
METHODS OF POTATO SEED PRODUCTION IN CEYLON

BY

D. V. W. ABEYGUNAWARDENA AND R. A. WIJESOORIYA

*Regional Research Station (Up-country)
Department of Agriculture, Ceylon*

PRODUCTION and maintenance of pure, disease-free and vigorous potato seed material demands a thorough knowledge of factors influencing yields, directly or indirectly. Cumulative infection of certain virus diseases which tend to cause rapid degeneration and reduction in yield potential of seed material is the most important of these factors. The troublesome virus diseases are chiefly : leaf-roll, leaf-drop streak or virus Y, and potato mottle or virus X. It has been the experience of potato-growers in the temperate countries that seed potato obtained from the cooler northern latitudes is more vigorous than that from the southern latitudes, and the disparity has been attributed to a reduction in the incidence of degeneration of seed potato produced in the northern latitudes. In the tropical and sub-tropical countries certain meteorological and ecological conditions obtaining at high altitudes have been found to favour the production and maintenance of vigorous seed material, and they have been exploited to advantage. As comparable conditions exist in Ceylon's hill country, it is possible to maintain potato seed stocks without an appreciable reduction in yield potential, by the judicious selection of seed areas and by making minor adjustments in agronomic practices.

Bacterial wilt, caused by *Pseudomonas solanacearum*, is perhaps the chief hazard in seed potato production in Ceylon. The bacterium is soil-borne and its growth and parasitic activity are favoured by warm and dry weather conditions. As the bacterium is disseminated through infected seed, it can gain entry into hitherto wilt-free land through the medium of infected seed. Main problems involved in the production locally of disease-free seed potato can be outlined as :

- (1) In the absence of direct methods for the control of bacterial wilt, seed production to be confined to wilt-free zones.

- (2) Control of virus diseases to conserve the yield potential of seed stocks.
- (3) Maintenance of the purity of the varieties.

Production of wilt-free seed

Preliminary trials conducted in *Maha* 1956/57 revealed that while the crop at Rahangala was riddled to some extent with bacterial wilt, the crop raised at Ambawela, Nuwara Eliya and Bopatalawa were refreshingly free of the disease. Based on these results, pilot plots with the following objectives were set down in cultivators' fields at two elevations, viz., 4,200 ft. and 6,200 ft.—

- (1) to ascertain the distribution of bacterial wilt at the two elevations.
- (2) to determine the effect of the cropping history on the incidence of bacterial wilt.
- (3) to test the validity of the popular theory that farmyard manure harbours the bacterium causing wilt disease.

Although inconclusive, the results of these trials brought out the following interesting points:

- (1) that bacterial wilt is absent at an elevation of 6,200 ft., (if not introduced).
- (2) that the wilt organism does not appear to be transmitted through farmyard manure.
- (3) that the wilt disease is present over appreciable extents at the lower elevations, and is particularly severe in plots in which solonaceous crops have been grown.

4. That bacterial wilt is more or less absent in paddy land. These results were of considerable value in the formulation of a 'Potato Seed Production Programme' in Ceylon, one of the aims of which is the production of wilt-free seed material. Hence, it was considered worthwhile to extend these trials over a wider range in the potential potato growing areas in order to be able to determine the soils free of *Pseudomonas solanacearum* and thus demarcate areas suitable for seed production.

Confirmation of the above-mentioned results was sought by setting down a total of 121 trials in cultivators' fields during *Yala* 1957. For this purpose, the probable cultivators in Nuwara Eliya and Badulla

METHODS OF POTATO SEED PRODUCTION IN CEYLON

districts were grouped into three categories according to elevation with the assistance of the Agricultural Extension Officers, and the elevation strata were as follows :

- (a) 3,000 to 4,000 feet.
- (b) 4,000 to 5,000 feet.
- (c) 5,000 feet and above.

Cultivators in each elevation stratum were selected in a random manner so as to include a minimum of one trial in paddy land and one in highland in each village within a Headman's division. As there is no paddy land in the elevation stratum 5,000 feet and over, all plots at this elevation were on highland. Certified seed potatoes of the variety Tedria were planted in plots 20 feet $\times$ 40 feet and one half of each such plot was fertilised with a mixture of sulphate of ammonia, concentrated superphosphate and muriate of potash in the proportions 4, 2½ and 1 cwt., per acre, respectively. The other half of each plot received the same fertilizer mixture at the same rate and also received farmyard manure at the rate of 10 tons per acre, applied in the furrows. Seed tubers were planted at a spacing of one foot within the row and the rows were spaced two feet apart. All trial plots received a routine protective spray of a copper fungicide as a measure against the incidence of late-blight. Records on bacterial wilt and other soil-borne diseases, aphid infestation, virus diseases etc., were taken at weekly intervals. Data on bacterial wilt are summarised in Table 1, and the other relevant data are discussed in this article.

TABLE I

Effect of elevation, nature of land of farmyard manure on the incidence of bacterial wilt

Badulla District				Mean percent		bacterial wilt	
Elevation	Nature of land			without f. y. m		with f. y. m.	
3,000'-4,000'	Paddy land	..	..	39.33	..	40.23	
	Highland	..	..	46.20	..	53.30	
4,000 -5,000'	Paddy land	..	..	29.40	..	26.80	
	Highland	..	..	75.90	..	67.20	
Above 5,000'	Paddy land	..	..	no trials	..	no trials	
	Highland	..	..	20.06	..	44.00	
Nuwara Eliya District							
3,000'-4,000'	Paddy land	..	..	18.80	..	26.10	
	Highland	..	..	33.20	..	36.20	
4,000'-5,000'	Paddy land	..	..	39.60	..	33.30	
	Highland	..	..	49.10	..	45.30	
Above 5,000'	Paddy land	..	..	no trials	..	no trials	
	Highland	..	..	0	..	0	

Trials in the Badulla district grouped under the elevation stratum of 5,000 ft. and above were all located at an elevation of less than 5,500 ft., while all except one in the corresponding elevation stratum in the Nuwara Eliya district were located over 5,500 ft. The results of these trials are summarised below, and they confirm the observations made from the preliminary trials conducted in Maha 1956/57.

1. There is a significant difference in the incidence and distribution of bacterial wilt in Nuwara Eliya and Badulla districts, the later district recording more than twice that of Nuwara Eliya district. The mean percentage of bacterial wilt in the two districts is as given below :

	<i>Nuwara Eliya District</i>		<i>Badulla District</i>		<i>Significant difference</i>
Mean per cent bacterial wilt	..	26	..	57	1.1

2. Paddy land is not totally free of bacterial wilt infection, the trend, however, being that the incidence of infection is less in paddy land than in highland. There is a highly significant difference in the two types of land in relation to the occurrence of bacterial wilt, plants grown in highland being over 50 per cent more susceptible than those grown on paddy land. The mean percentage of wilt disease on the two types of land is as shown below :

	<i>Paddy land</i>		<i>Highland</i>		<i>Significant difference</i>
Mean per cent bacterial wilt	..	32	..	55	1.5

P. Solanacearum is known to be aerobic, and it is, therefore, likely that the anaerobic conditions that obtain in paddy land over the greater part of the year are unfavourable for the survival and multiplication of the bacterium.

3. There is a highly significant difference in the distribution of the wilt disease in the different elevation strata. As shown below, there is about 50 per cent more incidence in the elevation stratum 4000' to 5000' than in the lower stratum of 3000' to 4000'. The higher incidence of the disease in the 4000' to 5000' stratum may be due to the fact that the cultivators' holdings in this elevation stratum are extensively cropped with solanaceous crops, particularly tomato, which are alternate hosts of the disease organism.

	<i>Elevation Stratum</i>				<i>Significant difference</i>
	<i>3,000'-4,000'</i>		<i>4,000'-5,000'</i>		
Mean per cent bacterial wilt	..	37.5	..	57.4	1.1

The 5,000 ft. and over elevation stratum is not included in the analysis as there is no incidence recorded in the Nuwara Eliya district. Areas over 5,000 ft. in the Nuwara Eliya district will constitute the 'wilt-free' zone, and therefore, the potential seed producing regions in Ceylon.

4. The application of farmyard manure made no significant difference in the incidence of bacterial wilt. There is no distinction in the incidence of wilt in plots that received the fertilizer mixture only and those that received the farmyard manure in addition to the fertilizer mixture. This confirms the view that the wilt organism is not transmitted in farmyard manure.

Other soil-borne diseases

The following bacterial and fungus diseases were also found to affect the potato crop in the hill country—Collar-rot, caused by *Fusarium* spp., *Rhizoctonia solani* and *Sclerotium rolfsii*, and Black-leg, caused by *Erwinia atroseptica*. The occurrence and distribution of these pathogens in the different elevation strata are shown in table 2. Diseases caused by the above mentioned bacterial and fungal pathogens appear to be not too troublesome, and if their spread is arrested in time, they may not present a serious threat to potato cultivation in the hill country.

Degeneration of Potato Seed Material

Degeneration of potato seed material is caused by a number of virus diseases, and leaf-roll, virus Y and virus X appear to play a major role. Leaf-roll and virus Y are transmitted by aphids colonising the potato plants, and virus X is spread mechanically.

As it is necessary that seed areas should be reasonably free of the aphids that transmit the leaf-roll virus and virus Y, colonisation of potato plants by the aphids was studied in the preliminary trials and in the subsequent trials conducted on a large scale. In the latter case, the strong winds experienced during Yala in the hill country were found to be unfavourable for aphid colonisation, and the aphid numbers recorded were negligible. Data on aphid colonisation and incidence of virus diseases were recorded at regular intervals and the results are tabulated in table 3.

TABLE III
Effect of elevation on colonisation of aphids on potato

Elevation	Aphid population mean, per leaf						Mean % leaf-roll detected	
	Upper leaf		middle leaf		lower leaf		Primary	Secondary
6,200 ft.	..	1.3 ..	..	1.7 ..	..	1.2 ..	0 ..	0.9
4,200 ft.	..	1.7 ..	..	5.9 ..	..	5.5 ..	0 ..	0

The results indicate that aphid colonisation on potato plants is more in the lower elevation, the warm, dry weather conditions obtaining at such elevations being favourable to the aphids. It is possible that the cold and humid climate of the higher regions is unfavourable to the survival and spread of the aphids. Specimens of aphids collected from potato plants in the course of these trials were identified as *Myzus persicae*, a well known efficient vector of potato viruses.

Although primary leaf-roll was not encountered in any of the trials, secondary leaf-roll was readily recognisable at the higher elevations. This is attributable to the clearer expression of leaf-roll symptoms in the higher colder elevation.

Detection of Potato Viruses

Leaf-roll and virus X have been detected in imported seed stocks. As the leaf-roll virus exhibits very clear symptoms at the higher elevations, it can be detected visually. This facilitates roguing, (or the removal of diseased plants from crops grown for seed purposes). Virus X which is often symptomless, is detected by serological methods. For this purpose sap from suspected plants is injected into rabbits and antisera is prepared employing standard serological methods. When a drop of diluted antiserum is mixed with the sap from an infected plant, a distinct flocculation reaction takes place. Hence this method can be employed for eliminating virus X from nucleus and foundation seed stocks. Locally prepared antiserum was compared with a sample of antiserum obtained from the Rothamstead Experiment Station (through the courtesy of Dr. P. H. Gregory) and the reactions have been identical.

Maintenance of purity of potato varieties

Potato varieties multiplied for seed production on a commercial scale are distributed as follows :—

Foundation Seed Farm : Pidurutalagala—variety : Tedria.

Foundation Seed Farm : Uda Radella—variety : Gineke.

The varieties are distinguished by the colour of the tubers, and this factor facilitates maintenance of purity. Each seed multiplication farm will specialise in the production of only one variety. Hence, maintenance of purity can be ensured by the isolation of potato varieties and by judicious roguing of all suspected off-types.

SCHEME FOR SEED PRODUCTION AND RECOMMENDED DIRECTIONS OF SEED MOVEMENT

FIGURE 1 indicates the scheme for potato seed production and the desired directions of seed movement.

It is proposed to maintain virus-free nucleus seed stocks of the commercially propagated varieties, under insect proof conditions, at the Central Potato Research Station, Nuwara Eliya. The nucleus stock will be progressively multiplied and moved to the foundation seed farms for further multiplication. At both these stages extreme precautions are necessary to eliminate the virus diseases and thus arrest degeneration in yield potential. Foundation seed will be multiplied at the seed farms for issue to cultivators as certified seed potatoes.

Summary

The following conclusions based on the data gathered from the studies discussed in this article are noteworthy :—

1. Climatic conditions at the higher elevations are relatively less favourable for aphid colonisation. Therefore, the incidence of virus spread and degeneration will be less at the higher elevations.
2. Bacterial wilt is absent at the higher elevations.
3. The various soil-borne diseases affecting the potato crop are unimportant.

On the basis of the above conclusions, the recommended movement of seed is from higher to lower elevations. Seed should not be moved from lower to higher elevations under any circumstances, as such movement of seed will result in the introduction of both the degenerative and the soil-borne diseases into the "disease-free zone".

Acknowledgments

The authors are grateful to Dr. M. F. Chandraratne, Director of Agriculture, and to Mr. A. V. Richards, Deputy Director of Agriculture, for valuable suggestions made in regard to the conduct of these investigations. They also acknowledge with thanks the assistance rendered by the Agricultural Extension Officers of Nuwara Eliya and Badulla Districts in conducting the trials in cultivators' fields. The authors thank the technical staff engaged in the potato project for their enthusiasm and interest and the Statistician for analysing the data presented in this article.

TABLE II

Effect of elevation, nature of land and farmyard manure on the incidence of soil-borne diseases affecting potato

Badulla District																
Elevation	Nature of land	without farmyard manure						mean percent disease				with farmyard manure				
		Fusarium sp.		Sclerotium rolfii		Rhizoctonia solani		Black-leg		Fusarium sp.		Sclerotium rolfii		Rhizoctonia solani		Black-leg
3,000'-4,000'	Paddy land	..	0	..	0	..	0	..	0	..	0	..	0	..	0	..
	Highland	..	0	..	0	..	0.1	..	0	..	0	..	0	..	0.4	..
4,000'-5,000'	Paddy land	..	0	..	0	..	0	..	0	..	0	..	0	..	0	..
	Highland	..	0	..	0	..	0	..	0.5	..	0	..	0	..	0	..
Above 5,000'	Highland	..	0	..	3.0	..	0	..	1.0	..	0	..	0.4	..	0	..
Nuwara Eliya District																
3,000'-4,000'	Paddy land	..	2.0	..	0.4	..	3.0	..	2.0	..	1.0	..	1.0	..	5.0	..
	Highland	..	0	..	0.3	..	0.1	..	3.0	..	0	..	0.2	..	0.6	..
4,000'-5,000'	Paddy land	..	0	..	0	..	0	..	0	..	0	..	0.1	..	0	..
	Highland	..	0	..	0	..	0	..	0.5	..	0	..	0	..	0	..
Above 5,000'	Highland	..	0	..	0	..	0	..	0	..	0	..	0	..	0	..

Figure 1

Scheme for Potato Seed Production and Seed Movement

