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CHEMICAL CONTROL OF THE POTATO TUBER MOTH, *Phthorimaea operculella* (ZELLER) (LEPIDOPTERA: GELECHIIDAE) ON STORED POTATOES[1]

Adhanom Negasie and Tessema Megenasa[2]

ABSTRACT

An experiment was conducted to test the efficacy of five insecticides as protectants against the potato tuber moth on stored potatoes. Test samples were dipped in solutions of fenithrothion, decamethrin, diazinon, methamidophos, profenofos at concentrations of 10, 25, 300, 500 and 3750, respectively and a check dipped in plain water. The treated potatoes, exposed to infested tubers, were kept for 90 days in a room having a temperature of 20-25° C and 30-35% relative humidity.

Profenofos with a mean percent infestation of 2.33 gave significantly better control than the check and the remaining insecticide treatments.

Residue analysis for the insecticides in the treated potatoes after 90 days of storage indicated 6 ppm for diazinon and none for the other insecticides.

One of the principal limiting factors in the production and storage of potatoes is the potato tuber moth, *Phthorimaea operculella* (Zeller). At present no adequate methods have been devised to store seed and/or table potatoes free of this pest in Ethiopia. In most areas great quantities of potatoes are available during and for some weeks after the rainy season (June, July and August). But supplies soon dwindle and become limited later in the year resulting in large price fluctuations. It is obvious that tubers

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[1] Part of a thesis submitted by the senior author to the School of Graduate Studies, Addis Ababa University in partial fulfillment of the requirements of the M.Sc. degree.

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which are to be used for next season's planting need to be stored for some time. Elimination of infested tubers before strorage could minimize the risk of a total loss; but adult moths could migrate from field to store and cause damage therein (7). Destruction of such tubers in itself may not ensure clean potatoes.

To-date, chemical control is one of the most effective means of protection against this insect. Historically, a wide variety of chemicals and formulations have been used to protect potatoes in store. Fumigation with carbon disulphide (CS_2) was recommended more than 50 years ago by Stoward (10). Delassus (4) recommended paradichlorobenzine (PDB) which killed all larvae and freed tubers from infestation without affecting their germination. Methyl bromide (CH_3Br) was first tried to control *P. operculella* by Mackie and Carter (9). Walker and Anderson (11) reported fumigation of infested potatoes with this chemical and effective control of all stages was achieved with no residue problems.

DDT is the most widely used contact insecticide but the residue after six months was not completely removed by washing or boiling (1). Chandhuri (3) recommended the use of DDD which gave excellent protection to sound tubers and consequently much safer table potatoes than was the case with DDT. Another excellent contact insecticide, according to Lloyd (8) was Gamma BHC which gave complete protection to tubers directly dusted and stored in treated bags and boxes. However, its toxicity to higher animals was reported to be two and half times that of DDT (2). Al-Ali and Talhouk (1) recommended carbaryl for use on stored table potatoes on account of its lower mammalian toxicity than DDT and Gamma BHC. It is the objective of this experiment to compare the relative saftey and efficacies of the five insecticides as protectants against the potato tuber worm in stored potatoes.

MATERIALS AND METHODS

This trial was carried out at Melkassa, Institute of Agricultural Research, Nazareth Station in 1980. Batches of 500 clean potato tubers were put in wooden crates (49 x 31 x 29 cm). The tubers for each treatment, arranged in a completely randomized design with three replications, were dipped in solutions of one of the following insecticides: fenithrothion, decamethrin, diazinon, methamidophos, profenofos, at 10, 25, 300, 500, and 3750 ppm, respectively, and one untreated control dipped in plain water. The treated potatoes were kept in a room with 20-25° C in and 30-35% r.h.

All the treated potato tubers were examined 90 days after infestation by the potato tuber worms. This period was considered long enough for at least three generations of the insect (one generation being ca. 1 month)

according to an earlier report by Dutt (5) who observed as many as 14 generations a year in warmer climates. The criterion used to measure the efficacy of the insecticides tested was the number of larval holes or mines in the tubers.

Five tuber samples from each treatment were submitted for residue analysis in which the organo-phosphate insecticides, diazinon, fenithrothion, profenofos and methamidophos were analyzed by alkali flame ionization detector (AFID) and the synthetic pyrithroid, decamethrin, on electron capture detector, N63 (ECD).

RESULTS AND DISCUSSION

Table 1 shows mean per cent infestations ranging from 2.33 to 91.00. There were significant differences among the treatments at the 1% protection level. Profenofos showed significantly better performance overall the other treatments with 2.33% infestation compared to 20.8, 37.8 and 52% for decamethrin, diazinon and fenitrothion, respectively. There was significant difference between decamethrin and diazinon. Methamidophos with 52% infestation gave the least protection against the moth and there was no significant difference between the latter and the plain-water treated check.

More than fifty per cent of the infested tubers treated with profenofos, decamethrin and diazinon were classified in the lightly infested category with 1 to 2 larval holes per tuber. Among tubers treated with methamidophos, fenithrothion and the plain-water treated check, the majority of the infested tubers were in the more heavily infested category (Table 1).

The insecticides to be recommended for use against this moth must show certain advantages such as low cost, longer residual actions and lower mammalian toxicity as reported by Al-Ali and Talhouk (1). If potatoes are to be stored as seed, insecticides with low cost and lasting residual effects will be preferred. This was also reported by the same authors. If potatoes are to be stored for human consumption, however, insecticides with lower mammalian toxicity and with more rapid detoxification and elimination from tissues are preferred (1).

As the results indicate in Figures 1, 2, and 3, analysis for diazinon in stored potatoes showed residues of 6 ppm, where as decamethrin, fenithrothion, profenofos and metamidophos left no residues following the

Table 1. Effectiveness of different insecticides in reducing the infestation of tubers by the potato tuber moth

Treatment	Appl. rate (ppm a.i.b)	Number of infested tubers 1-2 holes	3-5 holes	6 over 6 holes	Total infested tubers/1500	Mean % infestation	% Infestation reduction over the check
Check (plain water)	–	285	596	295	1176	78.40d*	–
Fenitrothion (Folithion) 1% D.P. [1)]	10	363	358	59	780	52.00c	34
						37.80bc	52
Diazinon (Basudin) 60% EC	300	259	258	340	567	20.80b	73
Decamethrin (Decis) 2.5% EC	25	191	112	9	312		97
Profenofos (Selecron) 50% EC	3750	30	5	0	35	2.33a	
Methamidophos (Tamaron) 50% EC	500	215	614	476	1365	91.00d	–
Mean						47.01	
S.E.						4.94	

(a) D.P. dusting powder

(b) PPM = Parts per million

(c) 500 = tubers sampled from each replicate/treatment

* Means followed by the same letter or letters not significantly different at 1% level of probability. (Duncans New Multiple Range Test)

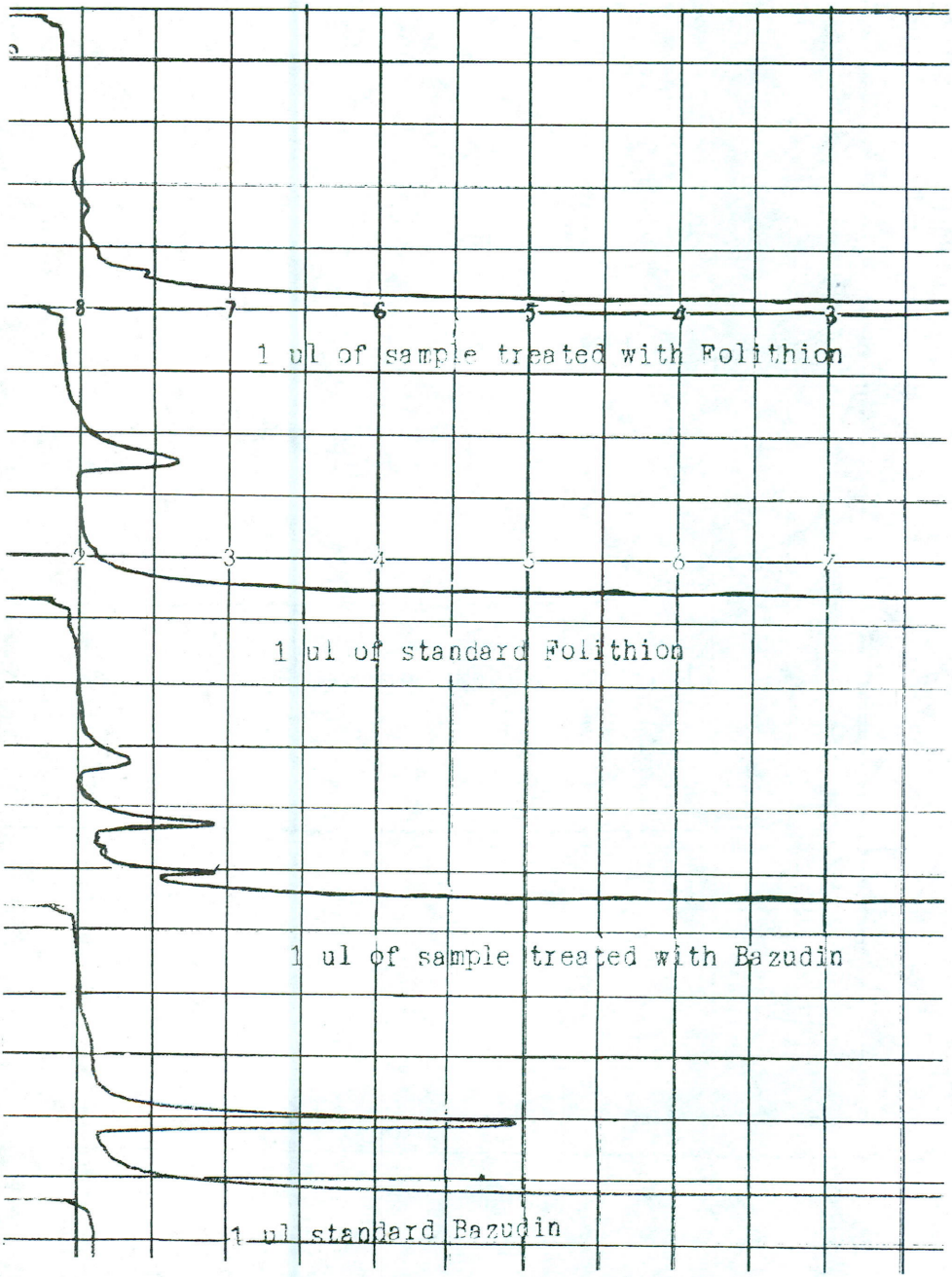

Fig.1 Results of residue analysis on pototo samples treated with fenitrothion (Folithion) and Barudin.

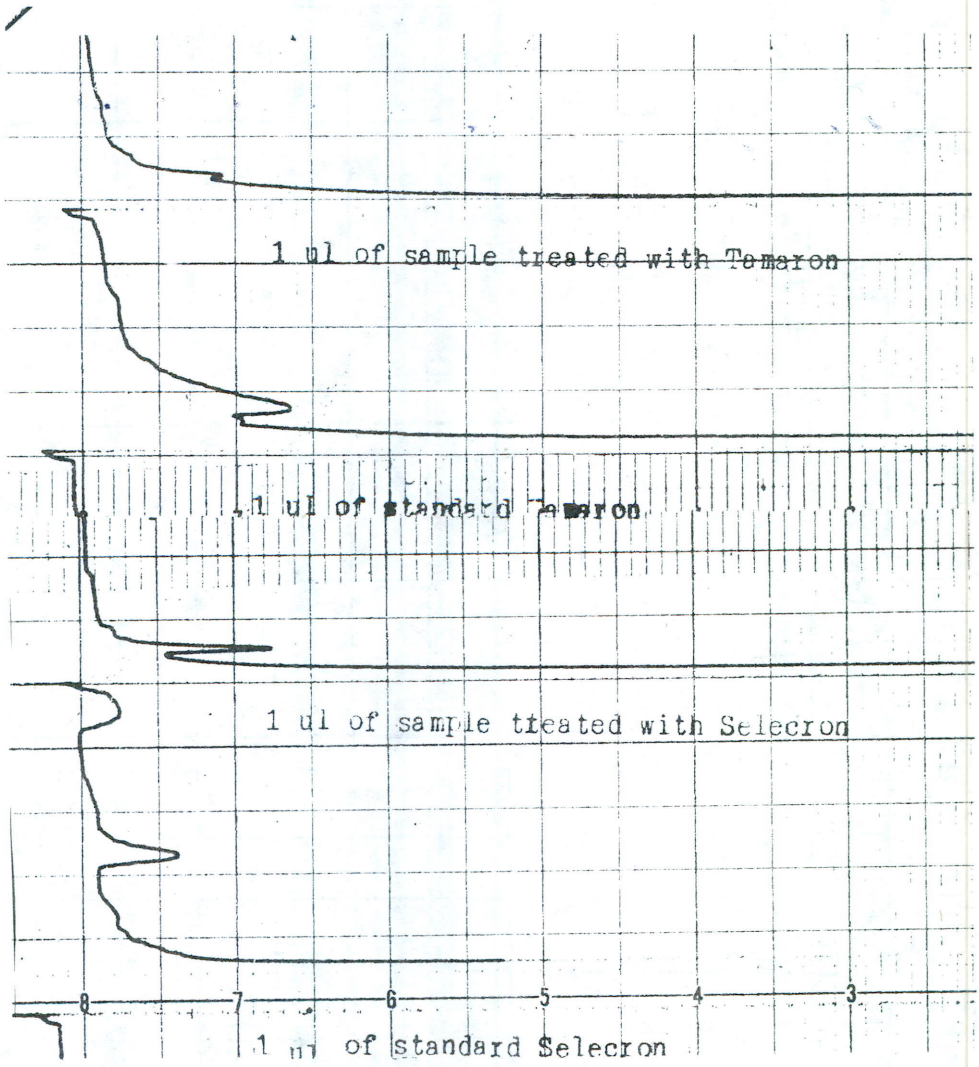

Fig. 2. Results of residue analysis on potato samples treated with metamidophos (Tamaron).

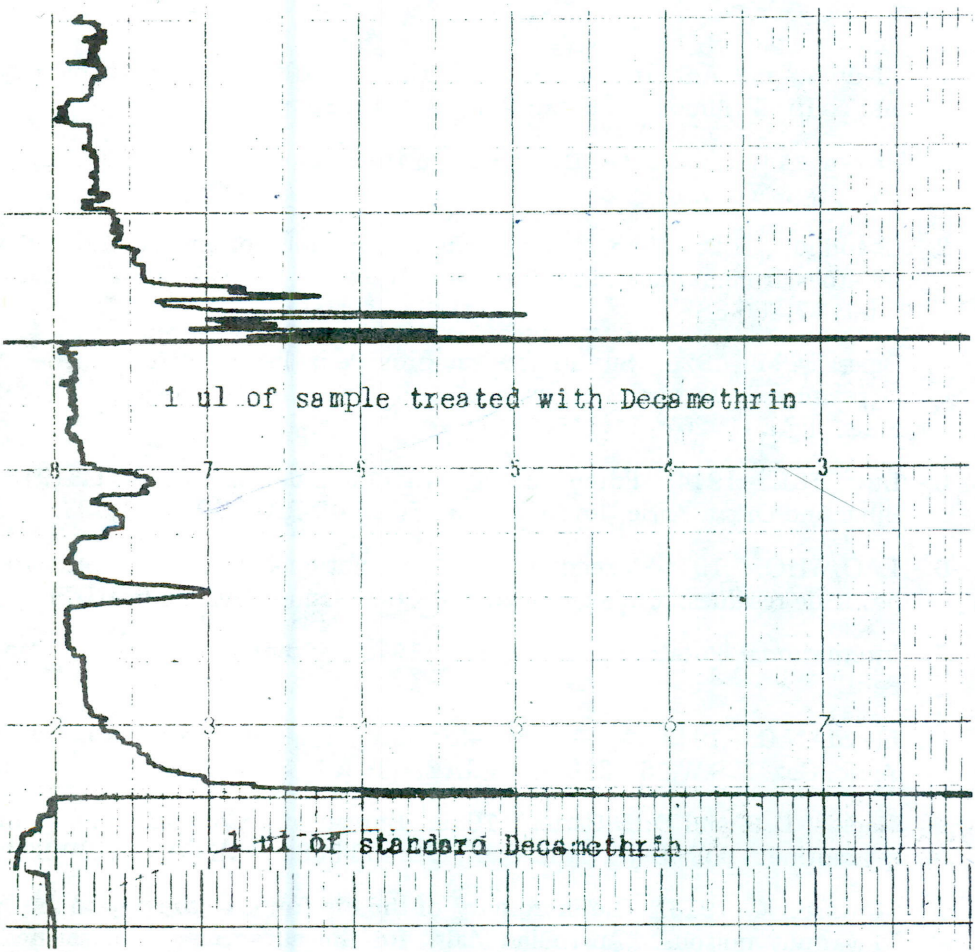

Fig. 3. Results of residue analysis on potato samples treated with decamethrin (Decis).

same period of storage. The residue of 6 ppm of diazinon was shown to exceed the recommended limits of tolerance established by FAO/WHO (6). However this study has shown diazinon as one of the potential candidates for use on seed potatoes because of its relatively long residual toxicity whereas potatoes for human consumption may be treated with the other more effective insecticides provided factors other than mammalian toxicity are not limiting.

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THE INFLUENCE OF DIFFERENT MEDIA ON THE ROOTING ABILITY OF POTATO STEM CUTTINGS[1]

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ABSTRACT

The best medium for the formation of a desirable root system by potato stem cuttings was determined in greenhouse using appropriate cuttings from three Alemaya selections (AL-562, AL-517 and AL-204) and variety Anita rooted in nine different locally available media. The basic ingredients of the media were sawdust, sand, soil and manure. There were 20 cuttings per medium per selection. Rooting ability of cuttings in each medium was evaluated on every other day starting from the 14th day to the 20th day from the time of insertion. The result indicated that all cuttings formed roots in all media within 16 days with the exception of selection AL-517 in sawdust, and AL-204 in soil and a 2:1 combination of sawdust and manure. When characters such as number and lengths of roots per cutting, and number of branch roots per adventitious root were considered, either sand or sand mixture medium with the exception of a 3:2:1 combination of sand, soil and manure respectively, gave better results. The formation of roots was comparatively poorer in sawdust and in a mixture of sawdust media. It was also observed that the formation of roots apparently varied among potato types. The Anita variety showed the development of more roots almost in all media considered, while selection AL-517 formed a relatively less number of roots as compared to the others.

Potato (*Solanum tuberosum* L.) is conventionally propagated by tubers. This method of propagation involves transportation and storage problems, high seed cost, and low multiplication rate. These basic shortcomings make

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[1] Part of a thesis submitted by the senior author to School of Graduate Studies of Addis Ababa University in partial fulfilment of the requirements for the degree of Master of Science in Agriculture (Horticulture).

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the method inefficient in the attempt to multiply and distribute to farmers enough seed tubers of improved potato clones in a relatively short period of time. Hence, an adoption of rapid multiplication systems becomes indispensable.

One of the rapid multiplication systems is the use of stem cuttings (6). Using this method, about 180 kg of potatoes can be produced from 1 kg of potatoes for the first generation of basic seed programme which is considered significant when compared to harvesting of about 10 kg of potatoes from 1 kg of potatoes in the traditional method (6).

The type and nature of cuttings seem to have an influence on root formation. Good results are obtained from cuttings with slender, flexible and well branched roots than cuttings with coarse, brittle and unbranched roots (8). The development of roots and the rooting ability in general are influenced by types of media (5, 8). Cuttings produce good roots in a medium which provides good anchorage, contains enough moisture and air around the cuttings and has good drainage system (5).

Among the media used for rooting stem cuttings and other organs of plants are soil, sand, peat, moss, perilite, pumice (5), shreded sphagnum (4), vermiculite (2, 11), and sawdust (1). Sand is the most widely used rooting medium for cuttings. However, it has a tendency to produce coarse brittle and sparsely branched roots which are considered undesirable (8). Hence, the use of mixtures of the above mentioned media instead of anyone of them alone is recommendable for the development of desirable rootings (5, 8, 11). The primary objective of this study was to select a medium that best favors the formation of desirable root systems for potato stem cuttings.

MATERIALS AND METHODS

Three potato selections: AL-562, AL-204 and AL-517 and one potato variety Anita were grown on alluvial soil at the experimental field of the College of Agriculture at Alemaya to provide planting materials for the study. When the plants were 30 cm tall, the terminal buds were removed with a disinfected (over flame) razor-blade following the methods of Cole and Wright (3) and Laurer (7), to initiate the growth of more lateral buds.

Nine different media with basic ingredients consisting of sawdust, sand, soil and manure were used in a completely randomized design (CRD) with two replications. The ratios for mixtures of media indicated in this paper are on volume by volume basis. Where sand was used alone, it was throughly washed with tap water and sieved to remove dust and other foreign matters.

Two types of sand media, i.e., fine sand, which passed through a 2.0 to 2.5 mm mesh size, and coarse sand which passed through a 2.5 to 5.6 mm mesh size were used. Although the general classification of particle size of sand ranges from 0.02 to 2 mm, in this study, particles with sizes of 2.0 to 5.6 mm were termed sand for ease of horticultural interpretation and discussion purposes. The soil medium used was alluvial type collected from the College farm at Alemaya. The media were placed in wooden flats of 50 by 30 by 10 cm and were placed in lath-house. The ambient room temperature in lath-house was almost the same as the outside temperature and was about 22° C.

As the newely grown bud-stems attained a height of about 15 cm, cuttings of about 10 cm were taken. The leaves were thinned to two leaves per cutting to avoid the possible effects of different number of leaves on the rooting behavior of cuttings. The basal portions of the cuttings were then dipped into a container of Seradix 1, a trade name of rooting hormone for herbaceous plants, and were immediately inserted in the media. Twenty cuttings per potato selection were cultured in each medium on May 29, 1979. The cuttings were kept moist by watering them three times daily.

In order to determine the rooting ability of the cuttings, number and lengths of roots per cutting and number of branch-roots per advantitious root were evaluated on every other day starting from the 14th day up to the 20th day after insertion. The samples were washed free of media before each evaluation. A total of 80 cuttings per medium were evaluated on four observation days with five cuttings per selection per observation.

RESULTS AND DISCUSSION

The data in Table 1 reveales that the differentiation of roots from potato stem cuttings varies among selections. Out of the four potato selections used in this study, Anita stem cuttings showed the highest differentiation of roots with all media used except with a combination of coarse sand, soil and manure at 3:2:1 ratio, respectively (Table 1). Stimulation of root growth and differentiation were also favourable when potato stem cuttings of the three selections and Anita were cultured in fine sand, and coarse sand and manure mixture media (Table 1). The results obtained in fine sand were significantly different ($P < .05$) in all selections except AL-562. In general, cuttings from selection AL-517 had the least number of roots formed in all media used except in a 2:1 mixture of soil and manure (Table 1).

Table 1. The influence of sand, soil, manure and sawdust based media on the number of roots developed from potato stem cuttings

Media	Number of roots per cutting [1/]			
	AL-562	Anita	AL-204	AL-517
Sawdust	10.8a	15.5bc[2/]	14.9b	7.0b
Soil	12.5a	14.5bc	9.4bc	11.5b
Fine sand	27.2a	44.5a	33.2a	30.0a
Coarse sand and manure (2:1)	20.2a	33.0ab	16.5b	12.5b
Soil and manure (2:1)	13.4a	15.0bc	8.3c	12.5b
Coarse sand and soil (2:1)	25.1a	37.5a	22.4b	10.5b
Coarse sand	20.6a	34.5a	29.5ab	13.5b
Coarse sand, soil and manure (3:2:1)	14.5a	16.0bc	19.8b	14.0b
Sawdust and manure (2:1)	10.4a	13.5c	13.4b	7.5b

1/ Each value is the average of two replications with 10 cuttings per replication.

2/ Means for columns followed by different letters are significantly different at the 5% level based on Duncan's new multiple range test.

The sawdust and manure mixture of 2:1 respectively, gave the lowest yield of roots in AL-562, and Anita (Table 1). The data reported in the same table indicated that stem cuttings grown in sand alone or mixed with soil or manure gave the highest root differentiation in most of the selections studied.

Several researchers including Hartmann and Kester (5) established that sand medium is the most suitable for the formation of roots for various species of plants. Unlike the soil medium, the fine or coarse sand medium seems to have a relatively better tendency to allow free movement of water and air that are essential for rapid root differentiation and growth. The need of adequate moisture and aeration for the formation of root system was reported by Long (8) and Hartmann and Kester (5).

Although coarse sand stimulated root differentiation of potato stem cuttings, the growth of cuttings in this medium was less vigorous than that of fine sand. Furthermore, there was a clear indication that some cuttings in coarse sand showed a sign of wilting. The probable cause for poor growth could be attributed, at least in part, to the physical properties of the medium such as high rate of percolation of water and poor retaintion of moisture. On the other hand, the adverse effect of excess water in rooting as reported by Chadwick (2), was also experienced in this study especially with the

combination of soil and manure medium. Since the manure seemed to cement together the soil particles, the soil and manure mixture medium had a poor percolation rate.

As shown in Fig. 1, two peaks of root growth with the four potato selections were evident after 20 days of growth. The highest peak was obtained with coarse sand, and a 2:1 ratio of coarse sand and manure media. The average root growth for AL-204 and Anita stem cuttings in these media was about 60 mm in length. Whereas selections AL-562 and AL-517 attained average root lengths of 45 and 40 mm, respectively.

The inhibition of root growth seems to be associated with high moisture retaintion and hence poor aeration of the media. This was experienced with soil, manure and sawdust based media. The importance of adequate aeration for rooting was also reported by Lunt and Khol, Jr. (9), Tinga (11) and Paul and Lee (10).

Cuttings from Anita variety produced significantly longer roots ($P < .05$) in a 2:1 mixture of coarse sand and manure while cuttings from AL-517 produced significantly shorter roots ($P < .05$) in sawdust and a 2:1 combination of coarse sand and soil. Selections AL-562 and AL-204 attained uniform lengths of root growth in all types of media considered in this study (Fig. 1).

The length of roots developed from cuttings seems to be influenced by the type of mother stocks as well as by the type of media. Cuttings of Anita and AL-204 generally formed longer roots either in pure sand or mixture of sand medium. This may be due to the fact that such media are well aerated and hence provide a more conducive condition for root elongation. In rooting studies of carnation cuttings, similar result was also reported by Tinga (11) that reduction of oxygen level decreased the lengths of roots. Selection AL-517 produced significantly longer roots ($P < .05$) in compact media such as soil, a mixture of soil and manure in contrary to other potato selections and variety studied (Fig. 1).

Within 16 days of growth, all cuttings studied produced extensive root systems with the exception of selection AL-517 in sawdust, and AL-204 in soil and a 2:1 combination of sawdust and manure (Fig. 2). The same figure indicates that cuttings in fine sand, and coarse sand media formed more number of branch roots per adventitious root. The development of branch roots from the adventitious roots is essential for increased water absorption. Such condition will improve the per cent of seedling recovery following transplanting.

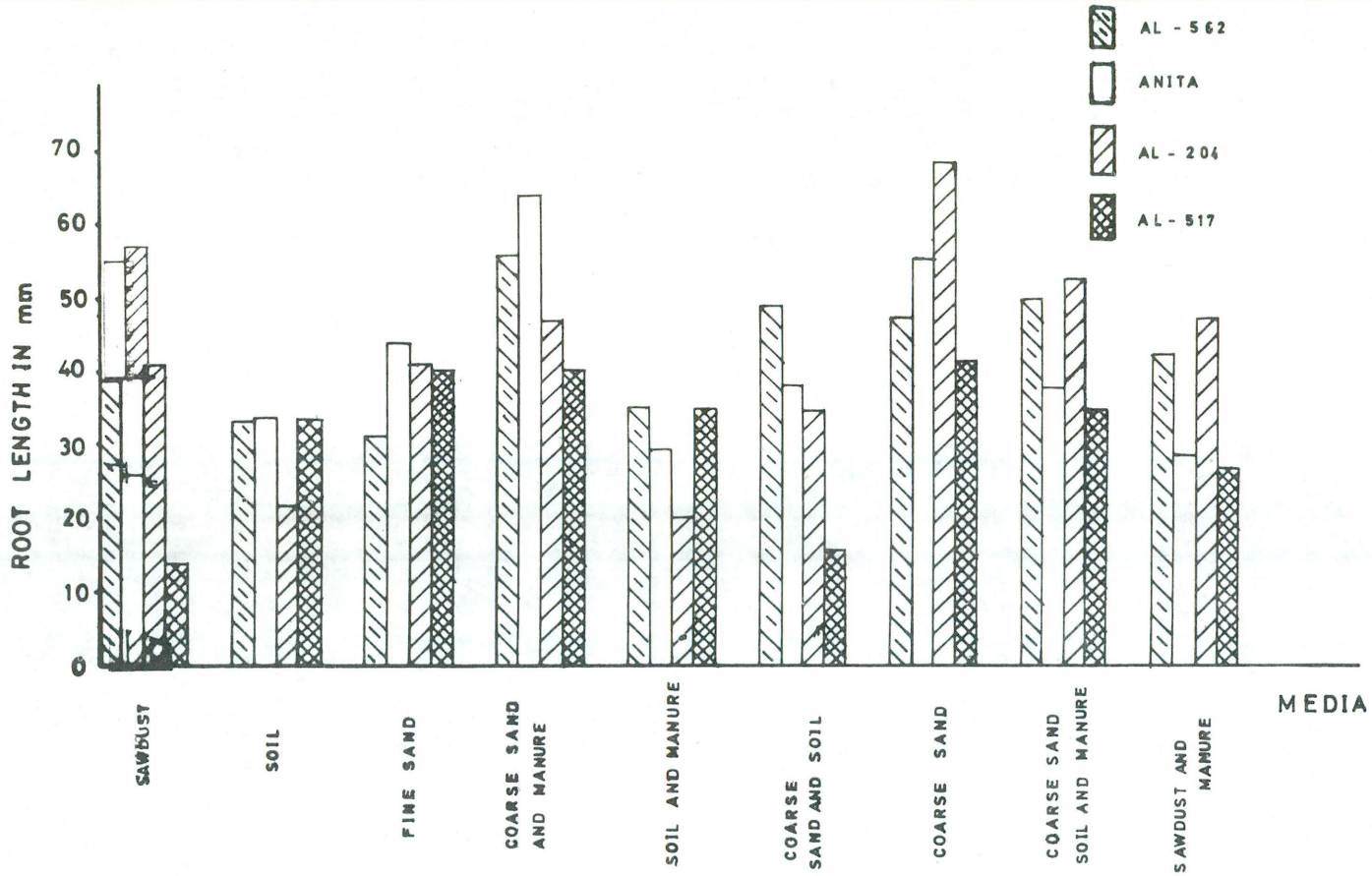

Fig. 1. Trends of root growth of potato stem cuttings cultured for 20 days in sand, soil, manure and sawdust based media.

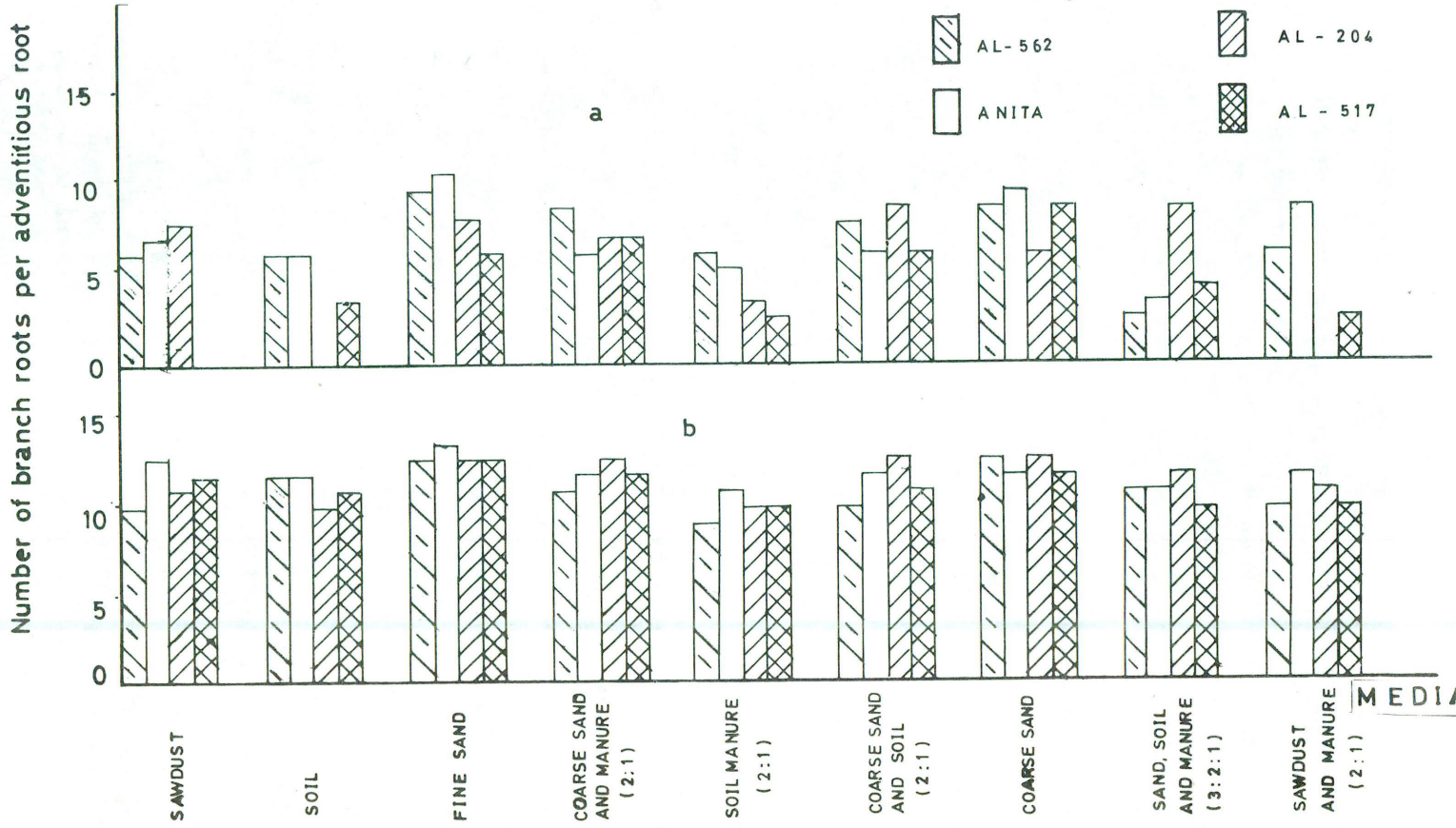

Fig. 2. Formation of branch roots per adventitious root from potato stem cuttings after 16 (a) and 20 (b) days from the time of culture.

In regard to the identification of suitable medium, the data presented in Table 1, and Figs. 1 and 2 showed that fine sand and coarse sand were suitable for the propagation of stem cuttings considered in this study.

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