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Effect of Foliar and Drench Applications of Acetyl Salicylic Acid on Control of *Rhizoctonia solani* and on Dry Matter Production and Partitioning of Potatoes

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Abstract: Different concentrations of acetyl salicylic acid 1, 5 and 10 mM were applied through soil drench and foliar application at weekly intervals starting from emergence of the plants to investigate the effect of ASA on the control or *Rhizoctonia solani* and on general growth responses. Application of ASA did not influence the development of stem canker. Increasing concentrations of ASA produced reductions in tuber fresh weight and in total and component part dry weights. A concentration of 10 mM increased main stem numbers significantly, although this concentration was some what phytotoxic.

Key words: Acetyl salicylic acid, *Rhizoctonia solani*, potato

Introduction

Rhizoctonia solani which is a seed borne and soil borne pathogen of potatoes, affects the marketable yield and quality of tubers thus causing economic losses. It produces sclerotia (black scurf) on progeny tubers, which are the imperfect stage of the fungus *Thanatephorus cucumeris* and the seed tubers bearing sclerotia are an important source of infection (Weinhold *et al*., 1978). This can be decreased by treating the seed tubers with a fungicide that stops the mycelial growth of the pathogen.

Salicylic acid affects numerous processes in plants such as regulation of heat and odour production in thermogenic lilies (Raskin *et al*., 1987; 1989; 1990) and flower induction in Lemna species (Khurama and Mahashwari, 1978). It is also recognized as a key molecule in defense responses of plants like Systemic Acquired Resistance (SAR) and induces Pathogenesis-Related (PR) proteins in dicotyledonous plants including potato (White, 1983). Some of these inhibit pathogen growth *in vitro* (Mauch *et al*., 1984). Salicylic acid also promotes the biosynthesis of tuberonic acid (TA) or jasmonic acid (JA) which result in tuber inducing activity in potato (Koda *et al*., 1992).

A number of researchers have investigated the role of SA in controlling diseases on various plants but no one has studied its effect on stem canker and black scurf (*R. solani*). Recently some studies have now been undertaken on soft rot (*Erwinia carotovora*, spp. carotovora) of potato (Palva *et al*., 1994; Lopez-Lopez *et al*., 1995). As these diseases can cause a major loss to the crop in the field as well as in store, their control is essential. The aim of the project was to assess the effect of acetyl salicylic acid on the growth and disease resistance of potato CV. Estima.

Materials and Methods

A factorial combination of four levels of ASA and two methods of application (drench and foliar) were employed. Treatments were randomized within the blocks. Each block consisted of eight pots, one per treatment combination. Seed tubers (CV. Estima) affected with black scurf were selected from the size range 40-45 mm, placed in wooden trays and stored in a temperature-controlled cabinet at 14°C constant temperature and provided with artificial strip lighting for 12 hours a day. These tubers were taken out from the cabinet after 8 days and moved to another cabinet at 4°C . After 52 days, these tubers were taken out and scored according to disease severity, i.e., the presence of sclerotia on the surface of the tubers. A severity scale of 0-3 was used in which 0 =uninfected, 1 = slight infection, 2 = moderate infection, 3 = severe infection. In replicate 1, severely diseased tubers (scored-3) were used whereas in replicates 5 and 6 slightly infected tubers were used. The tubers were planted singly in 17.5 cm plastic pots, volume 4.51, with the tuber apex 6 cm below the rim and filled with standard growing medium (John Innes No.2). Then these were transferred to an unheated glasshouse. Pots were irrigated daily from the top of the pot until plant emergence. Thereafter, plastic saucers underneath the pots were filled daily with water to the brim. The different concentrations of ASA i.e., 1, 5 and 10 mM applied on a weekly basis from complete emergence of plants in all pots. In the case of the control, distilled water was applied. Foliar treatment was achieved using a hand-held sprayer which wetted the foliage to the point of run-off. The quantity of solution used in foliar application was measured every time by subtracting the remaining volume from the total quantity of the solution. Approximately 52 ml solution per pot was applied at initial growth stages but later on 123 ml solution per pot was applied. For the drench application, during initial stages of growth, 250 ml of solution was applied per pot directly to the soil surface but at the later stages, 300 ml per pot was used.

Observations and measurements: Plant emergence was recorded twice a week until plants had completely emerged in all pots. Plant height (cm) was recorded on a weekly basis. Leaf area of five leaves per plant was measured by a Delta-T leaf area meter. After harvesting the plants were separated into roots, tubers, leaves and stems. The number and fresh weight of tubers <25, 23-35 and >35mm were recorded. The number of main stems, number of secondary stems, number of stolons and stem canker score were recorded. The stem canker score was taken from the mean of all stems assessed on a 0-3 scale as follows:

0 = no visible damage.
1 = slight infection (less than 1/3 of the stem circumference exhibiting a canker lesion).
2 = moderate infection (1/3-2/3 of the stem circumference exhibiting a canker lesion).
3 = severe infection ($>2/3$ of the stem circumference exhibiting a canker lesion).

Subsequently, samples were dried in an oven at 80° C for 48 hours. After that, dry weights of tubers, roots, stems and leaves were recorded.

Results and Discussion

Plant height (cm): There was no effect of method of application on plant height. However, the highest concentration of ASA reduced it significantly ($P<0.05$) throughout the period of growth (Table 1).

Number of stems per plant: There were no significant treatment effects on the number of main stems or the number of secondary stems. Total number of stems is given in Table 2.

Number of stolons per plant: Stolons were separated into healthy and diseased, i.e., showing signs of stem canker. The number in each category was analyzed separately, as was the total stolon number. Treatments had no significant effect on any of these counts. On average, approximately 9% of all stolons were diseased. Total stolon numbers are given in Table 2.

Stem canker score (0-3 scale): Levels of stem canker were disappointingly low in all treatments. There was no significant effect of acetyl salicylic acid concentrations or their methods of application on stem canker score. Replicates did not differ significantly although there appeared to be slightly more disease in replicate 1 (Table 2). Further analysis of the data failed to detect any significant block x treatment interaction as expected given the very low levels of disease. This confirmed the absence of any block effect. The same conclusion was drawn for black scurf incidence.

Black scurf incidence (0-3 scale): Incidence and severity of black scurf on progeny tubers was low and a high degree of variability was encountered (Table 2).
There were no significant effects of acetyl salicylic acid concentrations or their methods of application on the incidence of black scurf.

Total number of tubers per plant: Tuber numbers in all size grades were analyzed separately but no significant effects were identified. As shown in Table 2, variation between treatments for total tuber number was relatively small and again no significant effects were detected.

Tuber fresh weight: Data for total tuber fresh wight are given in Table 2. Highly significant effects of concentrations were found and also differences occurred between the methods of application, primarily at the highest concentration of ASA. Total fresh weight decreased with each increase in ASA concentration with even the 1 mM concentration having a significant effect. Total fresh weight was consistently higher in the drench treatments but the biggest difference occurred where 10 mM ASA concentration, the drench also reduced weight substantially but the effect was significantly greater where ASA was applied to the foliage.
Effects of ASA concentration were not significant for weight of smaller tubers, i.e., <45mm (Table 2). However, the larger size showed a substantial reduction at 10 mM in both drench and foliar treatments. In this size fraction alone, the drench treatments gave lower weights than the foliar treatments.

Tuber dry matter percentage: There was a highly significant interaction between concentration of ASA and method of application. Applied as a drench, there was relatively little variation between concentrations, but as a foliar treatment, TDM % decreased substantially at the 10 mM concentration (Table 2).

Total leaf dry weight (g) per plant: As indicated in Table 2 there was a significant reduction overall in leaf weight with increasing ASA concentration. However, a significant interaction occurred in that this reduction with increasing concentration was relatively slight in the foliar treatments but very pronounced when chemical was applied as a drench.

Above gerund stem dry weight per plant: This was reduced, especially in the drench treatment, with increases in ASA concentration (Table 2).

Below ground stem dry weight (g) plant: Table 2 indicates that in both methods of application, increasing concentrations of ASA decreased below ground stem dry weight significantly. The drench treatments overall gave a lower dry weight.

Total tuber dry weight (g) plant: Acetyl salicylic acid decreased total tuber dry weight per plant through both methods of application (Table 2). There was little effect of 1 mM ASA compared with the untreated control but the higher concentrations reduced tuber dry weight substantially. The effect was particularly marked with foliar application in which the 10 mM concentration reduced tuber weight by 44 % compared with the control. The same comparison in the drench treatments reduced tuber weight by 18%.

Total dry weight (g) per plant: Similar responses were found for total weight. Again there was a significant interaction between main effects. Both 5 and 10 mM concentrations reduced dry weight significantly but the effect of the highest concentration was more damaging when applied as a foliar spray (Table 2).

Specific leaf area ($cm^2\ g^{-1}$): The main effects showed a large and significant interaction again as the result of the response to the highest ASA concentration. Applied as a drench, this concentration gave the highest specific leaf area, but the lowest when applied to the foliage (Table 2).

Total leaf area (cm^2) per plant: Increasing ASA concentrations significantly reduced total leaf area (cm^2). In drench treatments, leaf area was greater than in foliar treatments (Table 2).

Harvest index: There was a highly significant interaction between main effects for this parameter. 10 mM ASA applied as a drench significantly increased harvest index compared with the control but applied as a foliar treatment, this concentration reduced harvest index significantly. The other two concentrations did not differ significantly from the control (Table 2).
Treatment with salicylic acid and acetyl salicylic acid has been shown to induce a number of plant growth responses including reduced transpiration, flower induction and increased seed yield in certain grain legumes (Raskin, 1992). In the experiment, the effect of application of ASA on growth were in most cases negative. ASA increased main stem numbers significantly when applied at the 10 mM concentration but effects on total stem numbers were not significant.

Table 1: The effect of drench and foliar application of acetyl salicylic acid on plant height (cm) of CV. Estima at different assessment dates

Acetyl salicylic acid concentration	Assessment dates								
	7th June, 1996	14th June, 1996	21st June, 1996	28th June, 1996	5th July, 1996	12th July, 1996	19th July 1996	26th July 1996	2nd August 1996
0 mM	8.62	28.73	43.32	45.38	45.69	46.10	46.36	46.47	46.60
1 mM	7.98	27.25	40.10	43.17	43.92	44.13	44.29	44.29	44.38
5 mM	9.09	28.33	41.44	43.71	43.98	44.30	44.36	44.44	45.51
10 mM	7.08	23.73	37.80	39.67	40.33	40.85	40.93	41.05	41.07
SE	0.631	1.262	0.979	1.115	1.099	1.117	1.114	1.122	1.109
P	NS	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Drench	8.59	28.26	40.43	42.77	43.30	43.53	43.75	43.77	43.85
Foliar	7.79	25.76	40.90	43.19	43.66	44.16	44.22	44.33	44.42
SE	0.44	0.89	0.69	0.79	0.78	0.79	0.79	0.79	0.78
P	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Nom significant

Table 2: Effect of drench and foliar application of acetyl salicylic acid on control of *Rhizoctonia solani* and growth of potatoes

Acetyl salicylic acid concentration		o mM	1mM	5mM	10mM	SE	P
Number of stems per plant	Drench	4.00	3.50	2.50	4.00	0.241	NS
	Foliar	2.67	2.33	3.50	3.83	0.241	NS
Total number of stolons per plant	Drench	13.50	13.00	12.33	13.17	0.685	NS
	Foliar	11.67	13.33	11.67	13.83	0.685	NS
Stem canker severity score (0-3 scale)	Drench	0.00	0.18	0.25	0.24	0.065	NS
	Foliar	0.21	0.00	0.00	0.00	0.065	NS
Black scruf severity score (0-3 scale) on progeny tubers	Drench	0.19	0.18	0.15	0.15	0.044	NS
	Foliar	0.20	0.07	0.15	0.02	0.044	NS
Total number of tubers per palnt	Drench	16.00	12.67	14.17	16.17	0.739	NS
	Foliar	15.17	18.83	13.33	13.33	0.739	NS
Total tubers fresh weight (g) per plant	Drench	449.68	437.43	392.28	365.71	3.283	<0.001
	Foliar	425.75	405.42	377.33	269.58	3.283	<0.001
Fresh weight (g) of tubers 25-35 mm per plant	Drench	136.07	113.93	126.68	165.20	12.154	<0.05
	Foliar	92.77	120.30	83.10	62.12	12.154	<0.05
Fresh weight of tubers 35-45 mm per plant	Drench	136.07	113.93	126.68	165.20	12.154	<0.05
	Foliar	171.45	140.23	137.08	151.95	12.154	<0.05
Fresh weight of tubers 45-55 mm per plant	Drench	53.80	106.28	29.80	0.00	15.291	<0.05
	Foliar	131.65	114.08	143.27	37.25	15.291	<0.05
Tuber dry matter percentage	Drench	19.93	20.47	19.93	20.09	0.143	<0.001
	Foliar	18.90	19.15	18.33	16.65	0.143	<0.001
Total leaf dry weight (g)	Drench	9.25	9.18	7.66	6.99	0.102	NS
	Foliar	8.87	8.42	8.40	8.15	0.102	NS
Above ground stem dry weight (g) per plant	Drench	3.30	3.07	2.55	2.33	0.087	NS
	Foliar	3.18	2.83	3.28	2.93	0.087	NS
Below ground stem dry weight (g) per plant	Drench	3.60	3.38	2.85	2.17	0.067	<0.05
	Foliar	4.03	3.60	2.95	2.50	0.067	<0.05
Total tuber dry weight (g) per plant	Drench	89.63	89.45	78.08	73.48	0.790	<0.001
	Foliar	80.42	77.65	96.13	44.87	0.790	<0.001
Total plant dry weight (g) per plant	Drench	105.78	105.08	91.14	84.98	0.851	<0.001
	Foliar	96.50	92.50	83.77	58.45	0.851	<0.001
Specific leaf area (cm^2/g)	Drench	273.07	249.13	263.30	309.15	5.811	<0.001
	Foliar	252.13	262.52	293.83	209.88	5.811	<0.001
Total leaf area (cm^2/g)	Drench	2529.57	2278.50	2010.16	2166.40	54.61	<0.05
	Foliar	2240.47	2209.13	2013.29	1705.54	54.61	<0.05
Harvest index	Drench	0.85	0.85	0.86	0.87	0.002	<0.001
	Foliar	0.83	0.84	0.83	0.77	0.002	<0.001

NS = Non significant

Manipulation of main stem numbers is potentially valuable as it determines the number of tubers produced in field grown crops and hence, tuber size grading (Allen and Wurr, 1992).

However, this concentration produced reductions in tuber fresh weight and in total and component part dry weights which could be due to the phytotoxic effect of higher ASA concentration on plant growth (Palva *et al.*, 1994). In some cases, however, interesting interactions occurred between the drench and foliar applications. For example, the drench treatment resulted in a more negative effect on leaf dry weight and above-ground dry weight than the foliar applications, whereas for leaf area, it was the foliar treatment that produced the more negative effect at 10 mM. Generally, foliar treatments reduced below-ground dry weights more, whereas

drench treatments reduced above-ground weights to a greater degree. As a result, there was an interaction for harvest index which increased with ASA concentration when applied as a drench, whereas it decreased in the 10 mM foliar treatment.

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