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Stimulation of Potato Root Growth and Symbiont Establishment in Roots with Thiourea Treatment

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Soaking sprouted potato seed tubers in a 10^{-3}M thiourea solution, or soil application of thiourea 5 kg/ha, promoted larger bulk and deeper penetration of the plants' roots, and consequently a greater uptake of phosphorus from the soil. Higher concentrations of the chemical proved decidedly toxic to the viability of the seed tubers. Soil application was the most successful treatment in enhancing crop productivity; it also intensified infection of roots by vesicular-arbuscular mycorrhizae in spite of the ecological constraints, probably by a predisposition mechanism. The observed dichotomy of physiological responses in potatoes to thiourea treatment is discussed.

Key Words: Potato root growth, Thiourea treatment, Symbiosis

Introduction

Roots are the principal organs of plants that mediate in the transport of water, nutrients and metabolites from the growth medium to other parts of the plant. With a more extensive growth of roots, it is obvious that the amounts of substrates transported must be proportionately larger. Besides, deep penetration into lower soil strata by extending roots would stabilize the supply of water to the tops against sharp changes in the moisture content of top soil, brought about by environmental stresses and also help in recycling of nutrients from the subsoil to the rhizosphere. Although these physiological advantages of enhanced root proliferation were well recognized, practically little attention was paid to this important aspect of crop culture until the advent of the P-32 injection technique developed by Racz et al. (1964) to study the rooting behaviour of crop plants.

Feasibility of stimulation of root growth by treatment with any of the plant hormones, i.e., auxins, gibberellins or cytokinins, has not been conclusively established (Wareing & Phillips 1970). However, Poljakoff-Mayber et al. (1958) have reported that soaking lettuce seeds in 10^{-2}M thiourea solution resulted in more intense root growth in the plants raised. Use of thiourea to promote root growth in other crop plants does not appear to have been made so far.

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The potato is a shallow-rooted plant and so, only a small volume of soil is enclosed by its root system. The advantages of producing a larger bulk of roots, so as to entrap more volume of soil, are self-evident, considering that its full productivity potential has not yet been tapped. The results from experiments to study thiourea effects on root growth of potatoes are reported herein.

Lots of 200 seed tubers each of cv. Great Scot, possessing short, sturdy sprouts, were soaked for 1 hr or for shorter durations, in aqueous solutions of thiourea of molarities, in the logarithmic scale, −1.0, −1.5, −2.0, −2.5, −3.0, −3.5 and −4.0 (corresponding to 10^{-1} M, 3.16×10^{-2} M, 10^{-2} M, 3.16×10^{-3} M, 10^{-3} M, 3.16×10^{-4} M and 10^{-4} M respectively), after which they were planted out in the field; to the above 7 treatments were added an untreated control and two others, in which 5 or 10 kg thiourea per ha was blended with the fertilizer mixture made up of 275 kg urea, 950 kg single superphosphate and 170 kg muriate of potash (corresponding to 125 kg N, 150 kg P_2O_5 and 100 kg K_2O per ha) and then band-applied at planting. These 10 treatments, quadruplicated in an RBD, constituted the experiment. The field soil analysed poorly for phosphorus (7.3 ppm P extractible with Bray No. 1 reagent) and exhibited a high phosphate fixing capacity (Bache-williams index: 58). Ninety days after planting, 4 plants at random in each plot were injected with C.F. P-32 by the decapitation technique (Swaminathan 1977). After equilibration, the tops were cut at crown level and cores centred over the plant were taken and activities in the ashed aliquots from core segments corresponding to soil depths of 0–10 cm, 10–20 cm, 20–40 cm and 40–60 cm were assayed as before. The contents of P in leaves at this stage of growth were estimated by analysing homologous sets of leaves. The plant population in each plot as well as tuber yields were recorded at harvest.

No plant emerged from seed soaked in the decinormal solution; with the two lower concentrations, the germination was scrappy. On digging up seed tubers from vacant locations, they were found to be sound and sprouts intact, except that the meristem tips were moribund. The reason for poor germination could therefore be the toxicity of the chemical and not due to attack by pathogenic organisms, since thiourea is known to possess bacteriostatic effect (De Ritis & Scalfi 1946). This behaviour could be likened to the "blind eye" phenomenon observed by Swaminathan (1954) in cold-stored seed tubers of cv. Voran (of Dutch origin) and which was traced to the build-up of toxic concentrations of ethylene in the storage atmosphere. Viability could not be restored to them with any of the known techniques (Ramanujam et al. 1957) used to break dormancy in potatoes. The safest concentration from the point of viability conservation appears to be 10^{-3} M, the threshold lying somewhat higher; safety potential could be augmented further by curtailing the time of soaking, as even a 15 min duration was equally effective in respect of the benefits accruing. The higher dose of soil application was also slightly hazardous.

A significant increase in the total bulk of roots and its pervasiveness through the soil profile resulted from soak treatments or more conspicuously by dressing the soil with thiourea (table 1). There is a distinct indication that roots of treated plants penetrate into deeper soil strata; this is reflected by the photograph of untreated and treated plants harvested with the entire root system intact (figure 1). Phosphorus uptake and yield responsed followed same trends, but soil treatment at the lower rate was pre-eminently beneficial in all respects. However, thiourea treatment produced neither multiple shoots, nor any stem elongation.

Roots from plants dressed with thiourea

exhibited a captive yellow pigmentation; a similar observation was made by Mayer (1957) in the case of lettuce. As roots infected with vesicular-arbuscular mycorrhizae are also reported to develop a bright yellow colour (Gerfemann 1976), these roots were examined for the presence of infection by standard procedures, described by Phillips and Hayman, 1970. All the root samples from plots dressed with thiourea and about 40 to 60% of those from the safe soak treatments were confirmed to carry VA mycorrhizal infection to a greater or lesser extent (table 1). This effect could find at least two explanations: either that roots proliferating under the driving force of the chemical effect hit more spores of the organisms preparatory to infection, or alternately, presence of thiourea in the rhizoplane imposes certain pre-disposing conditions for the effective interaction between the spores and the recipient roots. As Swaminathan and Verma (1977) have found spores of VA mycorrhizae to be sparse in these soils, the first explanation is rather weak; further, it is doubtful if spore population is greater in deeper soil zones. If the pre-disposition

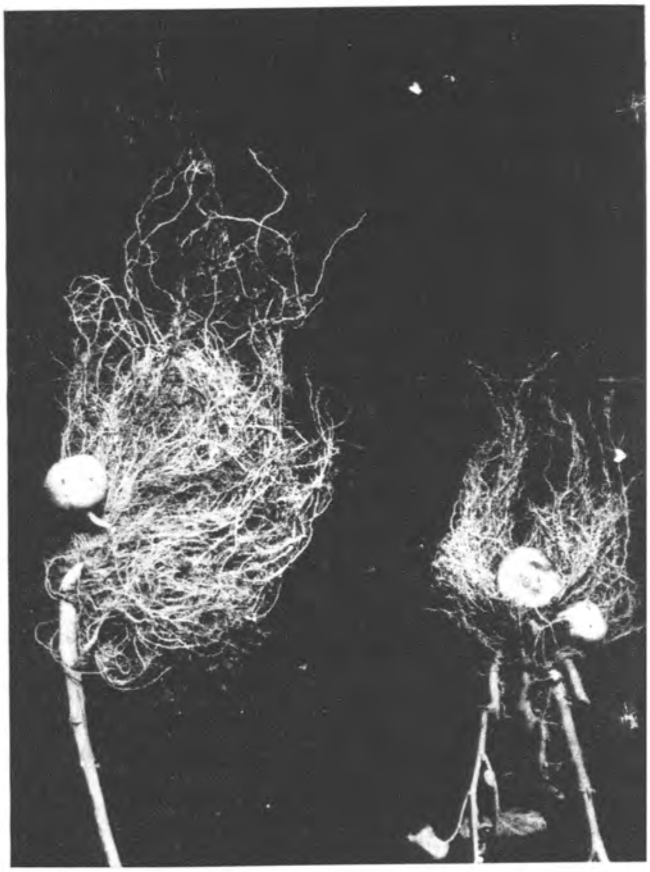

Figure 1

Table 1 *Responses of potatoes to thiourea treatment*

Concentration of thiourea solution in which tubers were soak-treated	Final stand %	Root dry wt. (kg/ha) detd. by P-32 injection at depths, cm				Root/ Shoot ratio	P in leaves %	Root infection mm/ 100cm	Yield of fresh tubers q/ha
		0-10	10-20	20-40	40-60				
Control	95	69	17	11	4	2.45	0.31	0.7	161
10^{-1}M solution	0	—	—	—	—	—	—	—	—
3.16×10^{-2}M ,,	11	47	9	2	—	1.34	0.48	2.5	37
10^{-2}M ,,	52	84	13	9	1	2.08	0.42	7.9	105
3.16×10^{-3}M ,,	79	128	48	23	8	3.81	0.44	11.3	148
10^{-3}M ,,	90	115	30	28	10	3.89	0.46	17.5	204
3.16×10^{-4}M ,,	97	99	30	19	3	2.77	0.41	8.8	172
10^{-4}M ,,	92	74	21	14	5	2.51	0.38	4.3	155
Soil application thiourea @ 5kg/ha	96	181	69	33	15	4.96	0.58	18.4	259
,, ,, @ 10kg/ha	81	112	45	23	19	3.81	0.49	15.5	211
C.D. 5%	12.8	17.4				1.07	0.09	5.4	39

theory is to be accepted, it is not clear how and on what milieu does the chemical act. It has also to be examined more critically whether partial sterilization of soil by thiourea is responsible for the observed effect. If proved, soil application thiourea holds great promise.

In conclusion, thiourea treatment appears to have two markedly different physiological effects on potatoes; at higher concentrations, i.e., $1\text{–}2\times10^{-1}$ M, it breaks the dormancy in freshly harvested tubers (Ramanujam et al. *loc. cit.*); these concentrations are however toxic to non-dormant tubers. At much lower concentrations, there is no effect on bud dormancy, but promotion of root growth preferentially results. Such a dichotomy in the physiological effect of thiourea has also been noted by a few earlier workers (Thompson & Kosan 1939, Mayer 1956); the results presented herein support their view that stimulation of germination is not a result of stimulation of growth, but these are two entirely separate processes.

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