100g	34.50
Secondary nutrients		
Calcium (Ca)	g/100g	0.57
Magnesium (Mg)	g/100g	1.15
Sulphur (S)	g/100g	1.54
Micro nutrients		
Zinc (Zn)	mg/kg	47.82
Manganese (Mn)	mg/kg	34.29
Sodium (Na)	g/100g	7.34
Boron (B)	mg/kg	119.20
Iron (Fe()	mg/kg	0.05
Silica (Sio_2)	g/100g	3.48
Chloride (Cl)	g/100g	39.35
Copper (Cu)	mg/kg	15.84
Cobalt (Co)	mg/kg	48.13
PGR		
Auxin	%	0.06
Cytokinin	%	0.07
Gibberellin	%	0.18
Amino Acids		
Threonine	g/100g	0.07
Valine	g/100g	0.01
Methionine	g/100g	0.02
Isoleucine	g/100g	0.12
Leucine	g/100g	0.14
Tyrosine	g/100g	0.11
Phenylalanine	g/100g	0.03
Histidine	g/100g	0.02
Lysine	g/100g	0.05
Arginine	g/100g	0.04
Tryptophan	g/100g	0.12
Proline	g/100g	0.02
Alanine	g/100g	0.12
Aspartic Acid	g/100g	0.07
Glycine	g/100g	0.06
Glutamine	g/100g	0.33
Serine	g/100g	0.05

Table 2. Seed germination and biochemical content of red gram applied with bio-stimulant Aquasap powder

Characters	Control	Treated plants
Seed germination (%)	79.73±6.02	96.56±6.15
Shoot length (cm)	20.18±1.69	19.63±1.12
Root length (cm)	4.21±1.35	8.73±0.57
Fresh weight (mg g^{-1})	0.13±0.005	0.38±0.03
Dry weight (mg g^{-1})	0.03±0.006	0.09±.006
Chlorophyll *a* (mg g^{-1})	0.30±0.04	0.59±0.03
Chlorophyll *b* (mg g^{-1})	0.28±0.03	0.41±0.02
Total chlorophyll (mg g^{-1})	0.54±0.04	1.06±0.04
Carotenoids (mg g^{-1})	0.40±0.02	0.71±0.02

Root length of control ranged from 2.12 cm to 6.89 cm (ave. 4.21 cm) and 7.80 cm to 9.72 cm (ave. 8.73 cm) in treated plants. The fresh weight ranged from 0.128 mg g-1 to 0.148 mg g-1 (ave. 0.13 mg g-1) and 0.326 mg g-1 to 0.420 mg g-1 (ave. 0.38 mg g-1) in control and treated plants respectively with significant negative correlation with chlorophyll a (r=-0.611; p=0.05) and chlorophyll b (r=-0.808; p=0.01). Dry weight germinated plantlet ranged from 0.025 mg g-1 to 0.042 mg g-1 (ave. 0.03 mg g-1) and 0.075 mg g-1 to 0.093 mg g-1 (ave. 0.09 mg g-1) in control and treated plants respectively. Average value of chlorophyll a in control and treated plants were 0.30 mg g-1 (0.218 mg g-1 to 0.335 mg g-1) and 0.59 mg g-1 (0.510 mg g-1 to 0.620 mg g-1) respectively. Chlorophyll b ranged from 0.215 mg g-1 to 0.318 mg g-1 (ave. 0.28 mg g-1) and 0.375 mg g-1 to 0.455 mg g-1 (ave.0.41 mg g-1) in control and treated plants respectively with significant positive correlation with total chlorophyll (r= 0.608; p=0.05). Average value of total chlorophyll in control and treated plants were 0.54 mg g-1 (0.475 – 0.586 mg g-1) and 1.06 mg g-1 (0.991 – 1.109 mg g-1) respectively. Carotenoids ranged from 0.375 mg g-1 to 0.455 mg g-1 (ave. 0.40 mg g-1) and 0.680 mg g-1 to 0.745 mg g-1 (ave. 0.71mg g-1) in control and treated plants respectively (Table 2).

Field study

Plants treated with 0.2% seaweed bio-stimulant Aquasap powder were generally greenish and uniform in height as compared to control plants. Plant biomass of control plant ranged from 337 g to 633 g with an average of 431.8 g and it was 195 g to 911 g (ave. 566.5 g) in treated plants; therefore 31.19% more yield than control with significant positive correlation with seed germination (r= 0.721; p= 0.02). Average pods weight per plant in control and treated plants were 53.4 g (24 g to 99 g) and 84.4 g (43 g to 140 g) respectively with significant positive correlation with number of pods (r=0.769; p=0.01), dry seed weight (r=0.975; p=0.01) and dry pod weight (r= 0.605; p= 0.05) with 58.05% increased in treated.

The no. of pods per plant ranged from 88 to 485 nos (ave. 222.1 nos.) and 181 to 467 nos. (ave. 327.2 nos.) in control and treated plant respectively with significant positive correlation with dry seed weight (r= 0.776; p=0.01) and dry pod weight (r=0.859; p=0.001) with 47.32% increased in treated plants. Seeds of treated pods were large and more uniform in size whereas the pods of control were irregular in size and smaller.
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Table 3. Vegetative growth, yield and yield percentage of redgram treated with 0.2% of bio-stimulant Aquasap powder

Characters	Control	Treated plants	Yield increase in treated plants (%)
Biomass/plant (g)	431.8±109.84	566.5±244.33	31.19
Number of pods/plant (nos)	222.1±128.09	327.2±94.94	47.32
Fresh pods weight/plant (g)	53.4±26.02	84.4±29.05	58.05
Dry pods weight /plant (g)	15.1±8.33	24.3±6.88	60.92
Dry seed weight /plant (g)	42.3±27.04	57.5±19.42	35.93
Net grain / plot (Kg)	3.440	4.678	35.99
Net grain / acre (Kg)	145.01	197.20	35.99

Table 4. ANOVA interpretation of control and treated plants of red gram

Characters	F-ratio	P
Plant biomass	2.275	0.149
Pods weight/plant	5.687	0.028
Number of pods/plant	3.911	0.064
Dry seed weight	1.876	0.188
Dry pod weight	6.516	0.020

Weight of dry seeds of control plant per plot ranged from 16 g to 103 g with average 42.3 g whereas in treated plants it was 31 g to 89 g (ave. 57.5 g) and yield was 35.93% more over control with significant positive correlated with dry pod weight (r=0.638; p= 0.05). Average weight of dry pod in control and treated plants were 15.1 g (7 g to 36 g) and 24.3 g (13 g to 34 g) respectively and dry pod increased to 60.92% as compared with control (Table 3, 4).

Table 5. Functional properties of red gram treated with bio-stimulant Aquasap powder

Functional Properties	Characters	Units	Control	Treated
Seed Weight	Seed	g/100g	42.30	57.50
Moisture Content	Seed	g/100g	4.38	4.14
	Flour	g/100g	8.03	7.89
Organic Matter	Seed	g/100g	3.78	3.95
	Flour	g/100g	2.65	2.69
Ash Content	Seed	g/100g	91.84	91.91
	Flour	g/100g	89.32	89.42
Seed Coat Percentage	Seed	%	1.47	1.51
Seed Density	Seed	g/cc	0.13	0.14
Production of Red Gram Flour	Flour	g	38.10	40.28
Bulk Density	Flour	g/cc	0.77	0.79
Swelling Index	Flour		1.40	1.50
Water Absorption Capacity	Flour	ml/g	2.22	2.38
Oil Absorption Capacity	Flour	ml/g	3.18	4.26
Gelation Capacity	Flour	˚C	78	78
Emulsion Capacity	Flour	ml/g	93.44	93.58
Foaming Capacity	Flour	ml/g	18.10	17.87
Wettability	Flour	g/min	11.82	11.92

Average grain weight of 100 seeds was 42.30 g and 57.50 g in control and treated plants respectively. Moisture content (MC) of control and treated plant was 4.38 g and 4.14 g in seed and in flour 8.03 g and 7.89 g were recorded resctively. In control, seeds and flour of organic matter were 3.78 g and 2.65 g and in treated it was about 3.95 g and 2.69 g respectively. Ash content of seeds from control and treated plant were 91.84 g and 91.91 g whereas in flour it was 89.32 g and 89.42 g were respectively. Seed coat percentage was recorded as 1.47% and 1.51% in control and treated plants respectively. Seed density in control was 0.13 g/cc and treated plants it was 0.14 g/cc. Production of red gram flour in control was 37.10 g and treated plants it was 40.28 g. Bulk density of flour from control was 0.77 g/cc and 0.79 g/cc in treated plants and swelling index was 1.4 and 1.5 respectively. The water absorption capacity and oil absorption capacity were noted as 2.22 ml/g and 3.18 ml/g respectively in control and they were 2.38 ml/g and 4.26 ml/g in treated plants but no difference in gelation capacity between control and treated plants. Emulsion capacity and foaming capacity were recorded as 93.44 ml/g and 18.10 ml/g in control and 93.58 and 17.87 ml/g in treated plants respectively. Wettability of red gram flour was observed as 11.82 g/min in control and 11.92 g/min in treated plants (Table 5).

DISCUSSION

The average germination in 0.03% Aquasap powder treated seed was 96.56% which were more than 19.85% when compared to control plants. Similar kind of observation was made by Ashok Kumar *et al*. (2012) in green gram as 100% when treated with low concentrations of LSF. Germination of brinjal and chilly seeds treated with LSF of Gracilaria textorii and Hypnea musciformis were 94% and 99% respectively (Narasimha rao and Chatterjee, 2014). It was also observed by Anandharaj and Venkatesalu (2001) that high concentration of Gracilaria edulis LSF reduced the seed germination in Dolichos biflorus. Biochemical parameters like chlorophyll a and b, total chlorophyll and carotenoids were also found higher in treated plants (Table 2). The application of LSF of Ascophyllum nodosum increased the chlorophyll of cucumber and tomato plants (Whapham *et al*., 1993). Chlorophyll a and b and total chlorophyll in Arachis hypogaea found increased when they were treated with 1% LSF of Sargassum wightii (Sridhar and Rengasamy, 2010). The application of Aquasap powder improved the growth of the radical significantly. The shoot and root length found increased in treated seeds. Balamurugan and Sasikumar (2013) reported that the shoot and length increased when the seeds of Abelmoschus esculentus treated with 10% Sargassum myryocystem.

Biomass and pod weight were found increased by 31.19% and 58.05% in treated plants respectively. Karthikeyan and Shanmugam (2015) reported that the pod weight increased in peanuts when treated with 5% extract of K. alvarezii. In the present study, number of pods increased to 47.32% in treated plants when compared with control plants. Asho Kumar *et al*. (2012) observed that LSF of Sargassum wightii on green gram showed increased number of pods. In the present investigation, dry seed weight and dry pod weight increased by 35.93% and 60.92% respectively in treated plants. The yield of grain increased to 80.44%, when the plants of wheat were sprayed with 1.0% of K. alvarezii (Zodape *et al*., 2009). The yield increased in Lycopersicon lycopersicum and Abelmoschus esculentus (Selvaraj *et al*., 2004), Allium cepa (De *et al*., 2013), Arachis hypogaea (Sridhar and Rengasamy, 2010) and Vigna radiate (Ashok Kumar *et al*., 2012) has been reported with foliar application of LSF. Application of K. alvarezii extract on banana showed that the fruiting time decreased with increased fruit weight (Karthikeyan and Shanmugam, 2014) and similar observation was made by Blunden (1972) on banana by treating with extract of brown algal species.

Early flowerings were observed in treated plants to promote hormonal activity. Low concentration of seaweed extract to raise the early flowers (Karthikeyan and Shanmugam, 2014; (Karthikeyan and Shanmugam, 2015; Taylor and Wilkinson, 1977) and the high dose seaweed extract with excess organic content will delay the flower production due to toxicity (Chaudhry and Loneregan, 1972). Seed weight, moisture content, organic matter, ash content, seed coat percentage, seed density, PRGF, bulk density, swelling index, WAC, OAC, gelation capacity, Emulsion capacity, Foaming capacity, wettability are shown in Table 5. Out of all the functional properties, moisture content and foaming capacity had low value when compared with control. The values of OAC were observed as 3.18 ml/g and 4.26 ml/g in control and treated plant respectively. Kinsella (1979) had reported that OAC of chick pea flour and cowpea were 1.10 ml/g and 0.89 ml/g respectively . Natt and Narasinga (1981) also gave that when the capability of OAC was high which would be suitable for making baked products for improving juiciness and mouth feel. Emulsion capacity were noted as 93.44 ml/g and 93.58 ml/g in control and treated plant respectively which exhibited high percentage of protein and this might moved to the interface and absorbed more oil and water (Gabriel and Elizabeth, 1986). When there was higher concentration of protein was observed, gelation capacity taken place readily because of higher intermolecular contact during heating (Wiltoon *et al*., 1997).

The present study showed that foaming capacity was less in treated plant (17.87 ml/g) when compared to control (18.10 ml/g). Similarly, protein isolated foamed less (4.93±0.050 ml) when compared with full fat (11.27±0.216 ml) and defatted flour (6.23±0.025 ml) (Olawuni *et al*., 2012). This showed that hydrophilic interaction was occurred but increased the protein flexibility (Aluko & Yada, 1995). It can be concluded from present study that red gram had responded well to seaweed extract powder at very low concentration (0.2%) and enhanced the yield of grain to 35.93% with good seed quality. Therefore, seaweed extract powder which is an organic product can be used in organic agriculture for seed treatment and field application in red gram cultivation for improved crop yield.

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