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The effect of foliar application of seaweed extract on potato

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Abstract. The effect of foliar application of commercial seaweed extract on potato growth was studied in long-day conditions (60°10′ N 25°00′ E) characterized by a cool and short growing season. The results showed that neither the doses, 0, 5, 10, 20 l/ha nor the spraying 24, 45, 58 days after the emergence had any remarkable influence on potato growth and yield if the other preconditions of production are in order. Only small, although insignificant benefit could be obtained with application done three weeks after emergence, clearly before tuber initiation.

Index words: seaweed extract

Introduction

Seaweed extract as a foliar fertilizer has been noted to have various beneficial effects on many crops (Button and Noyes 1964, Blunden 1972). In particular, carbohydrate storage crops, such as a sugar beet, benefit remarkably from the use of seaweed extract (Blunden et al. 1974). The use of seaweed extract as a foliar fertilization has also produced a significant increase in the yield of ware potatoes (Blunden and Wildgoose 1977). In addition, seaweed extract is considered to improve the evenness of the size of the tubers, and to give a better cooking, eating and keeping quality. It is also thought to give protection from marginal frosts up to —2°C (Chase Organics 1979).

From the point of view of plant nutrition, the usual application rates of seaweed extract are so low that the active compound, or compounds, must be effective in very low concentrations. Brain et al. (1973) showed a high cytokinin activity, in a commercial seaweed extract, which is responsible for its many effects. In England, Blunden and Wildgoose (1977) sprayed seaweed extract (SM3) on potato crop at the height of 45 cm; this gave a yield increase similar to that with kinetin, which is a derivate of cytokinins.

Cytokinins are active at very low concentrations. They regulate a number of plant functions, including cell division (Koda and Okazawa 1983), protein and CO_2 metabolism, enzyme formation, leaf ageing and senescence, shoot elongation and fruit set (Torrey 1976). The observations of Blunden et al. (1974) that cytokinin treatment augmented the ratio of RNA to DNA suggest that a critical effect of cytokinins in senescence might be the maintenance of the protein synthesizing machinery, perhaps by regulating

RNA (Osborne 1962). Cytokinins also promote nutrient mobilization to the points at which they have been applied (Helgeson 1968).

On potatoes, cytokinins activate the tuber initiation and growth (Palmer and Smith 1969, Forsline and Langille 1976). In sprouting seed tuber, the content of cytokinins increases in the surrounding of sprout bases (Engelbrecht and Bielińska-Czarnecka 1972), and contributes to a break of dormancy (Hemberg 1970, Engelbrecht and Bielińska-Czarnecka 1972). Hartmans and van Es (1979) reported that kinetin, a derivate of cytokinins, increased the branching of sprouts on potato. The most beneficial effects on potato growth were reached at a kinetin concentration of 10^{-6}—10^{-7} M. The vigorous haulm growth which is caused by cytokinins, however, does not decrease the tuber yield (Badizadegan et al. 1972).

Cytokinins are readily absorbed through leaf surface. Thus they are active only as a foliar application. If cytokinins are applied to the soil, their effects are lost (Brain et al. 1973).

Most experiments with seaweed extract have been done in short-day conditions. Vigne and Li (1974), however, recorded that under long-day conditions the applied cytokinins stimulate the stolons to form as air shoots, which causes decrease in yield. The aim of this research was to study the effects of the foliar application of commercial seaweed extract on potato growth and yield under growing conditions characterized by a long day and a cool and short growing season.

Material and methods

The experiment was conducted by the Department of Plant Husbandry, Helsinki University, on Viikki Experimental Farm (60°10′ N 25°00′ E) in 1979. The soil was a sandy loam and fertilized with a drilling fertilizer using a chlorine free NPK (8-11-12) at a rate of 1 000 kg/ha (80 kg N/ha). Each plot had two rows, 70 cm apart and 10 m long in a split-plot design with three replications. The chitted seed of the variety Record (30—45 mm) was planted on May 24 with a semiautomatic planter at a distance of 30 cm, representing 60 seedtubers a plot. Weed control was accomplished with metribuzin (Sencor 0,75 kg/ha) four days after emergence on June 20. Hilling was done on June 28. The trial was harvested on September 27, after the natural senescence of haulms.

The seaweed extract was applied at three different times according to the growth stages as main plots: the crop height of 25 cm, the beginning of bloom, and two weeks after the beginning of bloom. The respective spraying dates were 24, 45 and 58 days after emergence on July 10, July 31 and August 15. The doses of seaweed extract SM3 (Chase Org. (G.B.) Ltd.) 0 (water), 5, 10 and 20 l/ha were in subplots. They were diluted 0:100, 1:100, 1:50 and 1:25 in water, respectively, and applied as a foliar spray with an experimental sprayer at a volume equivalent to 500 l/ha.

According to the analyses of the Finnish State Institute of Agricultural Chemistry (Valtion Maatalouskemian laitos 1979), the constituents of SM3 were as set out hereunder:

Nitrogen	(N)	(Kjeldahl)	0.14	%
Chlorine	(Cl)		2.50	%
Calcium	(Ca)		0.13	%
Magnesium	(Mg)		0.17	%
Iron	(Fe)		0.0037	%
Manganese	(Mn)		0.0007	%
Iodine	(J)		0.083	%
Selenium	(Se)		0.01	ppm

According to English analyses (James 1967, Jones 1978), seaweed extract SM3 also contains 0.04—0.24 % P, 0.64—2.51 % K, 0.02—0.6 % amino acids, 1—150 ppm vitamins and, e.g., Molybdenum, Vanadium, Germanium, and other elements, but less than 2 ppm in total. Undiluted seaweed extract SM3 has been estimated to have an activity equivalent to 125 mg/litre kinetin in aqueous solution (Blunden and Wildgoose 1977).

Growth and yield analyses

In order to investigate the development of a stand, the height of three plants was measured once a week from June 25 to the end of August. The maturity of haulms was evaluated on a scale of 0—10 (0 = green, 10 = dead) on September 3. After the harvest the yields were screened into three groups using 35 mm and 55 mm riddles. Samples, of about 5 kg, for laboratory analyses were taken at random. From the samples the specific gravity was determined using the under water weight. This was converted to a starch percentage according to the table of Halz and Bucholz. The laboratory samples were also used to determine the mean tuber weight by calculating the number of tubers in the sample. The DM content of tubers was determined from 200 g chopped tubers that was dried for 24 h at 100°C.

The statistical difference in each treatment was evaluated by the split-plot analysis of variance. In order to get more information about the effects of different spraying doses, the variances of subplots were dispersed into variance components: water-seaweed extract means and seaweed extract on the average (Table 1 and 2). The significance levels for the results are shown in the usual manner. Comparisons of means were done according to Tukey's HSD (Steel and Torrie 1960).

Results and discussion

When seaweed extract was applied about six weeks after emergence, an increase in stem length was noticed by Blunden and Wildgoose (1977). In this trial the height growth was very slightly affected by the spraying date or dose. In the beginning the potato vines grew a little faster on plots where 20 l/ha seaweed extract had been applied three weeks after emergence, when the plants were about 25 cm high, and the height growth was still vigorous. The influence was strongest a week after ap-

Table 1. The analysis of variance of the potato height growth and the haulm senescence.

Factor	Growth phase						
	between 1st—2nd spraying			between 2nd—3rd spraying		after 3rd spraying August 20	Haulm senescence
	July 16	July 24	July 30	August 6	August 13		
Spraying dates A	—	—	—	ns	ns	ns	ns
Spraying doses B	ns	o	ns	ns	ns	ns	ns
water — seaweeds	ns	*	ns	ns	ns	ns	ns
seaweeds	ns	ns	ns	ns	ns	ns	ns
AB	—	—	—	ns	—	ns	ns

Table 2. The analysis of variance of the potato yield and quality.

Factor	Tuber yield t/ha	Tuber size (mm) classes (%)			Ware yield t/ha	Tuber size g	DM %	Starch %
		<35	35—55	>55				
Spraying dates A	ns	ns	ns	ns	ns	ns	ns	ns
Spraying doses A	ns	o	ns	ns	ns	*	ns	ns
water-seaweed	o	*	ns	ns	o	*	ns	ns
seaweeds	ns	ns	ns	ns	ns	ns	ns	ns
AB	ns	ns	ns	ns	ns	ns	ns	ns
$HSD_{.05}$	—	0.3 %	—	—	—	11.9 g	—	—

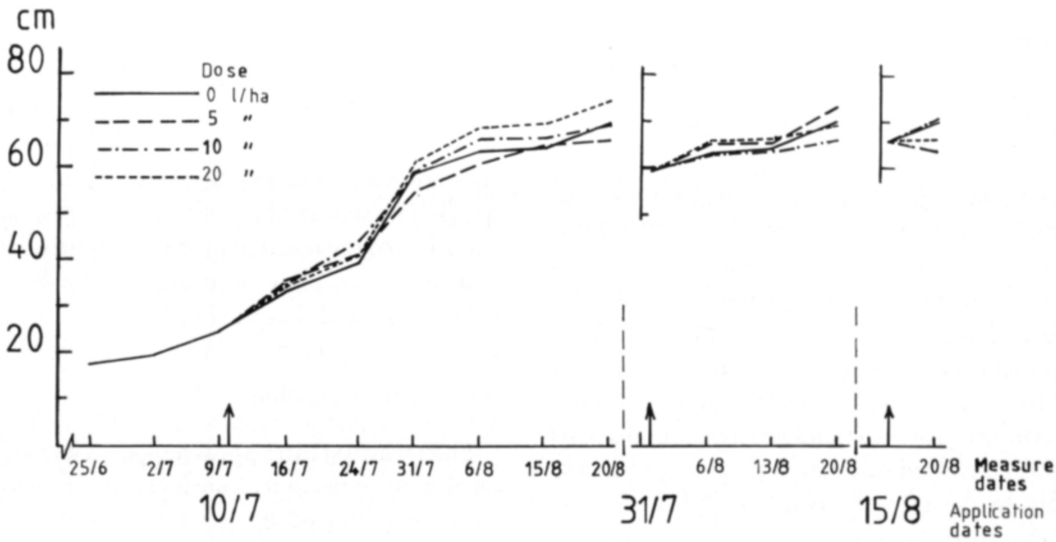

Fig. 1. The effects of seaweed extract on the height growth of potato haulms.

plication (Fig. 1). When the spraying was done at the same phase as BLUNDEN and WILDGOOSE (1977) used, about six weeks after emergence, in the beginning of bloom, or even two weeks later after the end of the height growth, there were no significant differences between application dates or doses.

According to VIGNE and LI (1974), cytokinins — the most important compound of seaweed extract — easily stimulate the stolons of potato crop to form air shoots under a long day. This trial included no estimation of shoot or tuber number. However, the small, although insignificant, acceleration of senescence was seen in potato sprayed with seaweed extract (Table 3).

The foliar spray of SM3 seaweed extract did not produce any significant increase in the potato yields at any spraying dates or doses (Fig. 2). In this respect the results are similar to those of DWELLE and HURLEY (1984), obtained in Aberdeen, Idaho, USA with cv. Russet Burbank; in this study foliar application of cytokinins, in seaweed extract or as kinetin, did not produce any measurable response. In the study of DWELLE and HURLEY (1984), the best time for application, however, was later — the 2-week period directly following tuber initiation — than in this study where the

Table 3. The effects of seaweed extract on the senescence of potato haulms (0 = green, 10 = dried).

Doses l/ha	Application date			Mean
	July 10	July 31	August 15	
5	5.7	4.3	5.3	5.1
10	5.7	5.3	5.3	5.4
20	5.7	5.3	5.3	5.4
Mean	5.7	5.0	5.3	5.3
Untreated				5.1

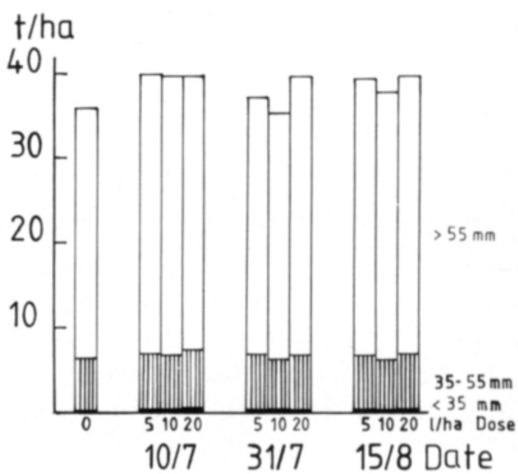

Fig. 2. The effects of seaweed extract on the tuber yield and its size distribution.

Table 4. The effects of seaweed extract on the tuber size (g).

Doses l/ha	Application date			Mean
	July 10	July 31	August 15	
5	96.9	93.8	92.0	94.2
10	108.5	107.5	97.2	104.4
20	99.7	96.2	105.1	100.3
Mean	101.7	99.2	98.1	99.6
Untreated				107.2

Table 5. The effects of seaweed extract on ware yield (t/ha).

Doses l/ha	Application date			Mean
	July 10	July 31	August 15	
5	39.60	36.60	39.00	38.40
10	39.33	34.90	37.57	37.27
20	39.21	39.30	39.36	39.29
Mean	39.38	36.93	38.64	38.32
Untreated				35.63

Table 6. The effects of seaweed extract on the DM-content of tubers (%).

Doses l/ha	Application date			Mean
	July 10	July 31	August 15	
5	20.4	21.3	20.4	20.6
10	20.7	21.1	21.6	21.1
20	19.6	21.0	20.3	20.3
Mean	20.1	21.1	20.8	20.7
Untreated				21.0

only benefits, although slight, were reached with application done three weeks after emergence, clearly before tuber initiation.

In disagreement with the results given by BLUNDEN and WILDGOOSE (1977), the foliar applications of seaweed extract gave, on average, a higher proportion of tubers under 35 mm ($P < .05$). This phenomenon was the strongest on the plots sprayed at height of plants about 25 cm. Similarly, the average tuber size also was smaller (Table 4). The differences between the doses of seaweed extract can be considered to be minimal. Because of the very small proportion of tubers under 35 mm, the ware yields (tubers over 35 mm) nearly equally followed the gross yields (Table 5).

According to BLUNDEN and WILDGOOSE (1977), the type of response expected from a plant treated with a cytokinin suggests that carbohydrate storage crops would benefit from foliar application of seaweed extract. Trials on sugar beet showed that the plants treated with seaweed extract had a higher root-sugar content than the control plants (BLUNDEN et al. 1974). In this study, the applied seaweed extract had no effect on the specific gravity or the dry matter content of tubers (Table 6). DWELLE and HURLEY (1984) also reported that a foliar application of a commercial seaweed extract, CYTEX, in a seven-year study had no significant effect on the specific gravity of potato in any trial year. HUMPRIES (1958) reported that the synthetic cytokinin, kinetin, even depressed both the leaf area and dry matter production of plants of Majestetic potatoes.

The results of the experiment show that in long-day conditions, foliar fertilization with seaweed extract has hardly any economical importance if the other preconditions of production are in order. Although the seaweed extract was used in nearly the double amount of the recommended application of 11 l/ha, the good status of nutrients in soil was able to cover the effects of the seaweed extract. In this respect, the results agree with the study of DWELLE and HURLEY (1984). Some Finnish trials with a foliar fertilization (ANON 1979, 1983, 1984) also show that, in connection of a balanced base fertilization of NPK, seaweed extract given as a foliar application has very slight effects on the yields and starch contents of starch potato.

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SELOSTUS

Merileväuutteen vaikutus lehtilannoitteena perunan satoon

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Merileväuutteen käytön lehtilannoitteena on havaittu tuottavan monia edullisia vaikutuksia useiden viljelykasvien kasvuun ja satoon. Erityisesti runsaasti hiilihydraatteja varastoivien kasvien kuten sokerijuurikkaan on todettu hyötyvän merkittävästi merileväuutelannoituksesta. Eräänä selityksenä merileväuutteen hyviin vaikutuksiin kasvien sadonmuodostuksessa on esitetty sen korkeaa sytokiniinipitoisuutta. Perunassa sytokiniinit mm. voimistavat mukulanmuodostusta ja varsiston kasvua sekä parantavat ravinteiden hyväksikäyttöä.

Merileväuutteen käyttöä perunan lehtilannoitteena tutkittiin Viikissä 1979. CHASE SM3 -merileväuutteen käyttömäärät vastasivat 0, 5, 10 ja 20 l:aa/ha sekoitettuna 500 l:aan vettä/ha. Käsittelyajankohdat olivat 24, 45 ja 58 päivää taimettumisesta. Koe osoitti, että hyvissä kasvuoloissa käytettäessä keväällä istutusvaiheessa tasapainoista lannoitusta (1 000 kg Ylkv/ha) merileväuutteen hyöty lehtilannoitteena on hyvin vähäinen. Vaikka uutetta käytettiin lähes kaksinkertainen annos (20 l/ha) suositellusta (11 l/ha), kasvualustan luontaisesti hyvä ravinnetila kykeni peittämään merileväuutteen mahdolliset lehtilannoitusvaikutukset. Ainoa vähäinen hyöty saavutettiin, kun käsittely suoritettiin kolmen viikon kuluttua taimettumisesta, vielä selvästi ennen mukulanmuodostuksen alkamista.