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Yield and oil content of peanut (var. TMV-7) and sunflower (var. Co-2) applied with bio-stimulant AQUASAP manufactured from seaweed

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The effect of bio-stimulant AQUASAP manufactured from seaweed *Kappaphycus alvarezii* (Rhodophyta) farmed in Indian water on the yield and oil content of peanut and sunflower was studied under field condition. The AQUASAP at 5% foliar application promoted the vegetative growth, yield and oil content in both peanut and sunflower significantly. Compared to control the yield of seed in peanut increased by 31.69% with 14.27% more oil content similarly on sunflower the increase in seed yield and oil content were 51.50 and 15.77% respectively. Therefore, the bio-stimulant AQUASAP can be applied on oil crops like peanut and sunflower to improve the yield and quality of crop and therefore, it has huge potential to contribute to organic agriculture in future.

Key words: AQUASAP, bio-stimulant, plant nutrient, seaweed, *Kappaphycus alvarezii*, peanut, sunflower, yield and oil content.

INTRODUCTION

The coastal ecosystems provide habitat to genetically, ecologically and economically valuable biological organisms. Seaweeds contain all the trace elements and plant growth hormones required by plant to enhance yield attributes (Latique et al., 2013). Seaweed liquid fertilizer contains micro and macro nutrient and growth promoters (Prasad et al., 2010). Seaweed extract or juice or suspension is used in agriculture and horticulture land for economical valuable. Kamaladhasan and Subramanian (2009) had reported that the seaweed extracts derived from *Sargassum wightii* (Ochrophyta, Phaeophyceae), *Gracilaria corticata* (Rhodophyta) and *Caulerpa scalpelliformis* (Chlorophyta) were effective in increasing the growth parameters. Some commercial seaweed based plant nutrients available in market are Maxicrop, Algifert, Goenar, Kelpak, Seaspray, Seasol, SM3, Cyctex and Seacrop. Seaweed bio-fertilizers are better than other fertilizers and very economical (Pise and Sabale, 2010). Effect of seaweed extracts have been studied on different range of agriculture and horticulture plants (Abetz, 1980; Crouch and Van Staden., 1990; Sridhar and Rengasamy, 2011) and found improved crop yield.

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Abbreviation: **SLF**, Seaweed liquid fertilizers; **Avg**, Average.

Increase in yield of several crops like *Capsicum annuum*, black gram, and canola plant (*Brassica napus*) were reported with foliar application of extract from seaweed *Kappaphycus alvarezii* (Zodape et al., 2010). Recently Karthikeyan and Shanmugam (2014) have observed the significant improvement in the yield and quality of some banana varieties applied with bio-stimulant Aquasap.

Groundnut is rich in oil, protein and high energy value and it is important in vegetarian diets. Groundnut is one of the major oilseeds of India. Total world production of groundnut in 2013-2014 was approximately 39.34 million tonnes. In India, groundnut production in Kharif (2012-2013) was 26.20 lakh tonnes and 47.15 lakh tonnes in Kharif 2013 to 2014 and in Tamil Nadu, during Kharif 2013-2014 it was about 1.80 lakh tonnes (TNAU, internet-1, 2014). The Seaweed Liquid Fertilizer (SLF) of *Hypnea musciformis* (Rhodophyta) could be used as foliar spray at low concentration of 2% to maximize the growth and yield of *Arachis hypogaea* and also increase the number of stomata in the yield (Ganapathy-selvam and Sivakumar, 2014). Babu and Rengasamy (2012) had recorded the maximum yield of groundnut of 170.6 g/pot treated with 1% SLF of *K. alvarezii* followed by 158.3 g/pot (2% treated) in the plants which were more than 30.6 and 21.2% respectively when compared to agriculture control (130.6 g/pot).

Sunflower is another important oilseed crops in India and it's occupied in fourth place of acreage and production. The presence of oil in sunflower is higher (45 to 50%) over other oil seed crop and the sunflower cake makes high quality cattle and poultry feed because of higher protein (40 to 44%) and balanced amino acid contents. Total world production of sunflower seeds in 2013 to 2014 was about 42 million tonnes and it was 36.40 million tonnes during 2012 to 2013. In India, sunflower seed production in kharif (2013 to 2014) was 1.85 lakh tonnes and the same was 1.50 lakh tonnes in Kharif 2012-2013. In Tamil Nadu the sunflower seed production was around 24,622 T for an area of 13,610 ha during 2011-2012 (TNAU, internet-2, 2014).

The bio-stimulant AQUASAP extracted from seaweed *K. alvarezii* is rich in potash (K) with other primary and secondary nutrients, additionally it contains substantial amount of plant growth regulators such as auxin, cytokinin and gibberellins (Prasad et al., 2010). The present investigation describes the stimulation effect of AQUASAP on the yield and oil content of peanut and sunflower for the first time.

MATERIALS AND METHODS

Seeds of groundnut (var. TMV-7) and sunflower (var. CO_2) were obtained from Regional Pulses Research station, Tamil Nadu Agriculture University, Coimbatore. The seeds were stored in metal tin as suggested by Rao (1976). Experiment of peanut and sunflower were conducted in Agri R&D plot of AquAgri Processing Private Limited, Manamadurai, India (Latitude 9°42′56″N and Longitude 78° 28′2″E) in August 2012. Farmyard manure was applied at 50 T/ha basis and ploughed the trial site 3 times and soil was broken into finely soil with rotovator. The plot size made was 6 m × 4 m and experiment was conducted in 8 plots per test crop. The seeds were treated with 0.1% mercuric chloride for sterilization and then carefully sowed into the field. 300 numbers of plants were maintained in each plot and extra plants were removed by handpicking on 25th day of sowing. The test crops were irrigated on weekly intervals by sprinkling method. Commercially manufactured AQUASAP (Batch no: 21042012-2) was collected from of stock of Aquagri Processing Private Limited, Manamadurai, India and used in the present study.

The AQUASAP was applied at 5% conc. for 3 times through foliar application for peanut, first spray was given at vegetative phase (25th day of sowing), second dose was applied at pod development stage that is, 45 days after sowing and last spray was given at maturity phase (65 days). The plants of peanuts were uprooted at the harvesting time and the pods were separated by hand picking. The data on plant weight, plant height, no. of branches, seed weight, no. of seeds, fresh and dry fodder, fresh and dry pods, dry seed and dry shell were collected.

Sunflower was similarly applied with 5% AQUASAP solution for 3 times through foliar application that is, first spray was given at vegetative phase (25th day of sowing), second dose was applied at flowering stage that is, 45 days after sowing and last spray was given at maturity phase (65 days). The harvested heads sunflower was thrashed and seed were collected. The data on plant height, diameter of flower, no. of seeds per head, fresh and dry weight of seed were collected. Oil was extracted by continuous extraction in a soxhlet apparatus used hexane as solvent, as described by Jambunathan et al. (1985).

Statistical analysis

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

RESULTS

Peanut

In peanut 10 plants were taken randomly in each plot of control and AQUASAP treated and measured the height, no. of branches and no. of seeds. Height of control plant ranged from 75 to 99 cm with an average of 84.5 cm and it was 104 to 120 cm (avg. 110.9 cm) in 5% AQUASAP treated plants; therefore 31.24% more yield over control with significant positive correlation (r=0.530; p= 0.1) was observed. Average (avg) no. of branches in control and treated plants were 6.6 nos. (4 to 10 nos.) and 8.1 nos. (5 to 15 nos.) respectively but not significantly correlated with control (Table 1).

The reading taken from 4 plots are given as follows. Weight of fresh fodder of control plant per plot ranged from 125 to 190 kg with average 159.9 kg whereas in treated plants it was and 162 to 219 kg (avg 192.8 kg) that is, 20.58% more weight was obtained in treated plants (r=0.524; p=0.1). Average dry fodder in control and treated plants were 88.3 kg (49-193 kg) and 108 kg (75-174 kg) respectively (r=0.624; p= 0.05) that is, dry fodder increased to 22.31% as compared with control

Table 1. Vegetative growth, yield and oil content of peanut applied with bio-stimulant AQUASAP.

Characters	Control	Yield of 5% AQUASAP treated plants	% of yield increase in treated plants
Plant height (cm)	84.5±6.45	110.9±5.72	31.24
No. of branches (no.)	6.6±1.62	8.1±3.69	22.72
No. of seeds (no.)	14.2±2.96	18.7±1.55	31.29
Fodder fresh wt/ plot *4 (kg)	159.9±17.77	192.8±19.01	20.58
Dry fodder wt/plot *4 (kg)	88.3±42.03	108±41.82	22.31
Fresh pods wt/plot *4 (kg)	84±8.84	112.4±17.51	33.81
Dry pods wt/plot *4(kg)	37.9±7.65	44.9±5.07	18.40
Dry seeds wt/plot *4 (kg)	14.2±2.96	18.7±1.55	31.69
Dry shells wt/plot *4 (kg)	19.8±2.89	27.4±3.55	38.38
Oil content (%)	47.16±2.63	53.89±2.73	14.27
Dry seed / ha (kg)	1479.00	1947.00	31.69
Oil content / ha (ltr)	697.40	1049.20	14.27

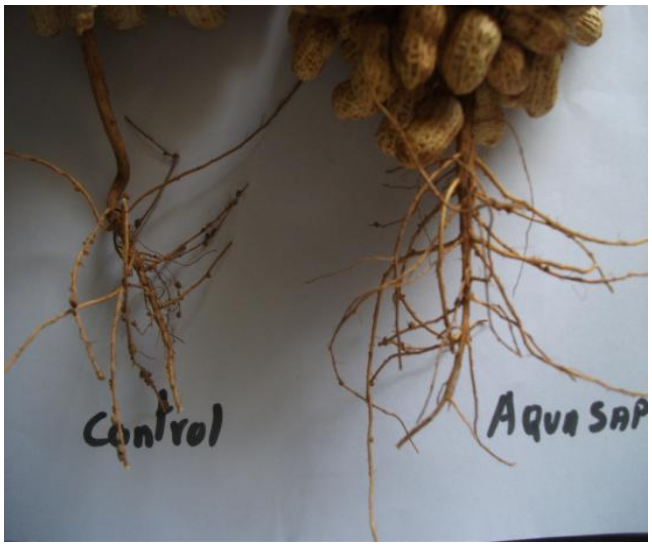

Figure 1. Root system of peanut – more no. of lateral branches with nodes in treated plant.

(Table 1).

First flower was observed on 35th day of plantation in treated plant and same was observed on 47th day in the case on control plants. Maximum flower was observed after 8th weeks of plantation. The root system of 5% AQUASAP treated plants had more no. of lateral branches with nodes as compared to agriculture control (Figure 1).

Seeds of treated pods were large and more uniform in size with 94% of two seeds per pod whereas the pods of control was irregular in size, smaller and 17% pods were with single seed (Figure 2). The no. of seeds ranged from 10 to 18 nos. (avg. 14.2 nos.) and 13 to 26 nos. (avg 18.7 nos.) in control and treated plant respectively with significant positive correlated with control (r= 0.537: p=0.1) and with 31.29% increased in treated one (Table 1).

Average fresh pod weight in control and treated plants were 84 kg (72 to 97 kg) and 112.4 kg (86 to 148 kg) respectively with significant positive correlation (r= 0.774; p=0.01) and with 33.18% more yield over control. Dry pods of control ranged from 25 to 48 kg (avg 37.9 kg) and 35 to 51 kg (avg 44.9 kg) treated plants and 18.4% more yield over control respectively and significant positive correlated with control (r=0.815; p= 0.01). The oil content ranged from 43.57 to 50.48% (avg 47.16%) and 50.15 to 57.88% (avg 53.89%) in control and treated plants respectively with 14.27% more yield over control. Dry seed weight ranged from 10 to 20 kg (avg 14.2 kg) and 16 to 21 kg (avg 18.7 kg) in control and treated plants respectively with significant positive correlated with control (r=0.797; p= 0.01) that is, 31.69% more yield as compared to control. Average dry shell weight in control and treated plants were 19.8 kg (15 to 24 kg) and 27.4 kg (21 to 34 kg) respectively (r= 0.660; p= 0.05) with 38.38% more yield over control (Table 1 and Figure 3).

Sunflower

Plant height of control ranged from 120.1 to 158.2 cm (avg134.18 cm) and 120.8 to 165.7 cm (avg 148.37 cm) in 5% AQUASAP treated plants with 10.57% more yield over control (Table 2) with no significant positive correlated with control plant. The flower head diameter ranged from 10.1 to 20.5 cm (avg 14.57 cm) and 16.7 to 21.5 cm (avg 19.2 cm) in control and treated plants respectively with 31.78% increased yield in treated plants (r= 0.820; p= 0.01). The no. of seeds per head ranged from 912 to 1020 nos. (avg 964.5 nos.) and 1128 to 1180 nos. (1150.2 nos.) in control and treated plants respectively that is, 9.25% increased yield in treated plants with significant positive correlated with control

Figure 2. Quality of seeds obtained from peanut treated with 5% AQUASAP and control plant.

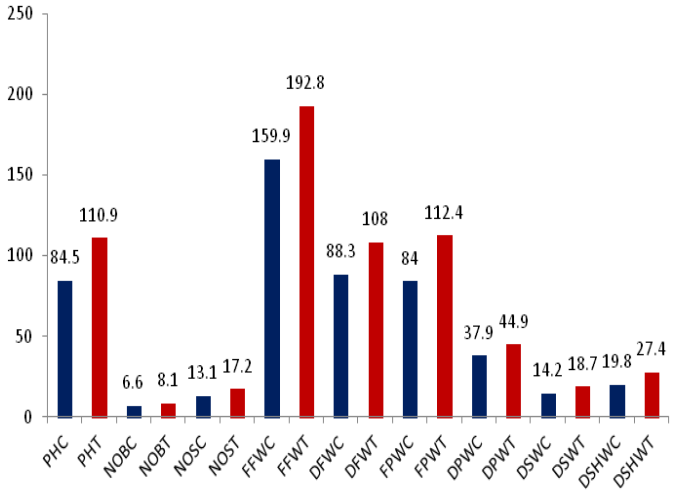

Figure 3. Vegetative growth and yield of peanut applied with bio-stimulant AQUASAP. PHC- Plant height in control, PHT – Plant height in treated, NOBC – No. of branches in control, NOBT- No. of branches in treated, NOSC – No. of seeds in control, NOST – No. of seeds in treated, FFWC-Fresh fodder weight in control, FFWT – Fresh fodder weight in treated, DFWC- Dry fodder weight in control, DFWT – Dry fodder weight in treated, FPWC- Fresh pod weight in control , FPWT – Fresh pod weight in treated, DPWC- Dry pod weight in control, DPWT – Dry pod weight in treated, DSWC – Dry seed weight in control, DSWT- Dry seed weight in treated, DSHWC – Dry Shells weight in control, DSHWT- Dry shells weight in treated.

(r=0.712; p=0.02). Average seed yield in control and treated plant were 9.98 kg (9.3 to 10.8 kg) and 15.1 kg (12.9 to 20.3 kg) respectively with 51.30% more yield over control respectively and with significant positive correlated with control (r=0.571; p=0.1). The oil content ranged from 19.37 to 32.18% (avg 27.14%) and 28.35 to 34.81% (avg 31.42%) in control and treated plants respectively with 15.77% more yield over control respectively (Table 2).

DISCUSSION

Seaweed fertilizers have often been more beneficial to the crop plants than the conventional chemical fertilizer. Seaweed meals provide nitrogen (N), phosphorous (P), potassium (K) and beside some readily available micro element to the plants (Elumalai and Rengasamy, 2012). Applying seaweed extract increases the response of different growth parameters and yield responses while the differences among hybrids remained the same (Abdel Mawgoud et al ., 2010).

The present investigation is additional evidence that seaweed extract increases the growth and production of crops. The plant height increased by 31.24 and 10.57% in treated plant of peanut and sunflower respectively. The no. of branches increased by 22.72% in treated plant of peanut. Aldworth and van Staden (1987) reported that Marigold seedling treated with seaweed concentrate were more robust and healthier in appearance than the control. Safinaz and Ragaa (2013) reported that the extract of *Laurencia obtusa*, *Jania rubens*, *Corallina elongata* (Rhodophyta) treated with Maize plant to increase the leave number and plant height. Abdel Mawgoud et al ., (2010) reported that vegetative parameters that is, plant length, number of leaves, leaf area, and number of branches and fresh weight of shoot, responded positively and significantly to the application of seaweed extract with a gradual effect relative to the applied concentration.

In the present investigation, fresh and dry fodder weights increased by 20.58 and 22.31% respectively in treated peanut plants. Balamurugan and Sasikumar (2012) have also observed similar kind of result when *Abelmoschus esculentus* raised from seed treated with 10% *Sargassum myryocystem* SLF. Kamaladhasan and Subramanian (2009) have reported the seaweed extracts derived from *Sargassum wightii* (Ochrophyta, Phaeophyceae), *Gracilaria corticata* (Rhodophyta) and *Caulerpa scalpelliformis* (Chlorophyta) were effective in increasing the growth parameters. Groundnut fodder is a good fodder and it is reported that milk production increased by 11% when it fed to cows and buffalos (New Agriculturist, Internet- 3, 2012). In sunflower, no. of loose seed observed in control was 8.5% and it was only 2.3% in the case of treated plants (Figure 4). It was also observed that roots of treated peanut grown lengthier with more nodes than control (Figure 1).

Zodape et al. (2010) had reported yield increased of 30.11% in green gram when treated with extract of *K. alvarezii*. In this present study, number of seeds in treated peanut and sunflower plants increased by 31.29 and 19.25% respectively. Pod weights of peanut plants were increased by 33.81 and 18.4% in fresh and dry

Table 2. Vegetative growth, yield and oil content of sunflower applied with bio-stimulant AQUASAP.

Characters	Control	5% AQUASAP treated	% of yield increase
Plant height (cm)	134.18±11.34	148.37±13.47	10.57
Head die (cm)	14.57±2.98	19.2±1.54	31.78
No. of seeds/ head (nos.)	964.5±42.69	1150.2±17.50	19.25
Seed yield / plot (kg)	9.98±0.49	15.1±2.36	51.30
Oil content (%)	27.14±4.54	31.42±2.08	15.77
Seed yield / ha (kg)	1039.60	1572.90	51.30
Oil content / ha (ltr)	282.10	494.20	15.77

Figure 4. Quality of seeds obtained from sunflower treated with 5% AQUASAP and control plant.

respectively and increase in dry seed and shells of peanut were 31.69 and 38.38% respectively. Peanut shells are important from nitrogen recycling point of view as it is a nitrogen rich material. Similarly, higher yields had been observed with brinjal (41.1%), wheat (42.8%), onion (22.0%) and sesamum (34.15%) when they were treated with extract of *K. alvarezii* (Eswaran et al., 2005). Seaweed extract application on plant is suggested to capable of increasing nutrient concentrations in the leaves, through involvement of growth hormone in the process of nutrients absorption and movements in a plant, thus increasing the weight of plants. Extract of seaweed *Hydroclathrus* sp. (Rhodophyta) increased the number of tiller, fresh weight of stem and root, number of panicles, number of grains, grains weight (Sunarpi et al., 2010).

Sunflower head diameter increased by 31.78% with seed yield of 51.03% in treated and control respectively. Zodape et al. (2008) have reported that length increased to 31.77 and 18.24% of diameter in okra when they were treated with extract of *K. alvarezii*. Seaweed concentration application improves the root and shoot fresh system, the number of leaves, the stem diameter and no. of flowers and flower buds produced (Aldworth and van Staden, 1987). De et al. (2013) observed that the onion applied with biozyme (*Ascophyllum nodosum,* Phaeopheceae), yielded better growth, yield and quality. Anisimov et al. (2013) have reported that the application of extract from seaweeds *Ahnfeltiopsis flabelliformis*, *Neorhodomela larix* (Rhodophyta) and *Stephanocystis crassipes* (Phaeophyceae) on buckwheat increased growth of the seedling roots in maximum by 16, 20 and 15% over control respectively.

The observation of SLF treated *Arachis hypogea* plants suggested that the growth and biochemical characteristic of pulse crop might by promoted by micro and macro elements and growth promoting hormones present in the extract of *H. musiformis* (Ganapathy-selvam and Sivakumar, 2014). Sun et al. (1997) reported the better developed root systems caused by SWC treatments may also reduce the stress on the plant delaying leaf senescence.

A. hypogaea treated with 1% SLF of *S. wightii*, *Ulva lactuca* (Chlorophyta) plus 50% recommended rate of chemical fertilizers showed an increased yield to ca. 4.1 kg fresh weight which was more than 11% to that the plants received with 100% recommended rate of chemical fertilizers (Sridhar and Rengasamy, 2010). Chouliaras et al. (2009) conducted to N and N+B treatments, the additional application of SWF (treatments N+SWF and N+B+SWF) increased productivity by 45 and 51% respectively and oil content of drupes (By 33 and 23% respectively) and accelerated maturation (colour development) of the olive fruits.

Impact of potassium

AQUASAP, bio-stimulant of *K. alvarezii* contains micro, macro nutrients and growth hormones and it is rich potash about 1.6% (Prasad et al., 2010). Potassium is a key element for the plants metabolism and contributes to the development of proteins, enzymes and vitamins as well as plant photosynthesis. Potassium plays an essential role in transport systems within the plant and it

improves water use efficiency. (SOPIB report, internet-4, 2011). Potassium improves the physical quality, disease resistance, and self life of fruits and vegetables (internet-5, 1998). Peanut is a leguminous crop and it's fixed in atmospheric nitrogen in root nodules. Potassium deficiency in control plant of peanut showed plants does not grow normally and appear irregular in shape. Plant leaves a yellowish green, exhibit chlorosis, dry and scorched at the edges and the leaf surface was irregularly chlorotic.

Christin et al. (2009) had observed that potassium deficiency in sunflower plants exhibited slightly reduced plant height and leaf number but highly reduced root length. Sami Suzer (internet-6, 2010) reported potassium provides strength to plant cell walls and is involved in the lignifications of sclerenchyma tissues of sunflower plant. Potassium deficiency can be one of reasons for early lodging because of a reduced growth rate of the cambium in stem of sunflower plant. Potassium increases root growth, improves drought resistance, and it helps in photosynthesis and food formation and to protect against pests and diseases. Potassium is well known to improve resistance to a number of pests, diseases and environmental stresses in sunflower crops. Increase yield and quality improvement may be due to presence of plant growth regulators and other macro and micronutrients including potassium present in the seaweed extract AQUASAP and it could also play a role absorbing other chemical inputs applied to the plants. Karthikeyan and Shanmugam (2014) have observed that the AQUASAP on some banana varieties increased the yield with improved quality.

Control of plant disease

Seaweed extract have been reported to increase plant resistance to pests and diseases, plant growth, yield and quality (Jolivet et al., 1991; Verkleij, 1992; Pardee et al., 2004). Sultana et al. (2011) had reported several seaweed extract control of root rotting fungi like *Macrophomina phaseolina, Rhizoctonia solani, Fusarium* species and root knot nematode (*Meloidogyne* spp.,) on various crops. Ara et al. (1996) had reported carried out on the use of seaweed viz*. Sargassum* spp. (Phaeophyceae), in the control of root rot disease of sunflower plant. Zahid et al. (1999) had reported seaweed fertilizer increase the resistibility against disease and reduce the chance of insect attack.

Conclusion

It can be concluded from present study that oil varieties of peanut and sunflower had responded well to 5% AQUASAP (Brand name of AquAgri for bio-stimulant of seaweed *K. alvarezii*) with average yield increased of 31.69 and 51.30% of peanut and sunflower respectively with much improved seed quality. Commonly SLF is a powerful, alternate to synthetic fertilizer and environmental eco-friendly and its approach to improve the plant growth and yield of all crops. SLF is helping our farmer to apply balanced fertilizer application and also reduce the cost of yield production. Present findings encourage the application of such seaweed extract as bio-stimulant in agriculture sector.

Conflict of Interest

The authors have not declared any conflict of interest.

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