Soil Environ. 31(2):157-162, 2012
www.se.org.pk
Online ISSN: 2075-1141
Print ISSN: 2074-9546

Impact of foliar application of seaweed extract on growth, yield and quality of potato (*Solanum tuberosum* L.)

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Abstract

A field trial was carried out in 2010 to investigate the effect of foliar application of seaweed extract "Primo" as an organic biostimulant on potato cv. 'Sante'. Foliar application of seaweed extract was carried out at different growth stages of the crop (i.e. 30 days; 45 days; 60 days; 30 and 45 days; 30 and 60 days; 45 and 60 days; 30, 45 and 60 days after sowing). Control plants were sprayed with water without seaweed extract. A significant improvement in growth, yield and tuber quality of potato was observed where treatment was applied. The highest tuber yield was recorded with applications of seaweed extract at 30 + 60 days interval after planting. The treatment also improved nitrogen, total soluble solids and protein contents of the potato tubers. The results of the study concluded a positive response of potato plant growth and yield to the foliar application of seaweed extract.

Keywords: Potato**,** liquid seaweed extract, growth, yield, quality

Introduction

Liquid seaweed extract has been reported as a beneficial treatment for the growth of plants (Metting *et al.*, 1990). It has its usage history of centuries in agriculture (Crouch, 1990). *Ascophyllum nodosum* is a prominent seaweed species belonging to the brown algae (Phaeochyceae) in the North Atlantic Ocean (Verkleij, 1992). According to a report by FAO (2006), a substantial amount of seaweeds (15 million metric tons annually) are used as supplement for nutrients and biostimulants for the production of agricultural and horticultural crops. Seaweed extracts have been used as soil conditioners and as a foliar spray to increase growth, yield and productivity of many crops (Norrie and Keathley, 2006). Seaweed extracts may improve crop growth through certain mechanisms, that is the provision of phytohormones (auxins, gibberellins, cytokinins and abscisic acid), macronutrients (N, P and K), certain micronutrients (Fe, Cu, Mo, Mn, Zn, Co, and Ni), and secondary metabolites as amino acids and vitamins (Challen and Hemingway, 1965). Various responses of plants to seaweed application have been observed. These include vigorous growth, higher yield, increased nutrient uptake, and more resistance to biotic and abiotic stresses (fungal diseases, insect attack and frost), improved quality and longer shelf life of fruits.

Potato is one of the most important cash crops amongst vegetables, being grown almost all over the world (Ewing, 1997). It is extremely nutritive and high energy producing food (Din *et al.*, 1997). Potato is a high yielding crop requiring ample amount of nutrients in a short period of time (Rahmatullah, 1996). Blunden and Wildgoose (1977) found that spraying potato plants (*Solanum tuberosum* L.) with seaweed extract increased chlorophyll contents in leaves over the control. Seaweed extracts have been found strongly bioactive even at very low concentrations (diluted as 1:1000 or more) (Crouch and Staden, 1993). They influenced tuber initiation and growth in potato plants (Staden and Dimalla, 1976). Similarly, Humphries (1958) applied seaweed extract on potato plants that enhanced the plant growth. But he did not precede his studies up to maturity of the crop. However, the findings of the experiments by Blunden and Wildgoose (1977) indicated a prominent improvement in tuber yield of the crop late in the plant development. In the same way, a field experiment was carried out by Dwelle and Hurley (1984) to determine the most suitable application time of seaweed extract for getting maximum yield and they found the best time during the 2-week period directly following tuber initiation.

Keeping in view the above all discussion the present study was planned to evaluate the impact of foliar application of "Primo" (trade name of seaweed product) on growth, yield and tuber quality of potatoes.

Materials and Methods

The trial was conducted in the Vegetable Experimental Area of the Institute of Horticultural sciences, University of Agriculture, Faisalabad, to determine the effect of seaweed extract on growth, yield and quality of potato (*Solanum tuberosum* L.) cv. Sante, sprayed at different growth intervals of crop. Soil was prepared well before planting.

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Tubers were planted on ridges and field was irrigated immediately after planting. "Primo" was used as a source of seaweed extract. "Primo" product was diluted at the rate of 250 mL per 500 L ha^{-1}. Foliar spray of extract was applied using knapsack. Application dates ranged from December 14, 2009 to Jan 1, 2010. All other growth conditions were kept unchanged. The treatments applied during the experiment were as, T_1 = control; T_2 = spray at 30 days after planting; T_3 = spray at 45 days after planting; T_4 = spray at 60 days after planting; T_5 = spray at 30 and 45 days after planting; T_6 = spray at 30 and 60 days after planting; T_7 = spray at 45 and 60 days after planting; T_8 = spray at 30, 45 and 60 days after planting. The plot size for each treatment was 9.75 m^2 with plant population of 50.

Data regarding growth and yield parameters was collected after 125 days, at harvest of the crop. Growth parameters including plant height (cm) and number of stems $plant^{-1}$ were recorded at the tuber initiation stage. However, yield parameters as number of tubers $plant^{-1}$, tuber dry weight (%), yield $plant^{-1}$ (g) and yield ha^{-1} (tons) was noted after harvest of the crop. Whereas, nitrogen (%), phosphorus (%), potassium (%) (Chapman and Parker, 1961), total soluble solids (TSS) (Anwar *et al*., 2008) and crude protein (%) of the tubers were estimated following standard protocols in the laboratory.

Statistical Analysis

The experiment was arranged according to randomized complete block design (RCBD) with four repeats. Data of the experiment were subjected to statistical analysis of variance using the computer software MSTAT- C (Russel and Eisensmith, 1983). Treatment means were compared with the help of least significant difference (LSD) test at 5% probability level (Steel *et al*., 1997).

Results

Vegetative growth parameters recorded during the experiment i.e. plant height and number of stems $plant^{-1}$; responded positively to the application of seaweed extract applied at different growth stages of the crop (Table 1). Maximum height (30.65 cm) of plant was noted with T_2 (spray at 30 days after planting), followed by T_3 (spray at 45 days after planting). However, minimum height (25.63 cm) of potato plant was recorded in T_1 (control). Maximum number of stems $plant^{-1}$ (2.70) were noted with T_6 (spray at 30 and 60 days after planting) followed by T_8 (spray at 30, 45 and 60 days after planting) (2.60) and minimum number of stems $plant^{-1}$ (1.95) were observed with control. Seaweed extract application showed statistically non-significant results regarding plant height. But number of stems per plant remained significantly different as compared to untreated control.

Similar trends were recorded in yield parameters such as number of tubers $plant^{-1}$ (Figure 1), tuber dry weight (Figure 2) tuber yield $plant^{-1}$ (Figure 3) and tuber yield ha^{-1} (Figure 4), where treatments gave optimistic and significantly higher response than control. Maximum number of potato tubers $plant^{-1}$ (7.10) were recorded in case of T_6 (spray at 30 and 60 days after planting) followed by T_2 (spray at 30 days after planting) (7.09) and minimum number of tubers $plant^{-1}$ (5.14) were counted in T_8 (spray at 30, 45 and 60 days after planting) followed by T_5 (spray at 30 and 45 days after planting) (6.15). Similarly, maximum tuber dry weight (%) was calculated with T_6 (spray at 30 and 60 days after planting) which was statistically significant than other treatments and minimum dry weight of tuber (%) was recorded with control. In the same way, 481g tuber yield $plant^{-1}$ (maximum) was recorded with T_6 (spray at 30 and 60 days after planting) treatment followed by T_2 (spray at 30 days after planting) compared to control. On the other hand, T_7 (spray at 45 and 60 days after planting) showed minimum (409g) but significantly higher tuber yield $plant^{-1}$ regarding control. Likewise, highest tuber yield ha^{-1} was obtained with T_6 (spray at 30 and 60 days after planting) (24.42 tons) while minimum in case of control (19.50 tons).

Table 1: Effect of treatments on growth parameters

Treatments	Plant height (cm)	Number of stems $plant^{-1}$
T_1 (control)	25.63 b	1.95 d
T_2 (spray at 30 days after planting)	30.65 a	2.25 cd
T_3 (spray at 45 days after planting)	29.10 ab	2.30 bc
T_4 (spray at 60 days after planting)	28.00 ab	2.45 abc
T_5 (spray at 30 and 45 days after planting)	26.90 b	2.55 abc
T_6 (spray at 30 and 60 days after planting)	27.00 ab	2.70 a
T_7 (spray at 45 and 60 days after planting)	26.60 b	2.30 bc
T_8 (spray at 30, 45 and 60 days after planting)	28.60 ab	2.60 ab
LSD value ($P \leq 0.05$)	3.09	0.33

Treatment means sharing same letter(s) differ non-significantly

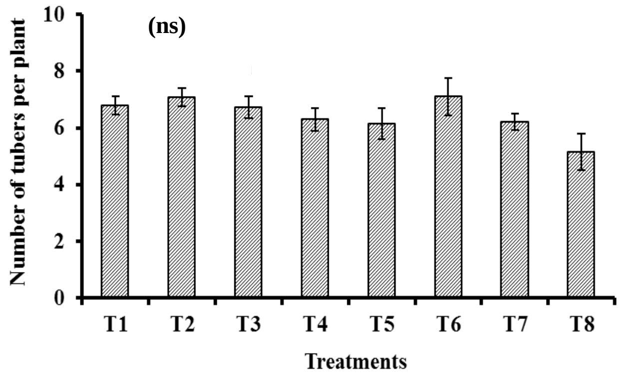

Figure 1: Effect of seaweed extract on number of tubers plant^{-1} of potato cv. Sante. Treatments sharing same letter(s) do not differ significantly. LSD value ($P\leq0.05$) = 1.009, NS: Non significant

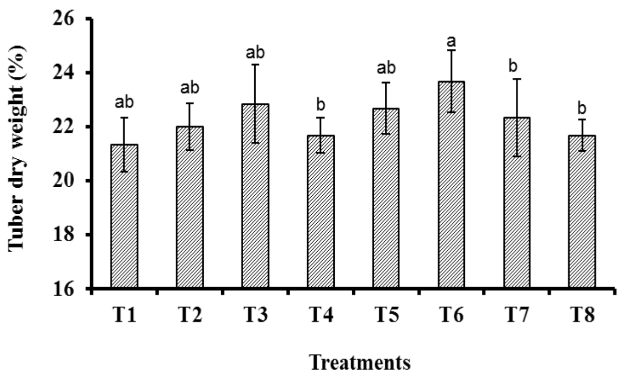

Figure 2: Effect of seaweed extract on tuber dry weight (%) of potato cv. Sante. Treatments sharing same letter(s) do not differ significantly. LSD value ($P\leq0.05$) = 1.674

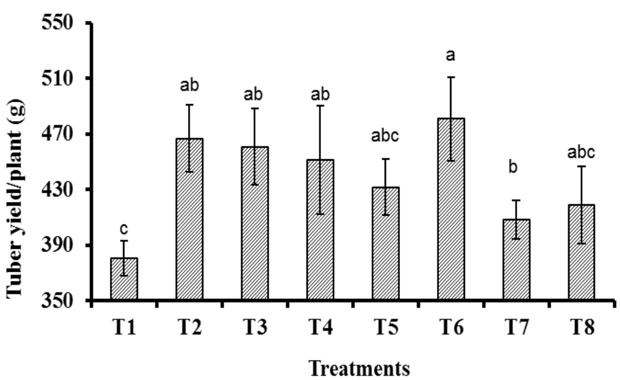

Figure 3: Effect of seaweed extract on tuber yield plant^{-1} of potato cv. Sante. Treatments sharing same letter(s) do not differ significantly. LSD value ($P\leq0.05$) = 64.170

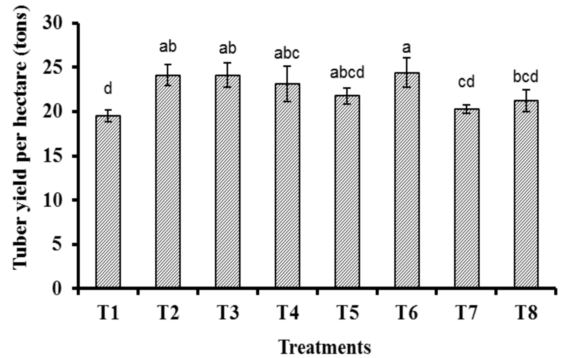

Figure 4: Effect of seaweed extract on tuber yield ha^{-1} of potato cv. Sante. Treatments sharing same letter(s) do not differ significantly. LSD value ($P\leq0.05$) = 3.187

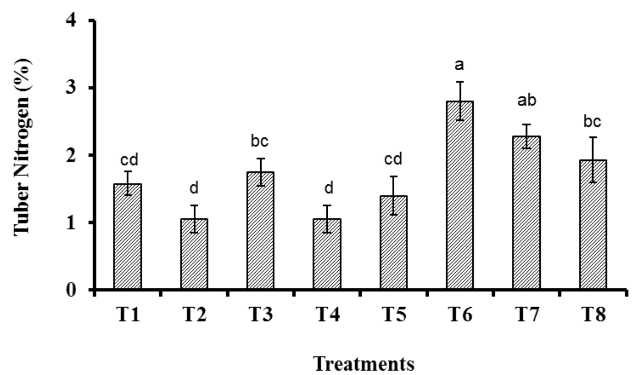

Figure 5: Effect of seaweed extract on nitrogen content (%) of potato cv. Sante. Treatments sharing same letter(s) do not differ significantly. LSD value ($P\leq0.05$) = 0.688

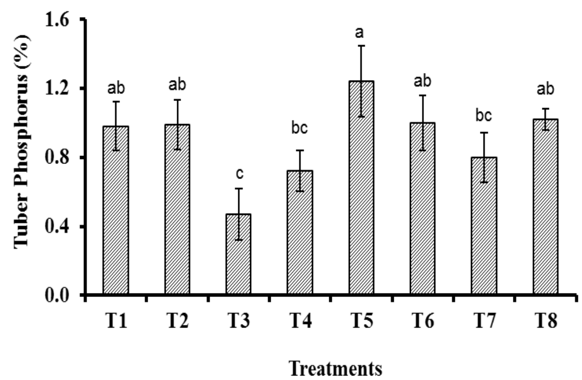

Figure 6: Effect of seaweed extract on phosphorus content (%) of potato cv. Sante. Treatments sharing same letter(s) do not differ significantly. LSD value ($P\leq0.05$) = 0.412

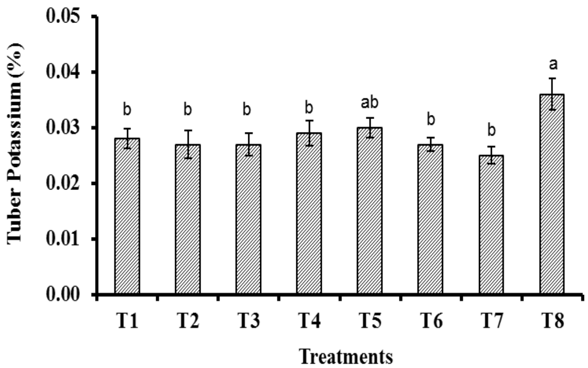

Figure 7: Effect of seaweed extract on potassium content (%) of potato cv. Sante. Treatments sharing same letter(s) do not differ significantly. LSD value ($P \leq 0.05$) = 0.006

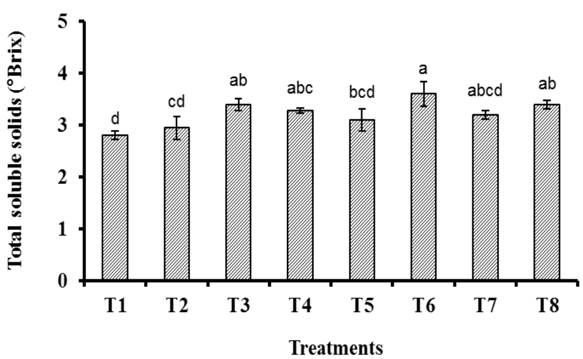

Figure 8: Effect of seaweed extract on total soluble solids (˚Brix) of potato cv. Sante. Treatments sharing same letter(s) do not differ significantly. LSD value ($P \leq 0.05$) = 0.425

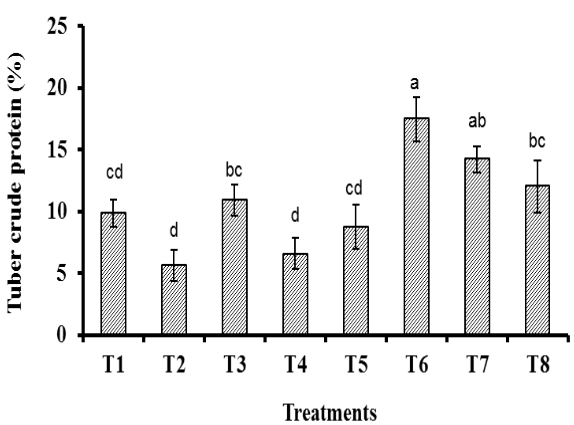

Figure 9: Effect of seaweed extract on protein content (%) of potato cv. Sante. Treatments sharing same letter(s) do not differ significantly. LSD value ($P \leq 0.05$) = 4.305

The use of seaweed extract significantly increased N, P and K concentrations in tubers. The maximum nitrogen content was 2.80% in tubers obtained from T_6 (spray at 30 and 60 days after planting) whereas, 1.58% with control (Figure 5). Phosphorus contents were also significantly influenced by seaweed extract application. Highest phosphorus content (1.24%) was observed in tubers of plants treated with T_5 (spray at 30 and 45 days after planting) while lowest content (0.47%) was noted with T_3 (spray at 45 days after planting) (Figure 6). Concentrations of potassium in the potato tubers also increased by seaweed extract treatment. Highest potassium content (0.036%) was observed in tubers where extract was applied at 30, 45 and 60 days after planting (T_8) and lowest content (0.025%) was noted with T_7 (spray at 45 and 60 days after planting) (Figure 7).

The data of various biochemical parameters showed a significant difference among treatments. In potato tubers, the maximum value of TSS obtained was 3.60˚Brix where seaweed extract was sprayed at 30 and 60 days interval while minimum TSS was 2.80˚Brix in control (Figure 8). The maximum crude protein content in tuber was 17.50% in the plants that had been treated with T_6 (spray at 30 and 60 days after planting) whereas, 6.57% protein content was noted in tubers treated with T_2 (spray at 30 days after planting) (Figure 9).

Discussion

Foliar application of seaweed extract produced a measurable response in potato crop. The results indicated that plants treated with lower concentrations of seaweed extract showed higher growth, yield, mineral contents and biochemical constituents against control. Improvement in growth may be due to the presence of certain growth promoting constituents in the extract. Similar observations have also been recorded in former studies by different renowned researchers. Highest stimulated seedling growth at lower concentrations of padina extract was measured in *Cajanus cajan* and *Vigna radiata* by Mohan *et al.* (1994) and Kumar *et al.* (1993), respectively. The potential of seaweed extract to enhance growth might be due to the presence of nutrients (Challen and Hemingway, 1965). Moreover, Mawgoud *et al.* (2010) found the matching results in watermelon treated with seaweed extract.

Results presented regarding potato yield validate the findings of Abetz and Young (1983) who had concluded that seaweed extract can improve the yield of potato crop. The obtained results are in line with findings of Fornes *et al.* (2002) who reported that yield of mango was increased by seaweed extract foliar application. The findings of the study also coincide with those of earlier studies carried out on *Zizyphus mauritiana* Lamk (Rao, 1991). In the same way, Selvaraj *et al.* (2004) reported that foliar application of seaweed extract was more effective in increasing the yield components of *Lycopersicon esculentum*. Results of potato tuber dry weight (%) are also in agreement with those obtained by Pise and Sabale (2010). Statistically significant differences observed for dry weight (%) by Fenugreek Sylvia *et al.* (2005) were also found similar as seaweed extract influenced the dry matter of plant.

Higher nutrient contents in the tuber also represent their quality. Nitrogen is one of the most important macronutrients, required by the plant and it influences the productivity and fruit quality (Torres *et al.,* 2004). Potassium has also been found to have high positive correlation with storage life of potato tubers (Whangchai *et al.,* 2001). Increase in nitrogen contents was observed in potato tubers treated with seaweed extract. As far as the phosphorus contents are concerned, they also increased in the potato tubers subjected to seaweed extract. Potassium contents were found to increase in the tubers of all treatments. Similar trend of increase in nutrient concentration was observed by Rathore *et al.* (2009) and Abd-Elmotty (2010) in soybean and mango, respectively, due to the application of seaweed extract. An increase in mineral nutrient concentration (N, P, K and Mg) of grapevines and cucumber was reported by Mancuso *et al.* (2006) in response to the application of seaweed extract which are in line with the findings of our study.

Application of seaweed extract significantly affected the biochemical constituents of potato tubers. Similar observations were recorded by Pise and Sabale (2010), who recorded the highest protein contents with the application of seaweed extract in fenugreek. It might be due to efficient uptake of most of essential nutrients by the seedlings (Anantharaj and Venkatesalu, 2002). The results regarding TSS are in accordance with those obtained by Spinelli *et al.* (2009) and Gobara *et al.* (2002).

Conclusion

This research revealed that seaweed extract applied at two stages of growth (30 and 60 days after sowing) is helpful in obtaining higher yields and quality potato tuber. Findings of this work may be helpful to further explore and assess the effect of seaweed extract on other commercial crops.

Acknowledgement

We are thankful to the Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan for financial assistance in the form of provision of plant material, chemicals and support of faculty members to complete the research and write-up of this manuscript.

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