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Evaluation of Herbicides for Potato Sprout Suppression Activity

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Herbicides including barban, embark, diuron, prometryne, simazine, atrazine, destmetryne, asulam, monuron and linuron are screened for potato sprout suppression activity. A potato sprout suppressant will be expected to inhibit growth of cress root, tomato shoot or potato tissue callus. It is observed that only embark shows pronounced inhibition of callus growth. Embark was found to be effective as a potato sprout suppressant at high application rate of 500mgkg^{-1}.

Key words: Sprout, Herbicide, Potato, Callus.

Introduction

Recently efforts were made to discover new potato sprout suppressants which will be superior to the existing ones (Oladimeji *et al* 1986). One way of developing a new potato sprout suppressant is to test all the available chemicals on potato tubers for potato sprout suppression activity. This approach would be expensive and impractical. Thus, these chemicals should undergo preliminary screening so that only the most promising will be tested on potato tubers.

It has already been observed that potato sprout suppressant can inhibit the growth of cress (*Lepidium sativum* L.) and tomato (*Lycopersicon esculentum*) (Danielson 1959; Leasure 1958; Oladimeji *et al* 1986). This property has been used in the screening of naturally produced volatile compounds for potato sprout suppression activity. The limitation of this screening procedure is that there may be a few chemicals which can produce significant inhibition on the cress or tomato test but do not possess adequate potato sprout suppression activity.

The use of excised potato buds as a screening technique has also not produced satisfactory results (El-Antably *et al* 1967; Hartmans and Van Es 1969; Van Es and Hartmans 1979). It is therefore necessary to develop another screening procedure which can be used to complement the earlier ones. By this it will be possible to arrive at the very promising chemical which can be tested on the potato tubers. Callus tissue is an ideal material for studies of non-photosynthetic growth and cell division (Wright and Northcote 1972). A potato sprout suppressant would be expected to inhibit growth in experiments with potato tissue callus. This assumption is the basis for the screening procedure proposed in the present study.

Chlorpropham and 2, 4 –D which are herbicides also behave as potato sprout suppressants (Martin 1972). The present work involves screening some common herbicides. Herbicides investigated included barban, embark, diuron, prometryne, simazine, atrazine, destmetryne, asulam, monuron, linuron and chlorpropham. The latter is already known to be a potent potato sprout suppressant and it is included to serve as a reference. The herbicides selected are those that were known to maintain varying degrees of vapour pressure at around 20^{0}C.

Materials and Methods

Barban and embark were obtained from Fisons Ltd., Agrochemical Division Essex; Diuron was purchased from Pfaltz and Bauer, Inc. Stamford, Conn. Technical grades of prometryne, simazine, atrazine and destmetryne were supplied by Ciba-Geigy AG, Basle. Asulam was obtained from the National Physical Laboratories, Chemical Standards Division, Teddington, Middlesex. Monuron was obtained from ICN, K & K Laboratories Inc. Ohio. Linuron was purchased from the Field Instruments Co. Ltd. Middlesex, England.

Cress and tomato bioassay. Stock solutions (1g l^{-1}) of each chemical to be assayed were prepared in ethanol. An exact volume of solution was pipetted onto the petri dish lid of a 9cm diameter. The lid was placed in a fume cupboard for 30 min to allow the solvent to evaporate off, resulting in a film of crystalline deposit of the test chemical on the lid surface. A filter paper was placed on the base of the dish, 25 test seeds were added and the paper moistened with 3cm^{3} and 5cm^{3} deionised water for cress and tomato seeds respectively. The seeds were then evenly spaced around the dish before chemically coated lid was replaced. The dishes containing cress and tomato seeds were incubated for 72 and 144 h respectively, after which cress root and tomato shoot were measured. Each chemical was employed at levels of 0, 0.1, 0.5 and 1.0 mg/dish.

Preparation of Nutrient Medium. The medium was a modification of that used by the previous workers (Anstis and Northcote 1973; Gavinlertvatana and Li 1980; Ingram and Robertson 1965; Kikuta *et al* 1977; Murashige and Skooge 1962). All the stock solutions were 100 times more concentrated than required for the nutrient medium. To prepare the nutrient medium, 10cm^3 of each was put in a litre flask. Into the flask was also added 2 g solid N.Z. amino (pancreatic hydrolysate of casein that contains in the form of mixed amino acids and peptides, all the amino acids originally present in the casein) and solid 20g sucrose. The mixture was made to the mark with deionised water. The pH of the mixture was adjusted to approximately 6.1 with a few drops of either M sodium hydroxide or M hydrochloric acid. Mixture (300cm^3) was put in each medicine bottle (400cm^3) and 2.2g powdered agar added and the total mixtures allowed to stay for about one hour before autoclaving.

Chemical application and callus growth. The chemical application and callus growth took place in a room sterilized with ultraviolet light. Cylinders of tissue were obtained by using a 6mm cork borer along the long axis of each tuber. A razor assembly cutter (4 mm apart) was used to cut the cylindrical tissue into discs of approximately 4mm thickness. From each of the prepared ethanol solutions of the test chemicals having concentrations 300 mg cm^3, 1500 mg cm^3 and 3000 mg cm^3 was taken 1.0 cm^3 and added to each medicine bottle to produce media containing 1 mg, 5 mg and 10 mg chemical per cm^3 respectively. The media were then put in petri-dishes and left overnight to solidify. Two potato tissue discs were placed in each petri-dish. Twelve petridishes were used for each treatment. The petri-dishes were incubated in the darkness at 25^{0}C and the mass of callus formed estimated after three weeks.

Assessment experiment with potato tubers Alumina (25g) was put into a 39g screw top glass jar, followed by the necessary amount of the test chemical. Solid chemicals were introduced using acetone. The jars were sealed and mixed overnight using an end-over-end shaker. The prepared formulations were dusted evenly over each 10kg sample held in 394 mm x 298mm x 152mm cardboard boxes with loosely fitting lids at two application rates of 100 mg kg^{-1} and 500 mg kg^{-1}. Untreated control samples were dusted with 25g alumina. The storage took place in a temperature controlled room at 10^{0}C. At the end of the 15 weeks treatment period, sprout growth in each 10kg sample was assessed according to Goodwin *et al* (1969) and Wurr (1978). The length of the longest sprout on 50 tubers from each box was recorded. The total number of replications from each treatment is 100. The mass of sprout per unit mass of tuber was determined.

Results and Discussion

Asulam, barban and chlorpropham are carbamates. Asulam produced no significant inhibition in either the cress or the tomato tests. Barban produced no inhibition in the cress test but in the tomato test it produced significant inhibition at levels of 0.5 and 1.0mg. The herbicidal properties of carbamates depend mainly on oxidative phosporylation, RNA synthesis and protein synthesis (Moreland and Hill 1959; Wessels and Van Der Veen 1959). Asulam and barban are less active in inhibiting seed germination and growth when compared with chlorpropham (Table 1). This may be due to the fact that chlorpropham is more easily absorbed by the germinating

Table 1
Effect of herbicides on cress root growth and tomato shoot growth at 32°C.

Chemical	Rate (mg/dish)	Cress root length (% of control)	Tomato shoot length (% of control)
Barban	0.1	97	78
	0.5	82	71[a]
	1.0	90	63[a]
Embark	0.1	99	92
	0.5	119	84
	1.0	56[a]	41[a]
Diuron	0.1	110	91
	0.5	111	97
	1.0	89	93
Prometryne	0.1	64	76
	0.5	102	48[a]
	1.0	71	43[a]
Simazine	0.1	100	107
	0.5	95	112
	1.0	105	91
Atrazine	0.1	62	94
	0.5	79	80
	1.0	68	87
Destmetryne	0.1	73	90
	0.5	85	76
	1.0	60	72
Asulam	0.1	92	93
	0.5	76	101
	1.0	82	94
Monuron	0.1	115	72
	0.5	137	88
	1.0	122	84
Linuron	0.1	70	95
	0.5	102	89
	1.0	66	78
Chlorpropham*	0.1	33[a]	9[a]
	0.5	26[a]	O[a]
	1.0	14[a]	O[a]

[a] Singificantly different from control at the 5% level.
*a known potato sprout suppressant.

Table 2
Effect of herbicides on the potato tissue callus growth

Chemical	Mean of fresh mass of callus + Disc (mg) Concentration of Chemical (μg per cm³) 1	5	10
Barban	302[a] (45)	288[a] (60)	250[a] (47)
Embark	248[a] (30)	230[a] (40)	210[a] (25)
Diuron	401 (60)	320 (41)	300 (46)
Prometryne	335 (55)	314[a] (48)	290[a] (58)
Simazine	310[a] (49)	292[a] (32)	281[a] (40)
Atrazine	380 (61)	345 (57)	320 (45)
Destmetryne	326 (46)	293[a] (36)	280[a] (18)
Asulam	332 (37)	284[a] (41)	279[a] (43)
Monuron	350 (59)	312[a] (46)	294[a] (56)
Linuro	300[a] (52)	288[a] (37)	280[a] (32)
Chlorpropham*	205[a] (52)	143[a] (30)	151[a] (19)

Initial mass of potato tissue disc is approximately 103mg
Control final fresh mass of disc plus callus is 366 ± 7mg.
Figures in the parentheses are the standard deviations over the results of 24 measurements.
[a] Values significantly different from control
* a known potato sprout suppressant.

Table 3
Influence of embark on the sprouts of potatoes (var. Record) stored for 15 weeks at 10°C

Chemical	Mean length of the longest sprout (mm)	Mass of Sport per tuber (mg g^{-1})
Control	175 (54)	130.7
Embark (100 mg kg^{-1})	61[a] (27)	35.1
Embark (500 mg kg^{-1})	17[a] (16)	6.0

Figures in parentheses are standard deviations
[a] values significantly different from control at 5% level.

seeds (Ashton and Helfgott 1966; Helfgott 1969). Asulam may be expected to behave differently from either barban or chlorpropham because it is a carbamate as well as a sulphonamide. Barban and asulam produced significant inhibition of callus growth but not as much as that of chlorpropham (Table 2). Simazine, atrazine and destmetryne produced no significant inhibition in the cress and tomato tests whereas prometryne produced significant inhibition at levels of 0.5 and 1.0mg in the tomato assay. Triazines are primarily absorbed by the roots and translocated to the leaves which are the sites of action wherever transpiration is going on (Biswas 1964; Sikka and Davis 1968). Their mode of action is by inhibition of the Hill reaction of chloroplasts or blockage of photosynthesis (Ashton and Grafts 1973). As the Hill reaction in chloroplast or photosynthesis is absent during the seed germination in the dark (Moreland *et al* 1959), the triazines can inhibit seed germination by disrupting respiration and amylase activity (Shaukat 1976). This may account for the inhibition observed in cress and tomato tests. The atrazines produced not much inhibition of callus growth. Diuron herbicides produced no significant inhibition in cress and tomato tests. Urea herbicides are systemic selective herbicides which are primarily absorbed by roots (Crafts 1967; Smith and Sheets 1967) and in some cases absorption may take place through the shoot (Borner 1965; Knake and Wax 1968). The site of action of these chemicals is generally considered to be in the chloroplast (Bucha and Todd 1951). Urea herbicides can therefore not affect to a large extent the germinating seeds until chloropalsts or leaves have been formed. Monuron and Linuron produced only a little inhibition of callus growth. Embark produced significant inhibition in both cress and tomato tests at the level of 1.0mg. Embark also produced the largest inhibition of callus growth apart from chlorpropham which is a popular potato sprout suppressant. These results indicate that embark could be said to have promise as a potato sprout suppressant, although perhaps high application rates may be necessary. This inference is confirmed from the results obtained on storing the potato tubers with embark (Table 3). High potato sprout suppression by embark occurs at the high application rate of 500 mg kg^{-1}. Embark also causes the rotting of potato sprouts. There is, therefore, limitation to the use of embark as a potato sprout suppressant since apart from high application rate, sprout rotting may encourage development of tuber disease. Further work needs to be carried out in order to determine the phytotoxic effects and residue level of embark when applied as a potato sprout suppressant.

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