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ACCEPTABILITY OF SNACK FOODS PREPARED WITH DEHYDRATED POTATOES BY PRE-SCHOOL CHILDREN

M.P. VAIDEHI[1]

ABSTRACT

Dehydrated potato in combination with protein food supplements such as soy-flour, defatted groundnut flour and cereal grain flours for traditional Indian dishes was tested for acceptability by children. The dishes were served along with fresh potato dishes following normal recipe ingredients. While scoring, all the dishes were coded.

The results showed no significant difference (P—0.05) in acceptability of the dehydrated potato dishes compared with dishes of fresh potatoes and addition of protein foods did not alter acceptability level by the children. Dishes had the scores of "liked" and "very much liked" by the children. It is concluded from the study that dehydrated potatoes in various forms namely sticks, gratings, sooji and flour can be utilized for preparation of Indian dishes without altering the cooking characteristics and even enrich the traditionally prepared potato dishes by this method.

INTRODUCTION

Potato ranks fourth among major crops in the world in terms of production of total food crops. Due to its capacity to produce more energy and protein per hectare per day than any other single food crop in the tropics and sub-tropics, it should be admitted as a desirable food crop rather than a mere vegetable for adult and child nutrition. In India potato production is fast increasing (3, 4).

Dehydration of potatoes is one of the important methods by which potatoes can be stored for a long period of time. This method of storage requires less space, cost and energy compared with other methods of storage. For children and aged

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people it may appeal by the bland flavour and smooth texture. When cooked in combination with other cereals and pulses potato has increased nutritional value (7). The present study has the objective of testing the acceptability of selected snacks prepared with dehydrated potatoes by children between 5 to 6 years of age. All these snacks were judged alongwith similar dishes prepared with fresh potatoes to find out any differences in their acceptability by the pre-school children.

MATERIALS AND METHODS

Potatoes were purchased in bulk from the wholesale dealers at the City Market, Bangalore.

Dehydration method : Potatoes were washed throughly, skin was peeled thinly and cut into sticks of 1 cm thickness to their complete length or sliced into round thin slices, or grated. The cut potatoes were immersed in 1% salt water till they were drained for blanching. A ratio of 1:1 cut potato to water was maintained for blanching. To blanch, water was boiled and cut potatoes were added to the boiling water. Blanching upto translucency stage required about 30 minutes for 5 kg potato sticks at medium heat in an electrical heater (Johnson and Co. domestic model). Blanching time varied with the quantity of potatoes blanched, eg. just 7 minutes for 1 kg potato. Aluminium thick pans were used for blanching. The potatoes after blanching were drained over a muslin cloth and removed to drying trays and spread about 2 to 3 cm layer thickness of 5 kg potato sticks per tray. These trays were stacked into pre-heated rotary air drier maintained at 140°F. The drying time required was 4 hour after which trays were removed from the oven, and then cooled to room temperature. In hot sun potato could be dried for 12 to 14 hours. Dried potato sticks were stored in polyethylene pouches for either immediate use or for further processing into milled products. The gratings were prepared with the use of domestic type graters and required less time to dry. The sticks were milled to prepare sooji (Semolina) or flour.

Rehydration Method : One measure (1 cup) dried potato flour or sooji required four (4 cup) measures of boiling water. Sticks and gratings were soaked for 6 hours to soften them. These soaked rehydrated potatoes were boiled for 10 minutes or pressure cooked for 5 minutes. After cooking the volume of dehydrated potato increased 4 to 6 times. This method of cooking was only for getting plain cooked potato from the dehydrated potatoes. Otherwise, the recipe methods were followed as directed in individual recipes. However, it was necessary to soak for rehydration before use except for fried chips.

Popular methods for the prepartion of the dishes were followed with modifications in the substitution for major ingredients namely, cereals and pulses with dehydrated potato products. A pilot study to fix up the desirable substitution level of dehydrated potato products was also conducted at the laboratory using referred recipe ingredients and methods for controls. There were ingredients like soybean flour, defatted groundnut flour added to the dishes to enrich the potato dishes with protein as compared with that of traditional recipes which required fresh potatoes only. Cutlet, Toffee, Sweet Pudding, Sweet Rings, and Cookies were prepared with added modifications in the ingredients following the recipes as described by Thangam Phillips 5) and the other recipes were as described by Vedamma (6). However, major methods of cooking of these dishes and ratio of major ingredients in the recipes are given in the Table 1.

Table I. Recipe variants in the study.

Item	Cooking method	Major Ingredients	
		Recipe "A"	Recipe "B"
1. Bonda	Frying	BF:RF 5:1	BF:PF:RF 3:2:1
2. Tikki	Shallow frying	MF:P 50:50	M:SF:PF 0.5:1:2.5
3. Crispies	Frying	WF:P 1:0	WF:PF 1:1
4. Mehti palya	Boiling	ML:P 1:3	ML: S 1:3
5. Kodu Bale	Frying	RF:GF:SF 2:0:66:1	RF:GF:SP:PF 5:1:1:3
6 Pappad	Frying	MF·Sago·SF:P 1:1:0.02:2	M:Sago:SF:PF 2.33:3.33:1:6.6
7. Chhapthi	Roasting	WF:SF 1.1.01	WF:SF:PF 5:1:4
8. Uppittu	Boiling	WS:P 1:0	WS:PS 1.1
9. Vada	Frying	Bld:P 1:0	Bld:PF 1:1
10. Thenkuzhal	Frying	RF:Bld 3:1	RF:Bld:SP:P 5:1:1.5:2
11. Chiwda	Frying	BR:P 1:0	BR:PG 1.1
12. Cutlet	Shallow frying	M:P 1:2	M:SF.PS 1:1:4

1	2	3	4	5
13.	Poori	Frying	WF:P 1:0	WF:PF:SF 5:4:1
14.	Dosa	Shallow frying	RF:UD 3:1	RF:UD:PF 1:1:2
15.	Chakkuli	Frying	RF:GF:SF 3:0.33:1	RF:GF:SF:PF 3:1:2
16.	Nippittu	Frying	RF:PBF 2:1	RF:PBF:SF:PF 2:1:1:2
17.	Idli	Steaming	WSO:P 200:0	WSO:PSO 1:1
18.	Chilli Cookies	Baking	M:P 1:0	M:PF 1:1
19.	Toffee	Open vessel cooking	P:GF 0:3	PF:GF 1:1
20.	Cookies	Baking	M:S 2.5:2.0	M:SF:S:PF 2.1:1:3.4:1.7
21.	Breakfast Squares	Baking	S:S:MILK:FAT 4:4:1.4	M:PF:MILK:FAT:S 2.66:1.33:4.1:1.33:4
22.	Laddu	Frying	WS:SF:S 1:0.5:1	WS:DGF:PSO:SF 5:1:4:1
23.	Halwa	Boiling	WS:S:FAT 4:5:1	WS:PF:S:FAT 2:2:5:1
24.	Jamoon	Frying	M:KHOVA:S 1:5:5	M:KHOVA:PF:S 1:5:1:5
25.	Sweet rings	Frying	M:MILK:SF 2 6:2.6:1	M:MILK:SF:PF 5:1.5:1.5:1.5
26.	Payasam	Boiling	WS:GO:S:M 2:1:4:5	WS:PSO:GO:S:M 1:1:1:4:5
27.	Kesari bhat	Boiling	WSO:S:FAT 2:2:1	WS:PSO:S:FAT 1:1:2.5:1.3
28.	Kheer	Boiling	WS:S:MILK 1:1..:5	WS:PSO:S:MILK 1:1:3:10
29.	Sweet Pudding	Boiling	MILK:S:V 1:0:0.5	PF:S:MILK:V 0.5:0.5:2.5:0.5

*Note : Dishes from 1 to 18 are with salt, Chillies and other spices.
Dishes from 19 to 29 are with sugar and sweet spices BF=Bengal gram flour, WS=Wheat sooji, RF=Rice flour, SF=Soy flour. PF=Potato flour, PS=Potato sticks, BSF=Puffed Bengal gram flour, UD=Black gram dhal, PSO=Potato sooji, Gr.d=Green gram dhal, M=Maida (All purpose flour), DGF=Defatted groundnut flour, S=Sugar, V=Vermicelli, ML=Methi leaves.

List of recipes prepared for acceptability test :

Twenty nine dishes prepared in combination with other basic ingredients are as follows :

I Sweet Preparations

1) Toffee 2 Plain cookies 3) Breakfast squares 4) Laddu 5) Halwa 6) Jamoon 7) Sweet Rings 8) Payasam 9) Kesari bhat 10) Kheer 11) Sweet Pudding.

II. Dishes with salt, chillies and other hot spices

1) Bonda 2) Tikki 3) Crispies 4) Methi potato palya 5) Kodu Bale 6) Pappad 7) Chapathi 8) Cutlet 9) Upittu 10) Vada 11) Thenkuzhal 12) Chiwda 13) Poori 14) Dosa 15) Chakkuli 16) Nippittu 17) Idli 18) Chilli biscuits.

Sensory Evaluation method : A hedonic scale of 1 to 4 was applied in evaluating the extent of children's likes and dislikes for the dishes served (1). The score sheet had the index as follows.

1=I dislike it very much

2=I dislike it

3=I like it

4=I like it very much

Pre-school children of the age group of 4 to 6 years old were trained for 3 days as how to score in the score sheet by serving potato dishes with codes for A and B variants (Table 1). There were 30 children who scored 3 days in a week and 4 samples at a time between 2-30 to 3-30 PM in the lunch room of the school. There was a control of the same dish prepared with fresh potatoes, included within the coded 3 samples of the dishes served.

RESULTS AND DISCUSSION

There were 29 recipes evaluated for the children's likes and dislikes. The analyses of variance showed no significant difference among the dishes tested for the extent of likes and dislikes as expressed in terms of scores by the children. Children liked both sweet and spicy dishes equally well. There was no difference between the control and the dehydrated potato substituted dishes in acceptance (Table 2). The scores ranged from 3 to 4 for almost all the dishes which means dishes were "liked (3)" and "very much liked (4)". The results showed that addition of dehydrated potatoes had no effect on the dishes in acceptance value and this can be effected as a desirable change in the preparation of snacks and dishes for children which included besides dehydrated potatoes other protein food supplements like soy or

Table 2. Mean scores of the dishes judged by 30 children*.

Dish No.	Mean Score	Dish No.	Mean Score
1	3.9	16	3.8
2	4.0	17	3.7
3	3.9	18	3.9
4	3.9	19	3.7
5	3.9	20	3.9
6	4.0	21	3.9
7	3.9	22	3.8
8	3.9	23	3.9
9	4.0	24	4.0
10	4.0	25	3.9
11	4.0	26	4.0
12	3.6	27	3.9
13	3.8	28	3.8
14	3.9	29	3.7
15	3.7		

*The average scores of 7 dishes was 4 meaning "like it very much". Rest of the dishes were in the range of "like it" to "like it-to-like it very much". None of the dishes were inferior to that of the dishes prepared with fresh potatoes.

peanut and skim milk powders (2). This would increase their protein consumption as well as meet the energy required by a given dish. Dehydrated potatoes used can be encouraged as a means of preserving potatoes and incorporating it in place of fresh potatoes in the pototo dishes as well as in cereal dishes. Further study is required to investigate actual nutritional benefit of these supplemented, protein foods and dehydrated potato products for children.

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DEPENDENCE OF TOTAL ROOT LENGTH CHARACTERISTICS ON AERIAL PARAMETERS IN TWO INDIAN POTATO CULTIVARS

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ABSTRACT

Total root length of two potato cultivars, Kufri Jyoti and Kufri Chandramukhi grown in sand culture showed a high correlation with plant height, leaf area and shoot weight The two cultivars varied significantly in their root dry weight, indicating that Kufri Chandramukhi has a finer root system and that Kufri Jyoti has a thicker root system. A linear model to predict root length, by measuring the three aerial parameters mentioned above, has been developed.

INTRODUCTION

Root development is important from the point of view of nutrient uptake, yield, drought resistance etc. There is scanty information on root : shoot relationship, as it is too laborious to study. The aerial parts and their development in Indian potato varieties have been studied in detail (5,6,7). Establishing a statistical relationship between growth of aerial parts and root would, therefore, facilitate evaluation of potato varieties for their root characteristics. With this objective, a simple experiment using two potato varieties Kufri Jyoti (KJ) and Kufri Chandramukhi (KC) was laid out.

MATERIALS AND METHODS

Chitted tubers of KJ and KC weighting 45-50g were obtained from Jalandhar and raised in acid washed sand, in 9″ diameter mud pots. They were supplemented with nutrient solution (1) 500 ml per pot at 5 days interval, and were raised on greenhouse benches. Thinning of extra stems were done at 3—4 leaf stage leaving one main stem per pot. Thirty days after planting, six plants of KJ and KC

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were uprooted at weekly interval to record plant height, leaf area, length of the longest root, total root length and dry weights of shoot and root. Leaf area was obtained by taking prints of the leaves on the sensitised paper (ferro prussiate) and measuring the area using planimeter. Total root length per plant was measured following Newman (4) and Tennant (10). For this purpose air dried root samples were used. Dry weights of shoot and root were had after drying the samples at 105°C in an oven. The experiment was terminated after 65 days of planting, when tuber initiation took place in KC.

Correlation coefficients were calculated between the measured parameters and total root length individually. For purpose of statistical analysis six plant samples collected at five sampling dates were considered as thirty different sets of observations. Multiple regression analysis (MRA) was worked out, taking total root length as the dependent variable and dry shoot weight, dry root weight, height of the plant and leaf area per plant as independent variables.

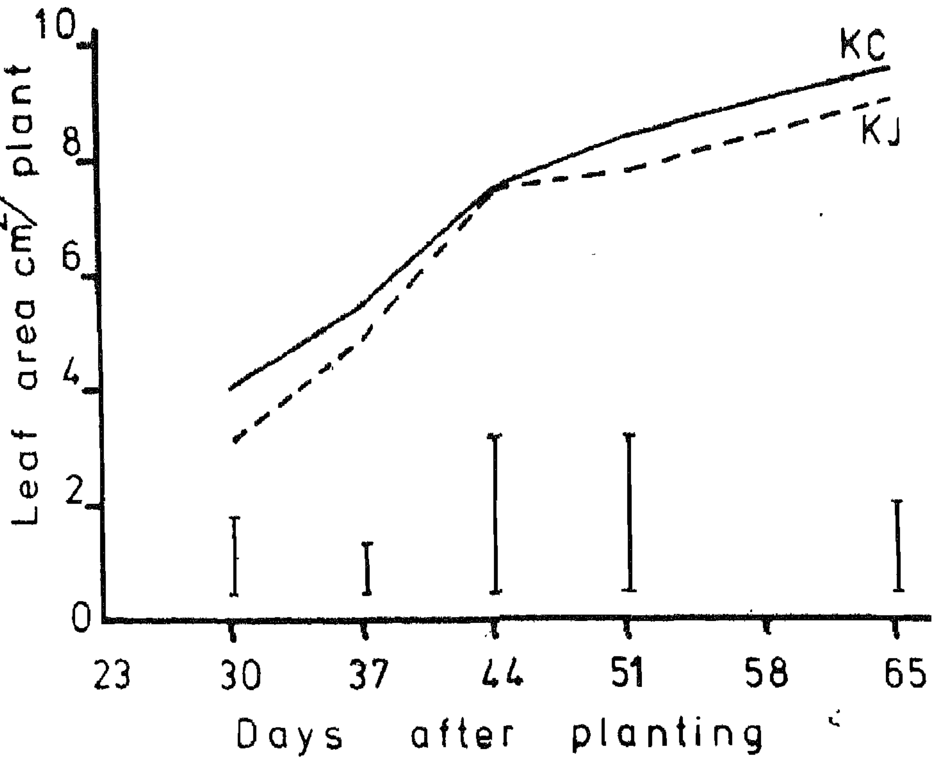
RESULTS AND DISCUSSION

Observations such as plant height, leaf area/plant, dry weights of shoot and root, root : shoot ratio, length of the longest root and total root length alongwith their standard errors have been shown in Figure 1 Variety KC consistently had higher values compared to KJ except for root dry weight. And, therefore, the root : shoot ratio was significantly higher in KJ, which shows that it possesses thicker and shorter root system. Variety KC had vigorous shoot growth, lower root : shoot ratio and hence longer and thinner root system Variety KJ is medium late while KC is early maturing (8) Swiezynski *et al.* (9) have shown that clones with early shoot growth have a short growing period and have early tuberisation Also clones with high root : shoot ratio exhibited delayed tuber formation and had a long growing period. Our findings with KJ and KC validates the observations of Swiezynski *et al* (9).

Total root length in KJ increased upto 44 days after planting and was constant till last date of sampling. While in KC total root length was constant upto 44 days after planting, thereafter, it steadily increased.

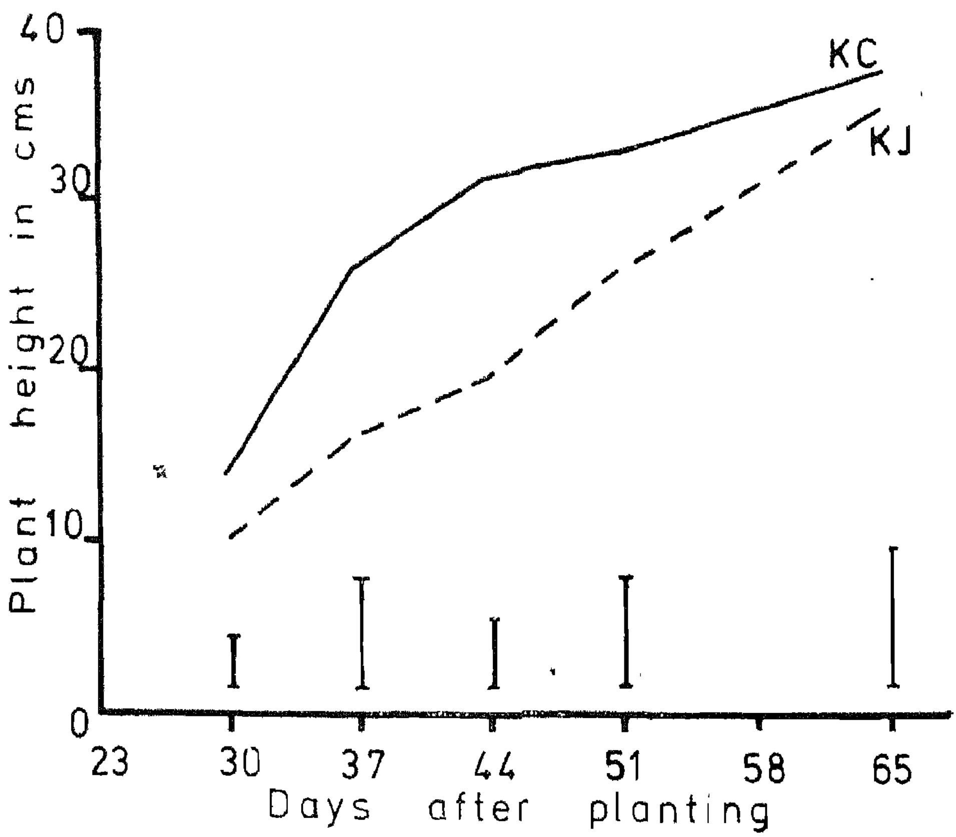
Results of the simple regression tests done between total root length and other plant parameters measured, have been shown in Table 1. Barring the height of the plant, all other parameters had a high correlation with total root length ($r>0.6$). and of the aerial parts leaf area was highly correlated ($r>0.65$). In all the cases correlations were better with KC than with KJ.

(a)



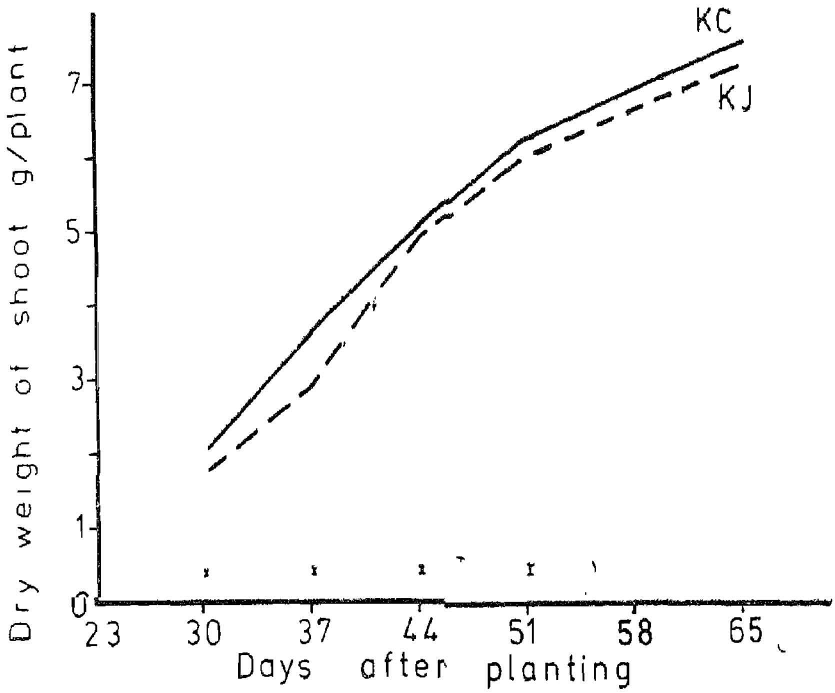
Leaf area cm²/ plant
10
8
6
4
2
0
KC
KJ
23
30
37
44
51
58
65
Days after planting

(b)

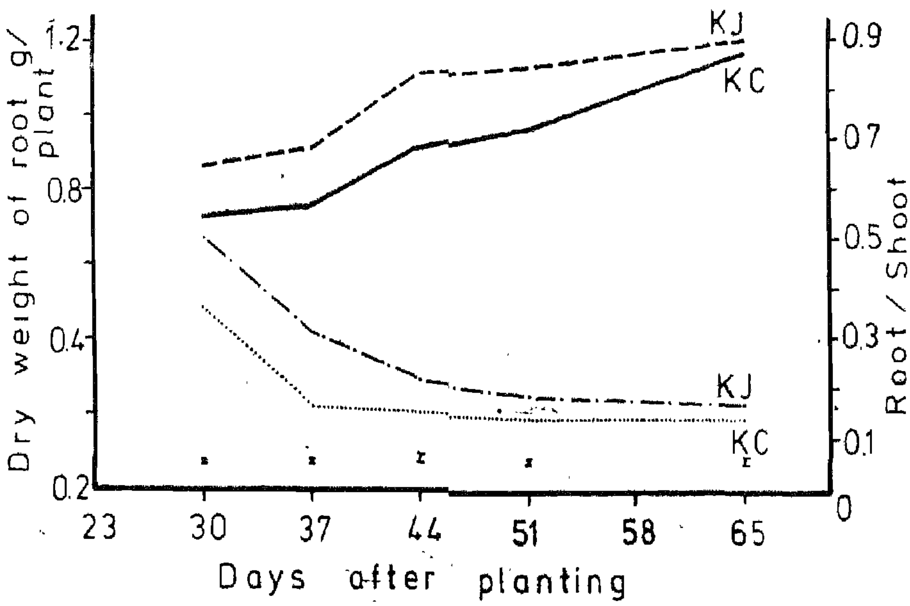


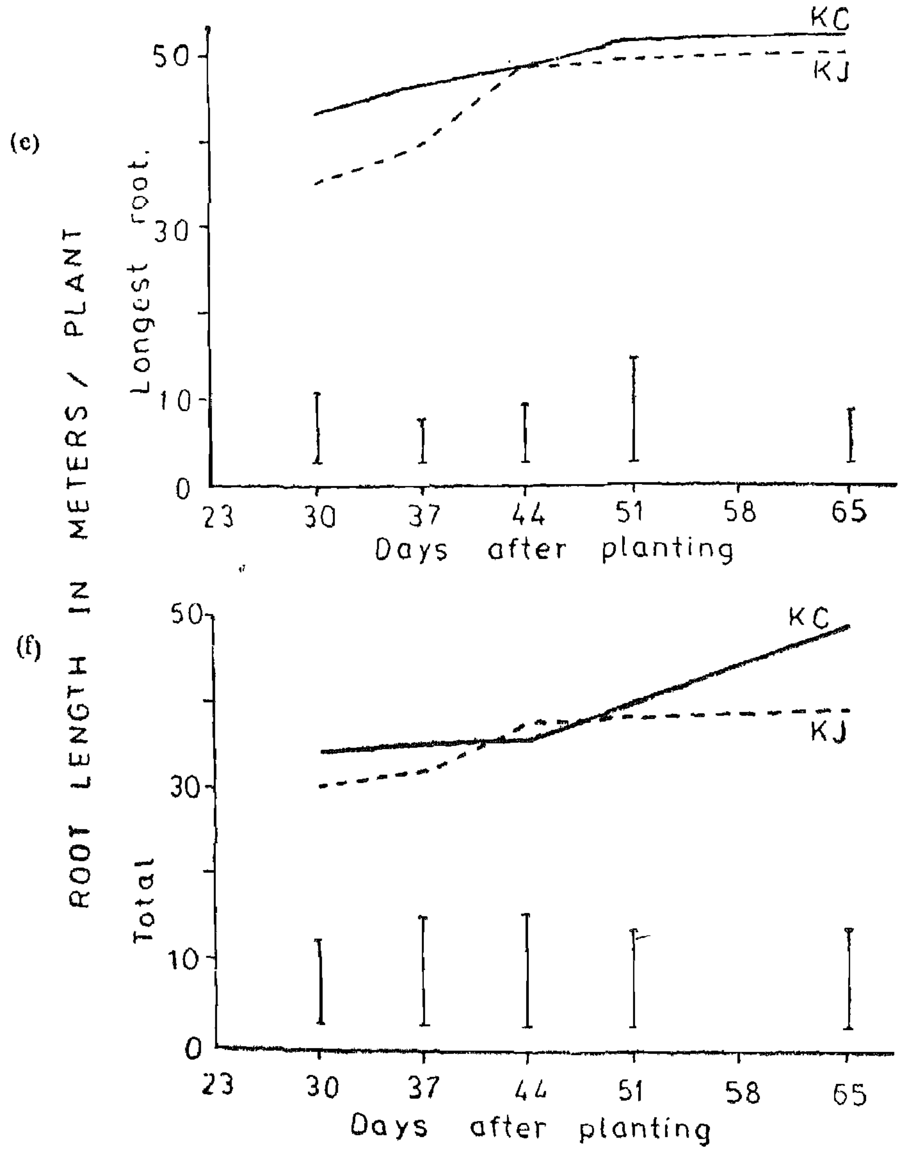
Plant height in cms
40
30
20
10
0
KC
KJ
23
30
37
44
51
58
65
Days after planting

(c)


KC
KJ
Dry weight of shoot g/plant
7
5
3
1
0
23
30
37
44
51
58
65
Days after planting

(d)


KJ
KC
KJ
KC
Dry weight of root g/plant
1.2
0.8
0.4
0.2
Root / Shoot
0.9
0.7
0.5
0.3
0.1
0
23
30
37
44
51
58
65
Days after planting



Figs. a—f : Variation of (a) Plant height, (b) Leaf area, (c) Dry weight of shoot, (d) Dry weight of root and Root : Shoot ratio, (e) Length of the longest root, (f) Total root length, with period of growth in two potato cultivar, Kufri Jyoti (KJ) and Kufri Chandramukhi (KC).

Table 1. Correlation coefficients of total root length in relation to different growth parameters.

Parameters	Variety	
	Kufri Jyoti	Kufri Chandramukhi
Shoot dry weight	0.6281***	0.7056***
Root dry weight	0.8208***	0 9214***
Height of the plant	0.5739**	0.7488***
Leaf area	0.6511***	0.8081***

** Significant at 1 0% level. *** Significant at 0.1% level.

Results of MRA have been shown in Table 2, that with all the four independent variables R values are 0.85 and 0.95 for KC and KJ, respectively. While with the three aerial part measurements they are 0.81 and 0.85, respectively. As there is no substantial reduction in the R values, it appears that measurements of aerial parts can be used as a reliable index to obtain total root length at least in two potato varieties studied. Significant linear correlation between root length and root dry weight has been observed with Russet Burbank potatoes grown in sandy loam soil (2). In soyabean, a technique for predicting root growth by measuring plant height and shoot dry weight, that holds good for crops raised under irrigated and non-irrigated conditions, has been developed by Mayaki *et al.* (3).

Table 2. Partial coefficient, constant, and R values for different concomitant variable combinations.

Sr. No	Variety	R value	Constant	Partial coefficient values			
				Shoot dry weight	Root dry weight	Height of plant	Leaf area per plant
1.	KJ	0.8531***	-7.4527	-2.0812	47.5196	-0.0724	0'6612
	KC	0.9472***	6.0137	-3 1238	35.2923	0.1862	1 4812
2.	KJ	0 8100**	22 8769	0.7153		-0.1887	1 8557
	KC	0.8513***	12.8014	-3.4399		0.4292	4.0203
3.	KJ	0.8208***	1.6333		31.9497		
	KC	0.9214***	9.2617		33.2067		

** Significant at 1.0% level, *** Significant at 0 1% level

From this study, it appears that at least in varieties like KC which has thinner root system and lower shoot : root ratio, a relationship can be developed between various aerial parameters and total root length. However, we realize that the plant growth characteristics change with soil types, varieties, climatic factors and cropping practices. Further experiments would validate and refine this prediction system.

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EFFECT OF REMOVAL OF PLANT TOPS ON GROWTH AND YIELD OF THE POTATO

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ABSTRACT

Field trials were carried out during rabi of 1978 and 1979 with three potato varieties Kufri Chandramukhi, Kufri Jyoti and Kufri Sindhuri to study the effect of removal of plant tops on plant growth and yield. The removal of plant tops on 20 days after planting or at tuber initiation stage increased the branches, leaves and prolonged leaf area duration (LAD). This increase in LAD influenced tuber size. but had adverse effect on tuber number and even on yields of Kufri Chandramukhi and Kufri Jyoti. Despite an increase in LAD during tuber development phase of all the three varieties tried, the removal of plant tops was found effective only for the late variety, Kufri Sindhuri, in which topping at the tuber initiation stage was found best for significant increase in yield of 13% (47 q/ha) over control.

INTRODUCTION

Topping and pruning of plants are known beneficial practices in horticulture. In field crops, nipping of the apical buds is very common in Bengal gram. Thus, studies had been made on sugar cane (8) and maize (6) crops wherein defoliation at particular stage of plant growth of a variety increased their yields. In the potato, (*Solanum tuberosum* L.), defoliation from any portion of the stem had been found detrimental to the tuber yield (2, 3, 7). This could, probably, be due to reduction in leaf area due to the defoliation of plants. Usually, as the tubers enlarge during bulking phase, no further leaves are initiated and leaf attains its senescence rapidly which may restrict the tuber growth. With this in mind topping was adopted in the present investigation, not to check this sharp decline in assimilatory area, but to increase longevity of the crop during tuber development with the hope of increase in tuber yields.

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MATERIALS AND METHODS

Potato varieties Kufri Chandramukhi (early), Kufri Jyoti (medium) and Kufri Sindhuri (late) were grown during, Rabi of 1978-79 and 1979-80 in experimental fields at Central Potato Research Station, Patna (Bihar). The 1978 trial was planted on November 21, while 1979 trial was planted on November 10. A randomized block design (3×4) and (3×5) was adopted for field trials in 1978 and 1979 respectively. Cultural practices recommended for the research station were followed with uniform fertilizer doses of 120 kg N, 60kg P_2O_5 and 80 kg K_2O per ha. Treatments of topping (removal of apical bud with two young leaves) of plants were i) 20 days after planting, ii) at tuber initiation stage, iii) 20 days after tuber initiation stage, iv) at tuber initiation stage and after another 20 days, and v) no topping of plants to serve as controls. Treatments of topping of plants were tried both in 1978 and 1979 years.

Records were made on tuber intiation between 24-25 days in Kufri Chandramukhi, 27-28 days in Kufri Jyoti and 29-30 days in Kufri Sindhuri. Observations on height, number of stems and leaves per plant were recorded at regular intervals. However, the observation made on 40 days crop age, after tuber initiation, is presented in (Table 1). In 1979, leaf area duration (LAD) per hill (DM^2 weeks) was also calculated according to method of Welbank *et al.* (9). On matutity of crop, plants were harvested and number and weight of the tubers per plot were recorded. Mean number of tubers per hill and tuber weight, and tuber yield were estimated. Results are presented in Table 2.

RESULTS AND DISCUSSION

The data (Table 1) reveals that removal of plant tops on 20 days crop age or at tuber initiation stage, in general, increased the number of stems and leaves per plant considerably, but had decreased plant height with all the treatments. LAD similarly, was found to be more than control. Treatment of topping at 20 days after tuber initiation stage was, however, less effective in all the potato varieties. Thus, topping of plants at tuber initiation phase followed by another topping after 20 days was not much different from topping treatment at tuber initiation once. Among the three potato varieties, Kufri Sindhuri was found to be more promising to these morphological variations.

All the increases in stems and its leaf number and even LAD resulted by tops removal were not beneficial in yield augumentation (Table 2) of the varieties tried.

Table 1. Effect of potato top removal on height, number of stems, number of leaves and LAD per (DM^2 Weeks) per plant.

Morphological characters	Varieties	Treatments: 20 days after planting	At tuber initiation stage	20 days after the tuber initiation stage	At the tuber initiation stage and after another 20 days	No topping of the plants (control)
Plant height in (cm)*	KCM	40.00	33.50	39.45	28 50	43.40
	KJ	32.60	25.10	33.85	27.70	37.85
	KS	48 20	40.95	47.65	37.20	57.45
Number of stems per plant*	KCM	11 20	6 95	2.35	5.80	0.75
	KJ	15.80	11.45	4 45	11.55	4.00
	KS	13.40	13.75	9.75	20 70	2.30
Number of leaves per plant*	KCM	66.70	52.25	43.50	44.90	51 05
	KJ	63 00	57.15	39 05	54.45	43 65
	KS	104.30	93.25	79.65	93.15	71 85
LAD (DM^2 weeks) per plat	KCM	369	383	234	387	364
	KJ	309	298	325	374	235
	KS	528	370	341	368	340

KCM=Kufri Chandramukhi, KJ=Kufri Jyoti, KS=Kufri Sindhuri, *=Average of 2 years data.

Table 2. Differences in yield and yield components of three potato varieties after removal of plant tops*

Yield components	Varieties	Treatments — Potato top removal: 20 days after planting	At tuber initiation stage	20 days after the tuber initiation stage	At the tuber initiation stage and after another 20 days	No topping of the plants (control
Number of tubers per plant	KCM	7 50	9.75	10 70	10.10	11.15
	KJ	5.50	7.55	6 80	7.60	7 45
	KS	11.00	13,50	1300	13.85	12,45
Fresh weight per tuber (g)	KCM	45.60	33.55	32.35	32 85	34 10
	KJ	54.20	46.10	48.60	41.30	49 15
	KS	33.80	30.15	29.20	28.80	28 85
Tubers yield (q/ha)	KCM	340.00	322.00	349.50	328.00	361 50
	KJ	299.00	343.00	329.50	333.50	362 50
	KS	371.00	404.50	378.00	392.00	357.50

KCM=Kufri Chandramukhi, KJ=Kufri Jyoti, KS=Kufri Sindhuri, * Average of 2 years data.

Thus, a positive linear association of LAD with tuber yields as observed by earlier workers (1,4), did not hold good in present studies (r=0.26).

Removal of the plant tops from 20 days old crop (i.e. during pre tuber initiation phase) caused general reduction in number of tubers per plant, which could be attributed to retarding effects of young developing leaves at tuberization(5). Increased LAD, however, influenced the tuber size of all the varieties, but losses in yields caused by reduction in tuber number could not be compensated at least in Kufri Chandramukhi and Kufri Jyoti.

Topping of plants at tuber initiation stage was found to be most detrimental to tuber yields in Kufri Chandramukhi (early) and less in Kufri Jyoti (medium), while reverse was observed when potato tops were removed on 20 days after tuber initiation in the case of Kufri Sindhuri. Kufri Sindhuri (late) responded favourably to topping treatments at all stages of plant growth, but tuber initiation stage proved most effective for registering increases in yield of 13% (47 q/ha) over no topping of plants (control). However, these varietal differences in response to topping treatment may, probably, be due to production of new branches and leaves induced by removal of plant tops at tuber initiation phase in Kufri Chandramukhi, and 20 days later in Kufri Jyoti during their active tuber development phase, and partitioning of entire available assimilates in two sinks (growing branches and developing tubers) which resulted in considerable loss in tuber yields. Kufr Sindhuri, late start of active tuber development phase and increased LAD appeared helpful in its increase in yield possibly due to more supply of assimilates to the developing tubers. Thus, topping at tuber initiation stage in late variety Kufri Sindhuri alone proved to beneficial

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EFFECT OF STORAGE ON ACID PHOSPHATASE ACTIVITY OF TUBERS OF SOME INDIAN POTATO VARIETIES

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ABSTRACT

Investigations were undertaken to find out the effect of conditions of storage on the activity of acid phosphatase (AcPh) in some varieties of potatoes. Both AcPh activity and specific activity of the tubers stored at room temperature were lower than that of the tubers stored in cold store.

INTRODUCTION

Acid phosphatase (E.C. 3.1.3.1) is lysosomal enzyme and its occurence in potato tubers has been very well documented (1,2,3). The enzyme is implicated in the host-parasite relationship (4,5) and in the break of tuber dormancy (6,7). However, the exact role of the enzyme is not yet known. In an effort to obtain information in this respect, we have undertaken some investigations and report in this paper, the effect of conditions of storage on the activity of acid phosphatase in some varieties of potato.

MATERIALS AND METHODS

Potato varieties were grown at the Central Potato Research Station, Modipuram, District Meerut. After harvest tubers were stored in the first week of April, 1979 in gunny bags at room temperature and in commercial cold store. Ten-tuber samples were withdrawn periodically for the determination of enzyme activity. At the time of sampling rotten tubers were removed and tubers were desprouted, if necessary, before the preparation of enzyme extract.

The enzyme was extracted and analysed by the procedure described by Pandey and Verma (3). Twenty gram tuber tissue was homogenised with 100 ml 0.05 M

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acetate buffer, pH 5.5 in a blendor for 2 min. The slurry was filtered through 2 layers of muslin and the filtrate was centrifuged at 1,500 x g for 20 min. The supernatant was used as the source of enzyme.

Enzyme activity was assayed with β-glycerophosphate as the substrate. The reaction mixture contained 1 ml acetate buffer, pH 5.5, 0.2 ml β-glycerophosphate, 0.1 M, enzyme and water to make up 2.0 ml. The reaction mixture was incubated at 37° C for 30 min and the reaction was stopped by the addition of 2 ml trichloroacetic acid, 10% (TCA). The substrate was added to the controls after the addition of TCA. After centrifugation for 5 min at 1,500 x g aliquots of the supernatant were taken for the determination of inorganic phosphorus (Pi), by the procedure of Fiske and Subbarow (8). Protein in enzyme extracts was determined by the procedure of Lowry et al. (9) Enzyme activity was expressed as μMoles Pi liberated/min under assay conditions Specific activity of the enzyme was expressed as μMoles Pi liberated/min/mg protein.

RESULTS AND DISCUSSION

Inorganic phosphate is reported to inhibit the activity of AcPh enzyme (2). Therefore, it was necessary to ascertain whether the endogenous Pi in the enzyme extract affected the rate of liberation of Pi from the substrate It was observed in the preliminary experiments conducted with enzyme extract prepared as described in the section, materials and methods, that the reaction was linear upto 60 min. During this period 4 μMoles of Pi was liberated. Under standard condition of assay 0 330 to 2.205 μMoles Pi was liberated. This observation, in our opinion, indicates that the endogenous Pi does not inhibit the liberation of Pi by the AcPh enzyme from β-glycerophosphate.

Evidence supporting the above conclusion was obtained by determining the AcPh activity of the extracts passed through a column of Sephadex G-25 to remove endogenous Pi. The column eulate showed a specific activity of 0.1875 μMoles Pi/min/mg protein as compared to 0.1854 μMoles Pi/min/mg protein of enzyme extract

Results are presented in Tables 1 and 2, and Figs 1 and 2.

The activity of AcPh was significantly different amongst the varieties (Table 1). It was highest in G-2524 followed by Kufri Bahar, Kufri Sindhuri, Kufri Lalima, Kufri Chandramukhi and Kufri Lauvkar. The varieties also differed significantly in

Table 1. Acid phosphatase activity of tubers of potato varieties (averaged over conditions of storage and dates of observation).

Varieties		Activity μ moles Pi/min	Specific activity μ moles Pi/min/mg protein
Kufri Bahar		0.0442	0.2808
Kufri Chandramukhi		0.0366	0.3333
Kufri Lalima		0.0389	0.2849
Kufri Lauvkar		0.0259	0.2131
Kufri Sindhuri		0.0400	0.2704
G-2524		0.0491	0.3771
	SEm	0.0020	0.0251
	CD (0.05)	0.0055	0.0696

respect of the specific activity of AcPh. However. the order was slightly different, G-2524 showed the highest specific activity followed by Kufri Chandramukhi, Kufri Lalima, Kufri Bahar, Kufri Sindhuri and Kufri Lauvkar.

Significant differences in AcPh activity and specific activity were also obtained during the storage of tubers (Table 2). The AcPh activity and specific activity increased till 32 days of storage and then declined. The decline in AcPh activity and specific activity of stored tubers between 62 days and 97 days was considerable and again between 158 days and 189 days of storage of tubers.

Table 2. Acid phosphatase activity during storage of potato tubers (averaged over varieties and conditions of storage).

	Period of storage days								
	0	32	52	97	126	158	189	SEm	CD (0.05)
Activity μMoles Pi/min	0.0527	0.0530	0.0468	0.0310	0.0292	0.0327	0.0202	0 0022	0.0061
Specific activity μMoles Pi/min/mg protein	0.3446	0.3808	0.3530	0.26825	0.2711	0.2607	0 1145	0.0273	0.0757

Both AcPh activity and specific activity of tubers stored at room temperature (0.031 μMoles Pi/min and 0.209 μMoles Pi/min/mg protein) were significantly lower than that of tubers stored in a cold store (0.0455 μMoles Pi/min and 0.3683 μMoles

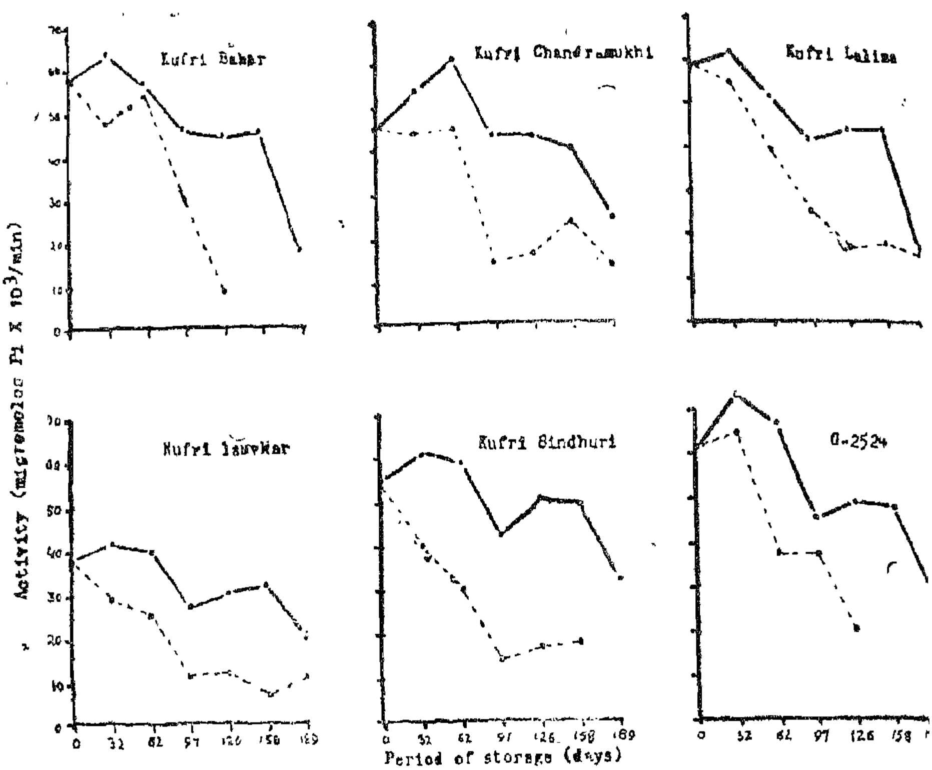

Figure 2. Activity of acid phosphatase enzyme in potato tubers during storage.
(---- Room temperature, ——— Cold store)

Pi/min/mg protein. This was in general due to a continuous decline in AcPh activity and specific activity in tubers stored at room temperature (Figs. 1 and 2). In case of cold stored tubers, AcPh activity increased initially. The subsequent decline was much less as compared with that observed in case of tubers stored at room temperature. The specific activity of cold stored tubers generally increased upto 62 days of storage, declined between 62 and 97 days and increased subsequently The specific activity at 126 days after cold storage was higher than at the time of storage in all varieties excepting Kufri Lalima. However, the specific activity was considerably lower in tubers stored for another 63 days (Fig. 1), due to very steep fall in specific activity between 156 and 189 days.

Differences in AcPh activity of potato varieties have been observed earlier (3) and our results confirm them. Our results for cold stored tubers (Figs. 1 and 2) are also in agreement with results obtained by Bielinska-czarnecka et al. (7), who observed two peaks of AcPh activity in tubers stored at low temperature (upto 8° C) Bailey et al. (6) also observed an increase in AcPh activity at the time of sprout

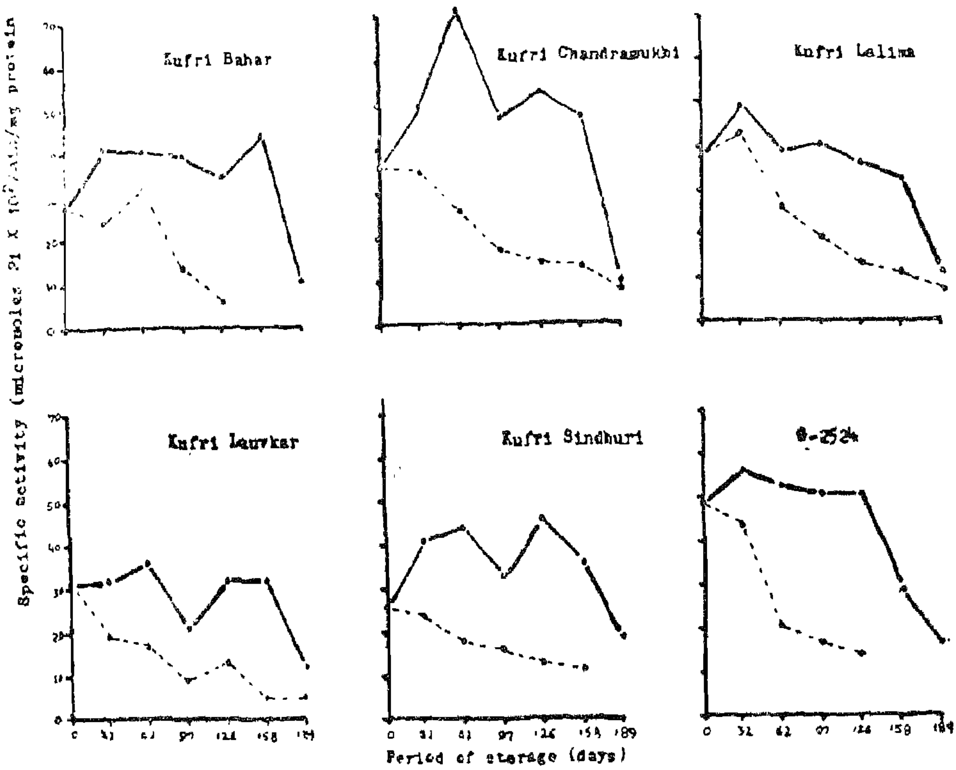

Figure 2. Specific activity of acid phosphatase enzyme in potato tubers during storage (--•---•-- Room temperature, —•——•—Cold store)

initiation. Lucas and Pitt (1) observed a decline in AcPh activity after sprout initiation in potato tubers. We have observed a continuous decline in AcPh activity in the tubers stored at room temperature, where sprout initiation occured within a few days of storage. It is pertinent to mention here that in sprouted tubers AcPh activity was always higher in the sprouts than in the tuber tissue (Pandey and Verma, unpublished).

These results suggest that AcPh activity is associated with physiology related to growth. It seems reasonable to assume that at about the time of sprout initiation, AcPh activity in tuber tissue increases and later declines when sprouts grow. This would be in confirmity to lower levels of activity observed by Pandey and Verma (unpublished) in the tuber tissue of sprouted tubers than in the sprouts.

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EFFECT OF IRRIGATION AND NITROGEN FERTILIZATION ON YIELD AND SIZE OF POTATO VARIETY KUFRI SINDHURI

U.C. PANDEY[1], KIRTI SINGH[2] AND J L. MANGAL[1]

ABSTRACT

Studies were conducted for two years (1970-71 and 1971-72) to compare three levels of irrigation (25, 50 and 75 per cent available soil moisture) and four doses of nitrogen (100, 120, 140 and 160 kg/ha). Higher potato yield was recorded when irrigations were applied at 75 per cent available soil moisture followed by 50 per cent and 25 per cent soil moisture. Application of nitrogen dose at the rate of 160 kg/ha produced highest potato yield in comparison to other treatments. Irrigation and nitrogen application at the rate of 100 kg and 120 kg/ha did not show any significant influence on tuber size.

INTRODUCTION

Yield and size of potato are greatly influenced by soil moisture, nutrients, environmental conditions and management practices. Absence of relevant information on these aspects adversely affects the production and quality of this crop. Among these factors role of adequate irrigation and optimum dose of nitrogen is of more importance. Since little information is available on the effect of irrigation intensities and fertilizer levels on yield and size of potato, the present investigation was, therefore, carried out to ascertain optimum dose of nitrogen and irrigation schedules for potato crop, in agroclimatic conditions of Hissar, Haryana.

MATERIALS AND METHODS

The experiment was conducted at Hissar during 1970-71 and 1971-72 on sandy loam soil of average and uniform fertility having average pH 8 3, conductivity

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(mmhos/cm) 0.72, organic carbon (%) 0.43, available P_2O_5 (kg/ha) 35.0 and K_2O (kg/ha) 865.0 on the variety Kufri Sindhuri both the years of experimentation. The studies were conducted in a split plot design with three main plot treatments of irrigation (irrigation at 25, 50 and 75% available soil moisture) and four sub-plot treatments of nitrogen doses (100, 120, 140 and 160 kg/ha). All twelve treatment combinations were replicated three times.

A basal dressing of 60 kg/P_2O_5, 120 kg K_2O/ha and half dose of nitrogen was applied as band placement at the time of planting. Remaining 1/2 dose of nitrogen was applied after 30 days of planting at the time of earthing during both the years. Potato seed tuber of optimum size were planted on ridges in a plot of 2.40 Mx2M at a planting space of 60 cmx20 cm on 26.10.71 and 23.10 71 in respective years.

Moisture percentage in the field was measured with the help of Parihar Moisture Meter before each irrigation and measured amount of water was applied as per treatment.

Table 1. Details of irrigation schedule.

Treatment	No. of irrigations		Date of first irrigation		Date of last irrigation	
	1970-71	1971-72	1970-71	1971-72	1970-71	1971-72
Soil moisture (%) *(Depletion of moisture (%))*						
25 (75)	2	2	7.12.70	8.12.71	9.2.71	11.2.72
50 (50)	5	5	26.11 70	29.11.71	16.2.71	19.2.72
75 (25)	11	11	18 11.70	20.11.71	19.2.71	21.2.72

Depth of irrigation water was kept 50 mm at each irrigation. Depth of irrigation water and length and width of plot were considered while measuring the volume of water per plot. The details of irrigation schedule for various treatments during the two years are given in Table 1 Two common irrigations were given to complete the uniform sprouting in each treatment before the irrigation schedule was followed as per treatment.

All cultural and plant protection measures were followed as and when required, The data were recorded on yield and size of potato tubers.

RESULTS AND DISCUSSION

The data in Table 2 revealed that significantly higher potato yield was recorded when irrigations were applied at 75% soil moisture followed by irrigations at

50 and 26 per cent soil moisture during both the years. Reduction in yield under irrigations at 25% soil moisture was about 132.5 and 64.9/ha during respective years as compared to irrigations at 75% soil moisture. Potato yield was also influenced by nitrogen application during 1970-71. Highest potato yield was noticed when nitrogen was applied @160 kg/ha followed by 140 kg, 120 kg and 100 kg/ha. However, there was no significant effect of nitrogen during second year. Interaction (NxI) was found to be non-significant during both the years. Reduction in potato yield per unit area under irrigations at 25% and 50% available soil moisture in comparison to irrigations at 75% available soil moisture may be due to moisture stress which affected the normal growth and develoment. The plants having irrigations at 75% available soil moisture appeared to have experienced no moisture stress and the various physiological processes went on smoothly resulting in better uptake of nutrients and better plant growth. According to Drew (2), proper balance of moisture in plants not only increase the photosynthesis but also helps in higher uptake of nutrients to meet accelerated rate of growth and ultimately the yield. These results are in conformity with the findings of Narang and Kanwal (4), and Bhattacharjee (1). But there was no significant difference in tuber size during the second year due to nitrogen application. Interaction effect was found to be non significant during both the years of experimentation.

Table 2. Effect of irrigation and nitrogen level on the yield (q/ha) of potato variety Kufri Sindhuri

Irrigation	Year	Nitrogen levels (kg/ha) 100	120	140	160	Average
Soil moisture (%)						
25	1970-71	165.3	192.3	223.4	283.3	216.1
	1971-72	133.8	172.3	205.3	231.0	185.6
50	1970-71	199.5	216.8	289.1	294 8	250.0
	1971-72	188.8	209.4	226.9	245 3	217.5
75	1970 71	288.9	321.0	396.0	388.6	348.6
	1971-72	215.2	215.9	260.3	274.5	250.5
Mean	1970-71	217.9	243.3	302.9	322.[illegible]	271.5
	1971-72	179.3	211.2	230.8	250.3	217.9

		(1970-71)	(1971-72)
C. D. at 5% for (i)	Irrigation levels (I)	16.8	7.5
(ii)	Nitrogen levels (N)	14.7	N.S.
(iii)	Interaction (I x N)	N.S.	N.S

Table 3. Effect of irrigation and nitrogen levels on size of potato tuber (g) in variety Kufri Sindhuri during 1971-72.

Irrigation	Nitrogen levels (kg/ha) 100	120	140	160	Average
Soil moisture (%)					
25	24.7	30.0	34.0	44.4	33.3
50	32·4	36.0	39.0	52.0	39.9
75	25.7	34.4	52 0	44.4	39.1
Mean	27.6	33.5	41.6	46.9	37.4

C. D. at 5% for (i) Irrigation (I) N. S.
(ii) Nitrogen (N) 7.3
(iii) Interaction (I x N) N. S

Irrigation treatments did not show any influence on tuber size (Table 3). However 100 kg and 120 kg/ha N did nct affect tuber size significantly. There was statistically no difference between the nitrogen doses of 120 kg N/ha. Interaction effect was found to be non-significant. The results are in agreement with the findings of Kapoor (3).

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EFFECT OF SEED SIZE AND SPACING ON GROWTH AND YIELD OF POTATO

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ABSTRACT

In a field trial at the Vegetable Research Farm, Haryana Agricultural University, Hissar intrarow spacing of 15 cm gave the higest tuber-yield in potato var. *Kufri Chandramukhi*. With wider intra-row spacing of 25 cm and 80 g seed-size the production of 'A' grade (above 50 mm) tubers were also improved. The closer spacing i.e. 15 cm, higer yields of 'B' (25 mm to 50 mm) and 'C' grade (below 25 mm) tubers was obtained. The height of plant and number of stems per hill were also higher in 15 cm spacing and 80 g seed-size. It was concluded that an optimum plant spacing (55 cm × 15 cm) with the seed-size of 80 g gave best performance under arid conditions prevailing at Hissar.

INTRODUCTION

The factors like seed-size and spacing influence economic potato growing. Because a slight variation in one or both apart from influencing the yield, affects considerably the physiological capabilities of the plant and also economics of potato production. In the absence of local cold storage facilities, there is always difficulty in securing desirable seed-size and the requisite amount of seed potatoes which must be imported from the hills or from certain other seed centres. The cost of imported seed is exorbitant during the planting season. Considerable amount of work in India as well as on exotic locations on these aspects have been reported by Suri (8), Singh and Wakankar (6), Azariah and Saptharishi (1), Bates (2), Findlay and Sykes (4), Choudhary and Choudhary (3), and Shukla and Samarjeet (5). The experiment reported here was planned to determine the most suitable seed-size and spacing which would be economically suitable and profitable under conditions prevailing in the arid region of Haryana.

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MATERIALS AND METHODS

This field trial was conducted at Vegetable Research Farm, Haryana Agricultural University, Hissar during 1978-79. Variety Kufri Chandramukhi of potato was used in view of its wide popularity and homeostatic nature. The spacing chosen for the experiment were 15 cm (S_1), 20 cm (S_2) and 25 cm (S_3) from tuber to tuber, 20 cm spacing being the local practice. The seed was sorted into two groups for size i.e. 50 g (W_1) and 80 g (W_2). The experiment was laid out in a randomized block design with three replications. The distance between rows was kept constantly at 55 cm. The net plot size was 2.40 Mx 3.30 M. Planting was done on October 9, 1978 and harvesting on January 19, 1979. Recommended manurial and cultural schedule was followed during the period of experimentation. Observations were recorded on various growth and yield characters.

RESULTS AND DISCUSSION

Results of total yield and in different grades of tubers are presented in Table 1. Among the intra-row spacing tried S_1 (15 cm) give the highest yields and next in succession were S_2 and S_3. The seed size W_2 (80 g) gave better results in all the spacings and proved the best with 15 cm spacing. In general increase in the plant spacing resulted in decrease of total yield and the yield of 'C' grade (below 25 mm) tubers. Similar results were also reported by Bates (2) and Findlay and Sykes (4). There was no significant increase or decrease in yield of 'C' grade (below 25 mm) tubers when the spacing between plants was increased from 20 cm to 25 cm. It was thus inferred that increased plant population increased the total number of small sized tubers ('C' grade) due to increase in intraplant competition. Whereas wider intra-row spacing induced production of higher yield of better grade ('A' grade) tubers per plant. It had been observed that tubers of 80 g i.e. larger seed-size give the best yields of 'A' grade tubers. The closest spacing of 15 cm gave higher yields of 'B' (25 mm to 50 mm) and 'C' (below 25 mm) grades tubers. The total yield from large seed-size (80 cm) was greater than from smaller seed-size (50 gm) because large seed produced more sprouts, greater yields and large number of tubers per hill. In small seed-size the effects of mosaic disease of potato is to produce dwarfed, unhealthy plants, which mainly produces small tubers and in consequence, only very poor yields could be expected. By eschewing the samll tubers and insisting on the ideal seed-size for planting, the percentage of mosaic affecting the crop could also be brought down considerably. Similar were the findings of Singh and Wakankar (6).

Table 1. Effect of seed size and spacing and growth characters of potato.

Seed size & spacing	Yield of A grade tubers (Q/ha)	Yield of 'B' grade tubers (Q/ha)	Yield of 'C' grade tubers (Q/ha)	Total yield of tubers (Q/ha)	No. of tubers per plant	Avg. weight of tuber (g)	Final plant stand (%)	No. of stems per hill	Height of plant (cm)
Seed size									
W_1	163.67	140.76	64.55	355.72	5.95	79.78	85.01	3.62	51.99
W_2	205 07	168.41	74.50	446.81	7.74	72.45	85.02	4.14	55.15
Spacing (cm)									
S_1	184.68	170.93	75.99	428.37	7 06	73.67	69.62	4.25	66.57
S_2	184.19	158.30	66.70	407.57	6.79	72.17	89.59	3.77	52.42
S_3	184.26	134 52	65.88	367.90	6.68	82.50	95.84	3 60	51.72
Seed size x spacing									
W_1S_1	184.52	139.77	75.36	393.21	6.36	75.33	69.10	4.27	56.60
W_1S_2	165.87	158.30	58.10	382.27	6.48	74.67	89.81	3.40	49.60
W_1S_3	140.61	124.20	60.18	291.68	4.99	89.33	96.11	3.17	49.77
W_2S_1	184.82	202.08	76.62	463.52	7.74	72.00	70.14	4 23	56 33
W_2S_2	202.50	158.30	75.30	432.79	7.09	69.67	89.35	4.13	55.23
W_3S_3	227.89	144.83	71.57	441.11	8.36	75.67	95 36	4.03	53.67
C. D. at 5%									
W	38.48	32.00	N.S.	50.85	1.50	N.S.	N.S.	N.S.	N.S.
S	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	7.74	N.S.	N.S.
WxS	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Seed size
W_1 = 50 gm
W_2 = 80 gm

Inter-row spacing
S_1 = 15 cm
S_2 = 20 cm
S_3 = 25 cm

Grade of tubers
'A' grade = Above 50 mm
'B' grade = 25 mm to 50 mm
'C' grade = Below 25 mm.

The effect of seed-size and spacing on number and weight of tuber, plant stand and growth characters is also given in Table 1. The data revealed that S_1 (15 cm) spacing and 80 gm seed-size was all along effective in producing more number of tubes per hill. As the size of seed increases the number of tubers per hill increased but reverse was the effect on average tuber weight. The spacing S_3 (25 cm) was most effective in increasing the weight of tubers in both the seed sizes. Same trend was oberved for final plant stand. There were no significant effects of both seed size and spacing on number of stems and height of plant although larger seed size (80 g) produced slightly higher number of stems and height of plant. The data depicted that seed-size had a direct bearing on the metabolic activities of potato plant which resulted in increased growth and tissue formation. Similar results had been reported by Singh (7). Since the mother tuber functions as a store house of food for the plant in infancy thus bigger the seed possesses more is the reverse of nutrients. Consequently such seed tubers result in early and relatively high germination and also with stronger and vigorous sprouts which ultimataly grow faster and yield better

From the present investigation, it was concluded that an optimum plant spacing (55 cm x 15 cm) with the larger seed size (80 g) the best yield performance of variety Kufri Chandramukhi could be obtained. With wider intra-row spacing (55 cm x 25 cm) and 80 g seed-size the yields of 'A grade (above 50 mm) tubers were also improved. The closest spacing of 15 cm gave higher yields of 'B' and 'C' grade tubers in both the seed sizes.

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EFFECT OF SPACING AND SEED SIZE ON GROWTH AND YIELD OF TOTAL AND SEED SIZE TUBERS IN POTATO

S. C. KHURANA AND M. L. PANDITA

ABSTRACT

An experiment with nine combinations of inter-and intra-row spacing and three seed sizes laid out at H. A. U. Regional Potato Research Station, Kharindwa (Kurkushetra) in 1972-73 and 1973-74, showed that total and net yield and quantity of 25-50 mm tubers, plant height and number of stems per plant all increased with the increase in seed size. The total yield and yield of seed size tubers increased with increase in plant population. Spacing of 50 and 60 cm between rows was found better than 70 cm during both the years under study.

INTRODUCTION

Potato (*Solanum tuberosum*) crop requires optimum conditions for proper growth and harvest of high yields. In such row crops, yield per unit area is dependent not only on the number of plants per unit area but also on special arrangement of these plants. Potato is vegetatively propagated crop and hence has higher seed requirement. Too close spacing causes the individual plant to suffer from competition and impairs the crop growth. On the other hand, too wide spacing causes increase in the size of tubers and yield per plant but total yield per unit area may be decreased because of less plant population (1,4). Hence there is a need to work out the optimum spacing both for table as well as seed purposes. Large seed can also be effectively used by increasing spacing and smaller seed by decreasing the spacing between plants (2).

The vegetative growth, number of stems and yield increased with increase in the seed size (4), by proper adjustment of spacing with seed size, both yield and average tuber size can be modified.

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The present project was, therefore, undertaken to study the effect of combination of inter-and intra-row spacing and seed size on growth, yield and grades of tubers especially in relation to the production of seed size tubers.

MATERIALS AND METHODS

An experiment with three seed sizes (25-35,(28 g), 35-45 45g) and 45-55 (75g) mm diameter) in potato variety Kufri Chandramukhi was planted at 18, 30 and 42 cm apart in rows at distance of 50 cm; 15, 25 and 35 cm apart in rows at a distance of 60 cm and 13, 23 and 30 cm apart in rows at a distance of 70 cm so as to get a plant population of 48,000, 67,000 and 1,11,000 per ha in each case.

The experiment was laid out in split plot design in three replications with combinations of nine inter-and intra-row spacing as main treatments and three seed sizes as sub treatments as shown in Table 1. The soil was sandy loam. Plot size was 17.64 sq.m. (4.20 m 4.20 m) and planting of well sprouted tubers was done on 20th October in 1972 and 30th October 1973, at H A.U. Regional Potato Research Station, Kharindwa (Kurukshetra). Data on number of stems per hill was recorded 50 days after planting and height of plant after 70 days.

RESULTS AND DISCUSSION

Total Yield

Among the 9 main treatments, 60 cm x 15 cm out yielded other treatments during both the years under study (Table 1) which gave 253.83 q/ha^{-1} in 1972 73 and 311.79 q/ha^{-1} during 1973-74. This treatment was statistically at par with 50 cm x 18 cm and 70 cm x 13 cm and was statistically superior to remaining 6 treatments. This treatment also gave highest net yield of tubers during both the years (Table 3). The data further revealed that plant geometry was not important factor but plant population was very important factor contributing towards the most yield. Lowest yield of potato tuber was given by the spacing of 70 cm x 30 cm which gave 153.99 q/ha^{-1} during 1972-73 and 236.55 q/ha^{-1} during 1973-74. During1972-73 it was statistically inferior to all the remaining 8 treatments. It also gave lowest net yield of 130.33 q/ha during 1972-73 which is significantly lower than all the remaining treatments. However during 1973-74 main treatments did not differ statistically as for as net yield was concerned but the net yield of this treatment was lower than all the treatments except 70 cm x 23 cm. The lowest yield may be due to lower plant population alongwith optimum combination of plant geometry. Lowest yield with the spacing of 70 cm x 30 cm has also been reported by Krishnappa and Gowda (6). This may be attributed to more width of ridge resulting in poor

Table 1. Effect of combination of inter-and intra-row spacing and seed on total yield of in tubers q/ha-1

Spacing / seed size	1972-73				1973-74			
	25-35mm	35-45mm	45-55mm	Average	25-35mm	35-45mm	45-55mm	Average
50 cm x 18 cm	218.91	224.39	265.01	236.10	250.38	327.85	353.36	310.53
50 cm x 30 cm	213.99	219.19	248.01	227.06	224.87	281.08	306.12	270.67
50 cm x 42 cm	188 48	220.61	235.72	214.94	213.06	261.72	291.48	255.42
60 cm x 15 cm	225.33	260.76	275·40	253.80	256 05	324.07	355 25	311 79
60 cm x 25 cm	185.18	222.02	266.43	224.54	247.07	248.49	307.54	267.70
60 cm x 35 cm	177.62	182.81	204.07	188.17	193.26	237.15	279.19	236.53
70 cm x 13 cm	210.41	215.41	276.82	234.15	274.94	288.64	320.29	294.62
70 cm x 23 cm	168.17	206.43	248.01	207.54	180.46	247.07	306.12	244.55
70 cm x 30 cm	140.30	149.27	172.42	154 00	188.02	263.13	257.94	236 36
Average	192.02	211.21	243.54		225.35	275.47	308.59	

	1972-73	1973-74
1. C. D. at 5% for main treatments		
2. C. D. at 5% for sub treatment	26.53	45.43
3. C. D. at 5% for sub treatments within given main treatment	12.32	14.03
4. C. D. at 5% for the body of the table	36.90	42·00
	40.23	56.85

seepage to root zone thus making less quanitity of water available to the growing plants compared to 50 to 60 cm row spacings. It might also be due to poor utilization of space. There was no difference between 50 and 60 cm row spacings which corroborates the findings of Rostropowiez (8).

Among the three plant populations tried, population of 1,11,000 ha^{-1} gave the highest gross yield per unit area during both the years under study, irrespective of seed size and row spacings used and maintained its superiority over 67,000 and 48,000 plant population. It gave an average yield of 241.35 q/ha^{-1} as compared to lowest yield of 185.70 q/ha^{-1} given by the plant population of 48,000 during 1972-73 while in 1973-74 its yield was 305.65 q/ha compared to 242.75 q/ha^{-1} given by 48,000 plant population. However its net yield was equal to the plant population of 67,000 during 1972-73 and highest during 1973-74. Increase in gross yield with increase in plant density has also been reported by Bianco (1). Sub treatments (seed size) also differed significantly during both the years. Planting large (45-55 mm) seed tubers increased yield by 51.33 q/ha in 1972-73 and 83.25 q/ha in 1973-74 and planting 35-45 mm seed size tubers increased yield by 19.20 q/ha in 1972-73 and 50.13 q/ha in 1973-74 over those of 192.01 q/ha in 1972-73 and 225.34 q/ha in 1973-74 obtained by planting small tubers of the size 25-35 mm Net yield also increased with increase in the size of tubers used for seed purpose (Table 3). The increase in yield is attributed to the increase in the number of stems per unit area. Similar findings have been reported by Iritani et al. (4) and Pandey and Ghai (7).

Seed size tuber 25-50 mm

In general the yields were better during 1973-74 than 1972-73 because of optimum time of planting and better climatic conditions. With the increase in row spacing to 70 cm the yield of seed size tubers was reduced Table 2). Plant population of 1,11,000/ha exhibited the highest yield of seed sized tubers during both the years under study. This is attributed to the increase in number of stems per unit area leading to more competition between plants consequently reduction in tuber size. This agrees with the work done by Khurana (5), Ifenkwe (3), Ghai et al. (2), Svensson and Carlsson (9) and Krishnappa and Gowda (6). With the use of large sized tubers for planting, yield of seed sized tubers increased significantly. It was 94.79 q/ha during 1972-73 and 107.70 q/ha during 1973-74 using tubers of the size 45-55 mm for planting as compared to the yield of 75-88 q/ha during 1972-73 and 58.89 q/ha during 1973-74 obtained by planting the tubers of the size 25-35 mm.

Table 2 Effect of combination of inter-and intra-row spacing and seed size on the yield of seed size (25 to 50 mm) tubers in q/ha^{-1}

Seed size/spacing	1972-73				1973-74			
	25-35mm	35-55mm	45-45mm	Average	25-35mm	35-45mm	45-55mm	Average
50 cm x 18 cm	106.16	108.17	142.66	118 99	149.40	181.40	192.73	174.47
50 cm x 30 cm	95.42	107.23	115.26	105 97	85.55	102 03	145.49	111.02
50 cm x 42 cm	76 52	99.67	115.26	97 15	59.52	84.08	96.46	79.99
60 cm x 15 cm	123.29	131.32	140.30	131.64	135.10	191.79	198.88	175 26
60 cm x 25 cm	84.08	104.87	126.60	105.15	87.86	135 10	159.67	127.54
60 cm x 35 cm	82 67	78.41	100.14	87 07	56.68	91.64	96.36	81.56
70 cm x 13 cm	109.59	111.01	153.53	124.71	122.82	138 88	196.88	151.79
70 cm x 23 cm	84.55	100 62	103.45	96.21	67.08	111.48	156.83	111.80
70 cm x 30 cm	67.55	66.60	68.97	67.71	60.46	101.56	130 38	97.47
Average	92.20	100.88	118.46		91.59	126.44	152.66	

	1972-73	1973-74
1. C. D. at 5% for main treatments	15-68	20.91
2. C. D. at 5% for sub-treatments	7.48	8.43
3. C. D. at 5% for sub tteatments within given main treatment	22.39	25.30
4. C. D. at 5% for the body of the table	24 01	29.38

Table 3. Effect of combination of inter-and intra-row spacing and seed size on the net yield (total—seed used) of tubers in q ha^{-1}

	1972-73				1973-74			
Seed size/spacing	25-35mm	35-45mm	45-55mm	Average	25-35mm	35-45mm	45-55mm	Average
50 cm x 18 cm	187.84	174.41	181.77	181.34	219.30	277.87	270.11	255.76
50 cm x 30 cm	195.25	189.05	197.74	194.01	206.11	250.93	255.84	237.63
50 cm x 42 cm	175.05	199.02	199.73	191.27	199.62	240.12	255.48	231.74
60 cm x 15 cm	194.26	210.79	192.16	199.07	224.97	275.09	272.00	257.02
60 cm x 25 cm	166.42	191.88	216.16	191.49	288.31	218.34	257.26	234.64
60 cm x 35 cm	164.18	161.22	168.08	164.49	179.78	215.55	243.20	212.84
70 cm x 13 cm	179 14	165.44	193.58	179.39	243.87	238.66	237.04	239.86
70 cm x 23 cm	149.42	176.29	197.74	174.48	161.70	216.92	255.84	211.49
70 cm x 30 cm	126.87	127.68	136.43	130.33	174.58	241.54	221.94	212.69
Average	170.94	177.31	187.04		204.25	241.56	252,01	

	1972-73	1973-74
1. C. D. at 5% for main treatments	38.38	N.S.
2. C. D. at 5% for sub treatments	12.77	14.04
3. C. D. at 5% for sub treatments within given main treatment	38.32	42.11
4. C. D. at 5% for body of the table	49.50	56.95

Table 4. Comparative economics of various treatments.

Seed size/spacing	25-35mm	35-45mm	45-55mm	Average	25-35mm	35-45mm	45-55mm	Average
50 cm x 18 cm	16501	14160	18072	16244	21075	25430	27010	24505
50 cm x 30 cm	17413	16719	18672	17601	17632	20765	24402	20933
50 cm x 42 cm	15386	17685	19240	17437	16172	19705	22103	19327
60 cm x 15 cm	17892	17979	18674	18182	20692	25736	27481	24636
60 cm x 25 cm	14773	16787	20585	17382	19313	20302	25282	21632
60 cm x 35 cm	14964	13869	16193	15009	14630	18401	21243	18091
70 cm x 13 cm	16094	13687	19497	16426	21339	20346	24731	22139
70 cm x 23 cm	13608	15462	18023	15698	13508	18904	25026	19146
70 cm x 30 cm	11520	10872	12263	11552	14467	20768	21627	18954
Average	15350	15247	17913		17648	21151	24323	

Cost of seed used : 25-35mm and 35-45mm, Rs. 150 q^{-1}, 45-55mm, Rs. 125 q^{-1} .
Price of potato : 25-50 mm (seed size) Rs 100 q^{-1} , over 50 and below 25 mm, Rs. 70 q^{-1}

Table 5. Effect of combination of inter-and intra-row spacing and seed size on height of potato plant in cm.

Seed size spacing	1972-73				1973-74			
	25-35mm	35-45mm	45-55mm	Average	25-35mm	35-45mm	45-55mm	Average
50 cm x 18 cm	14.73	15.46	18 80	16 35	18 46	25.60	29 40	24.49
50 cm x 30 cm	18 80	17.53	19.86	18.73	17.26	20 46	23.86	20.53
50 cm x 42 cm	16.73	19 26	20.20	18.73	13.90	19.66	21.46	18.34
60 cm x 15 cm	16.86	19.00	18.86	18.24	20.50	30.40	30 13	27 01
60 cm x 25 cm	16.40	19.00	19.26	18 22	20.00	14.60	25.16	19.92
60 cm x 35 cm	18.73	19.26	17.73	18.57	15.43	20.30	24.60	20.11
70 cm x 13 cm	21.00	15.53	22.66	19.73	28 26	30.23	38 36	32 28
70 cm x 23 cm	16.26	19 60	20.60	18 82	17 33	22.23	29.63	23.06
70 cm x 30 cm	15.73	18.00	16.40	16.71	20.06	26.10	25.00	23 72
Average	17.25	18.07	19.37	—	19 02	23.29	27.51	—

	1972-73	1973-74
1. C.D. at 5% for main treatments	N.S.	5 61
2. C.D. at 5% for sub treatments	2.03	2.25
3. C.D. at 5% for sub treatments within given main treatment	6.07	6.80
4. C.D. at 5% for the body of the table	6,09	7.94

Table 6. Effect of combination of inter-and intra-row spacing and seed size on the number of stems hill.

	1972-73				1973-74			
Seed size spacing	25-35mm	35-45mm	45-55mm	Average	25-35mm	35-45mm	45-55mm	Average
50 cm x 18 cm	4.06	4.40	4.53	4.33	2.30	2.96	4.00	3.09
50 cm x 30 cm	3.20	3.60	5.80	4.20	2.30	3.20	4.03	3 18
50 cm x 42 cm	3 93	5.06	4 80	4.60	2.10	3.00	3.93	3.01
60 cm x 15 cm	4.26	4.33	4.06	4,22	2.63	3 53	3.96	3.37
60 cm x 25 cm	3.26	3.73	5.26	4.08	2.23	2.76	3.66	2.88
60 cm x 35 cm	3 86	4.33	3.93	4.04	1.83	3.13	3.96	2.97
70 cm x 13 cm	4.93	4.40	5 60	4.98	2.76	3.90	4.30	3.65
70 cm x 23 cm	3.13	3.80	4.13	3.69	2.30	3.00	4.26	3.19
70 cm x 30 cm	3.00	4.00	4.20	3.73	2.33	2.73	3.66	2.71
Average	3.74	4.18	4.70		2.31	3.13	3 97	—

	1972-73	1973-74
1. C.D. at 5% for main treatments	0.86	0.50
2. C.D. at 5% for seed treatments	0.34	0.23
3. C D. at 5% for sub treatments within given main treatment	1.03	0.69
4. C.D. at 5% for body of the table	1.23	0.76

Economics of various treatments

During both the years, income increased with increase in plant population (Table 4). The population of 48,000 plants/ha gave the income of Rs. 14,666/ha during 1972-73 and Rs. 18,791/ha during 1973-74 while an income of Rs. 16,963 and Rs. 23.760 was given by the population of 1,11,000 plants/ha, during 1972-73 and 1973 74, respectively. Seed size of 45-55 mm used for planting was most economical during both the years. Among three row spacings used highest income of Rs. 16,951 ha during 1972-73 and Rs 21,588/ha during 1973-74 was given by 50 cm and lowest income of Rs 14,558/ha and Rs. 20,080/ha during 1972-73 and 1973-74 by 70 cm respectively. However, 50 and 60 cm row spacings did not differ greatly.

Vegetative growth

Height of the plants increased significantly with the increase in size of tubers during both the years under study (Table 5). This is attributed to the availability of more quantity of food in the large size of tubers for intial boost to individual plants which were able to draw more water and nutrients from the soil compared to plants from small sized tubers and these plants were stout and healthy. Height of plant increased with the increase in spacing between rows. Since with the increase in spacing between rows the spacing between plants was reduced to maintain the optimum plant population per unit area, the competition between adjoining plants increased and thus plants became lanky. Highest plant height was given by 70 cm x 13 cm spacing during both the years

Number of stems per plant increased with increase in the size of tubers (Table 6). It can be attributed to more number of eyes on the large sized tubers compared to small size ones. This agrees with the findings of Khurana (5) and Iritani et al. (4).

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SHORT NOTE

CORRELATIONS BETWEEN STORAGE CHARACTERS OF SEED TUBERS AND YIELD IN POTATO

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Yield being a combined expression of interactions and associations of various component factors, can not be measured in terms of a single trait nor can its inheritance be analysed on the basis of individual characters. The contributions and relationship among the involved plant characters have, therefore, to be studied to find out the correlation coefficients employing the biometric estimation methods for calculating the variances and covariances. The information could be further used for evolving criteria to select suitable breeding lines in the concerned crop for yield.

In potato (*Solanum tuberosum* L.), Salaman (4) and Whitehead et al. (7) have reported correlation studies on certain morphological and tuber characters of qualitative nature. Dayal (1,2), Maris (3), Sidhu and Pandita (5) reported positive relationship between yield and other characters of quantitative nature. Tarn and Tai (6) observed positive association between yield and number of tubers/plant and average tuber weight. However, information is not available on storage behaviour of the produce and its effect on yield. An experiment was, therefore, conducted to find out the relationship of storage characters with tuber yield during the winter of 1980-81 at Central Potato Research Station, Kufri.

One hundred tubers of equal size and similar physiological age were taken from the harvest of 17 varieties/hybrids done in October, 1980. The cultures selected for study were SLB/M—17, SLB/M—18, SLB/M-70, SLB/O-239 SLB/Z-864-13, K-2500, K-85, G-2524, JH-214, F 5242, VB-8, O-1135, Kufri Sindhuri, Kufri Jyoti, Kufri Chandramukhi and Kufri Badshah. To begin with initial weight of the tubers of each culture was recorded and subsequently weight losses recorded at 45 days interval. The final weight loss on percentage basis was calculated on 135 days in each case. Average number of sprouts/

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tuber worked out as average of 5 randomly sampled tubers in each genotype, was counted. At the time of planting, maximum length and weight of sprout of five sampled tubers were also recorded A replicated trial was laid out with the tubers of all varieties/hybrids in April, 1981 at Kufri with recommended doses of NPK and other cultural practices

At flowering time, 5 plants of each culture in different replications were observed for number of stems/plant and for number of tubers/plant and yield at the time of harvest. Range, mean, coefficient of variability and simple correlation values were calculated by adopting standard procedure of analysis of variance and covariance for a randomized block design.

High range of variability was observed for all the characters studied (Table 1). Values of correlation between yield and various plant and tuber storage characters are shown in (Table 2). At any specific date per cent weight loss showed positive but non-significant 'r' values for sprouts/tuber, average weight/sprout and number of tubers/plant. Per cent weight loss, however, showed negative and non-significant correlation with length of sprout, number of stems/plant and tuber yield/plant. Number of sprouts/ tuber showed positive and non-significant correlation with average weight/sprout, number of stems/plant and tuber yield/plant.

Table 1 Range, mean and co-efficient of variability for different storage characters of seed tubers and tuber yield in potato.

	Characters	Range	Mean	C.V.
1.	Total % weight loss	4.06-12.52	8.46	27.42
2.	Average No. of sprouts/tuber	1.00-12.00	6.35	49.61
3.	Average weight/sprout (g)	0.80-12.40	4.10	61.91
4.	Maximum length of sprout (CM)	4.30-14.10	8 38	48.27
5.	Number of stems/plant	1.95-5.60	3.82	24 87
6.	Number of tubers/plant	2.53-11.70	7.22	16.62
7.	Tuber yield/plant (g)	18.05-348.25	214.38	40.44

The association between average number of sprouts/tuber with length of sprout was found to be significantly negative. Average weight of sprout showed negative correlation with length of sprout but positive non-significant association with number of stems/plant, number of tuber/plant and tuber yield/plant. Length of sprouts

Table 2. Simple coreelation between storage characters of seed tubers and yield in potato.

Characters		2	3	4	5	6	. uber yield/ plant 7
Total % weight loss	1	+0.3331	+0.2956	—0.006	—0.0992	+0.2150	—0.0616
Average No. of sprouts/tuber	2		+0.4572	—0.5366*	+0.2417	+0.2916	+0.2913
Average weight/ sprout (g)	3			--0.2992	+0.1916	+0.2174	+0.3421
Length of sprout (CM)	4				0.3196	—0.2866	—0.3782
Number of stem/ plant	5					+0.7455**	+0.4480
Number of tubers/ plant	6						+0.4981*

*Significant at 5% level, **Significant at 1% level.

showed negative association with number of stems/plant, number of tubers/plant and tuber yield/plant. Number of stems/plant showed highly significant and positive correlation with number of tubers/plant and positive but non-significant correlation with tuber yield/plant. Significant and positive correlation value was also found between number of tubers/plant and tuber yield/plant.

Higher values of coefficient of variability shown by the characters tend to point that these traits can be helpful in selection for better yield performance.

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J. Indian Potato Assoc. 9(2, 3 & 4) · 88-90, 1982.

SHORT NOTE

VARIATION FOR TUBER DRYMATTER IN ANDIGENA POTATOES

P. C. GAUR[1] AND M. S. RANA[2]

Low genetic variability for tuber drymatter has been reported in Tuberosum varieties and segregating progenies (2, 3). Since Tuberosums represent only a fraction of the total genetic variability present in cultivated tetraploid potato, it was decided to screen Andigena collection (introductions as also those generated by intermating them) available with the Central Potato Research Institute, Simla, India for tuber drymatter content and identify suitable genotypes for use in the breeding programme. No information on this aspect, in this collection has been available so far.

The collection comprising about 5,000 genotypes was grown at Central Potato Research Station, Jullundur, during 1975-76 crop season. The genotypes were planted in single rows of 20 tubers each in augmented design. The variety Kufri Chandramukhi was planted on every twentieth row. The distance between and within the rows was maintained at 50 and 25 cm, respectively. Normal manurial and cultural schedules were followed during the season. At harvest, 766 genotypes were visually selected in the field on the basis of tuber shape, colour and bulking. Tuber samples from nearest rows of the variety Kufri Chandramukhi were also drawn.

The per cent tuber drymatter was estimated by drying duplicate samples (50 g each) of sliced tuber tissue, from each genotype, to a constant weight at 70°C. For the estimation of various genetic parameters the variance of the variety Kufri Chandramukhi was taken as an estimate of the environmental variation (VF). The variance of Andigena population was taken to be containing the genotypic variance (VG) and the environmental variation (VE). Genetic coefficient of variation, heritability and genetic advance were calculated as per usual procedures.

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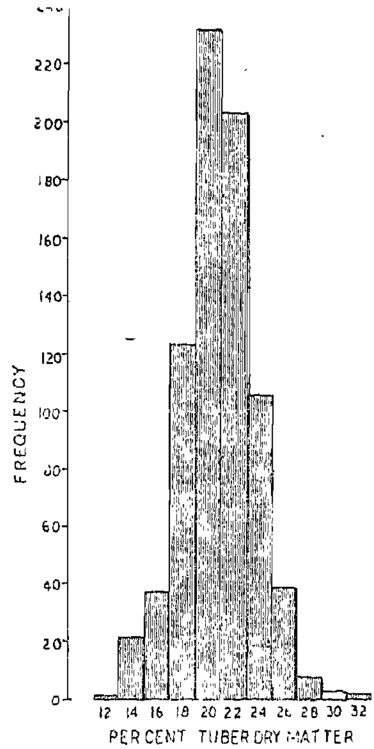

The Andigena collection showed a wide variability for tuber drymatter (Fig. 1). The drymatter values ranged from 11.2% in the genotype JEX/B-2959 to 31.4% in JEX/A-857. The mean tuber drymatter value for Andigena population (21.02%) was a little lower than the mean of the variety Kufri Chandramukhi (22.04%). The genetic coefficient of variation (GCV) for Andigena population was high (Table 1). This together with high heritability and expected genetic advance for 5% selection pressure, indicated the suitability of this population for the improvement of tuber drymatter in cultivated potato.

Table 1. Values of mean, coefficients of variability and genetic parameters for per cent tuber drymatter.

Population	Mean	CV	GCV	Variances		Heritability %	Genetic advance as % of mean
				Phenotypic	Genotypic		
Andigena	21.02	26.24	24.63	30.37	26.79	88.21	47.62
Kufri Chandramukhi	22.04	8.59	—	3 58	—	—	—

Thirteen genotypes, viz. JEX/A Nos. 27, 30, 97, 114, 248, 588, 651, 857; JEX/B Nos 723, 732, 1423, 2346 and Miscellaneous 4, possessed 27% or more tuber drymatter. These genotypes, however, did not have adequate yield potential for direct commercial exploitation Almost all the genotypes except JEX/A-114 flowered when planted at Kufri during 1976 crop season. The genotypes JEX/A-97, 248; JEX/B-723, 732 & 1423 were male fertile. The genotypes JEX/A-651, JEX/B-723, 1423 and 2346 possessed resistance to late blight also.

The identification of Andigena cultures with high tuber drymatter, good flowering, has a significance in breeding, since Tuberosum-Andigena hybrids are known to exhibit heterosis for yield (1, 4, 5). These high drymatter Andigena genotypes can be exploited through:—

1. Crossing them with Tuberosums and selecting genotypes combining high yield and drymatter.
2. Intermating the selected Andigena genotypes followed by selection for drymatter and yield.

Whereas, good yielders can directly go to the trials, those with high drymatter but only moderate yield can be crossed again with Tuberosums. The selections can also be intermated to establish recurrent selelection cycles. A breeding programme on these lines is in progress, and the results will be presented elsewhere.

ACKNOWLEDGEMENTS

We are thankful to Sh. Baldev Dass Sharma for providing the Andigena collection used in this study.

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EPIDEMIOLOGY AND SPREAD OF POTATO EARLY BLIGHT IN WEST BENGAL

S.B. CHATTOPADHYAY[1] AND B.K. DE[2]

ABSTRACT

Studies were undertaken for two consecutive cropping seasons on prevalence of air borne conidia of *Alternaria solani* in relation to weather conditions. Counts of conidia trapped on slides on aeroscopes exposed for 12 hours were made twice daily once at 5 p.m. and another at 7 a.m. Daily records of maximum and minimum temperature, maximum and minimum relative humidity, wind velocity, dew deposition and sunshine hours were kept. Conidia could be detected from the third week of December till end of March with perceptible increase from third week of January to end of February. Highly significant positive correlation was found between maximum and minimum temperature, maximum relative humidity, wind velocity and dew deposition. Partial regression showed maximum temperature to play the major role and wind velocity to some extent.

Study on progress of infection of early blight of potato in the field and individual plant for two consecutive years on cultivar Kufri Chandramukhi was made. In the first year of study, disease appeared early in the first week of Janury and progress was comparatively slow in the initial stages. A typical logarithmic curve of progress of infection could be made out. In the second year, diseases appeared in the third week of January and progress was very rapid and almost linear. Spread was local and limited to surrounding plants Disease in an individual plant was found to be located more on the leaves near the base and intensity gradually decreased on the leaves towards the apical region.

INTRODUCTION

Chattopadhyay (1,2) reported that the disease appears annually from January onwards and is responsible for heavy spotting of leaves and premature defoliation of plants resulting in decrease in yield particularly in late maturing ones.

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For adequate control of the disease through application of fungicides, a precise schedule based on epidemiological data is necessary which also requires knowledge of spread. For these reasons a detailed study was undertaken on cipdemiology and spread of early blight of potato, as knowledge under Indian conditions is lacking.

Rands (16), reported early blight to be the most severe in years characterized by high moisture early in the season followed by high temperature and sufficient moisture to promote abundant conidial formation. Jones (20) and Rolfs (17) demonstrated that the development of early blight disease in both potato and tomato was favoured by warm and moist weather Lutman (10), concluded that early blight was most severe in drier seasons Moore (11) established that principal limiting factor in leaf spot infection of tomato seeldling by *A. solani* was humidity. Hirst (9) reported maximum concentration of *Alternaria* spores in the afternoon when the temperature and wind velocity were high and relative humidity low. Guthrie (7) reported importance of dew on the development of early blight disease of potato. Fury and Durie (4) found *Alternaria* to be common in January and February. Differences in prevalence of conidia corresponded roughly with differences in temperature, relative humidity and rainfall. Rotem (18) showed maximum dispersal of spores of *A. porri* f. sp. *solani* (*A. solani*) and *A. tenuis* to take place during the final stage of early blight disease of tomato and potato, and during two weeks following death of plants. A diurnal periodocity was observed in spore dispersal with a maximum at 11 a.m. before minimum relative humidity (1 p.m.) and maximum wind velocity (3 p.m.).

Harrison *et al* (8) reported that low temperature and low relative humidity resulted in decreased infection of early blight. Gemawat and Prasad (5) observed airborne conidia of *Alternaria burnsii* to be most abundant at 9 a.m. to 12 a.m. Ohms and Fenwick (12) noted wind as the principal means of dissemination of spores of *A. solani*.

MATERIALS AND METHODS

Field experiments were conducted at the University farm, Kalyani, Nadia, West Bengal. The cultivar Kufri Chandramukhi was planted in both the years in the 3rd week of November (normal for the area).

Spores were trapped in aeroscope developed by Chattopadhyay (unpublished) to measure the periodic sporeload of *A. solani* during the growing season. Height of the aeroscopes was adjusted periodically to keep the trapping surface at approximately the same level with the top of the plants. Glass slides covered with a thin film of vaselin on one side were placed regularly at 7 a.m. and 5 p.m daily through out the cropping season. Four aeroscopes were placed in different places in the potato fields. Uncoated side of the slide was marked into eight equal parts with the help of a glass marking pencil and conidia of *A. solani* were counted and average was made for 4 slides. Periodical measurement of conidia were made to ascertain whether the conidia belonged to *A. solani* or not.

For observation on presence of viable conidia of *A. solani* the exposed slides were placed in the saturated moist chamber at 26°C for 24 hours. Counting of germinated conidia was made under microscope.

Observations were also recorded daily on maximum minimum temperature, maximum and minimum relative humidity (by placing Thermohygrograph in the experimental plot), wind velocity, dew deposition and sunshine hours.

To determine the relationship between defferent factors of weather on the prevalence of airborne conidia as determined by deposition of conidia on the aeroscopic slides, correlation coefficients were worked cut in respect of each factor and airborne conidia trapped. For this purpose, data on five dates were choosen at random in each month in the cropping season from December to March of the following year which constituted the period of observation. Total number of conidia trapped on aeroscopic slides on these dates, as well as the data on maximum and minimum temperature, maximum and minimum relative humidity, sunshine, wind velocity and dew deposition were recorded and correlation coefficient between number of conidia and each of these factors was determined according to the formuala described by Panse and Sukhatme (15).

For study of spread, experiments were undertaken to find out (a) time of first appearance and progressive increase of disease as well as (b) spread of the disease in infected plant.

Observations were recorded on plots specially selected for the purpose. In each plot 50 plants were grown. The variety Kufri Chandramukhi was planted in both the years. Row to row distance was 50 cm and plant to plant 20 cm. Plots were kept under close observation to record the date of first appearace of symptoms of early blight. Plants which showed first signs of infection were marked as 'A' with the date of infection recorded. Plots were closely observed at 3 days' interval to find out whether infection appeared on any other plants. Plants subsequently found to be infected were marked as 'B' with date of observation. In this way recordings were taken on the spread of the disease and plants showing infection at later stages were marked 'C', 'D', 'E', 'F', 'G' and H. Progressive infection was recorded till majority of plants were found to be affected with disease

For this purpose a schematic plan of the plot indicating the position of plants was made and progressive incidence of the disease was recorded on the plants in the said diagramatic plan on the paper. Diagramatic representations are illustrated in Text figures 1 to 8.

1st Year

Indicating the plants showing first symptoms of disease and progressive spread of the same

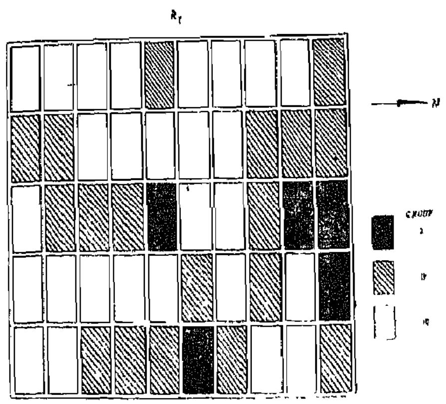


Fig 1

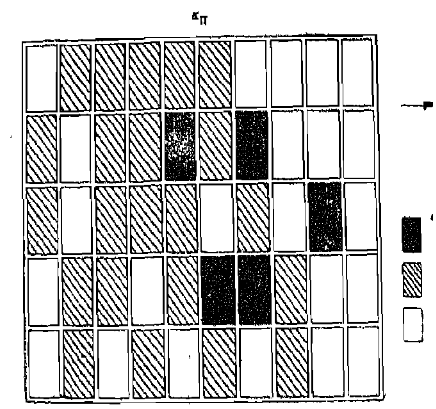


Fig. 2

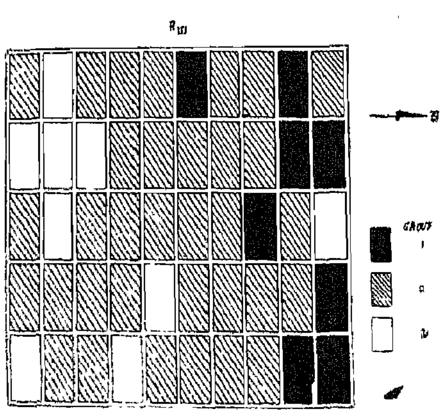


Fig. 3

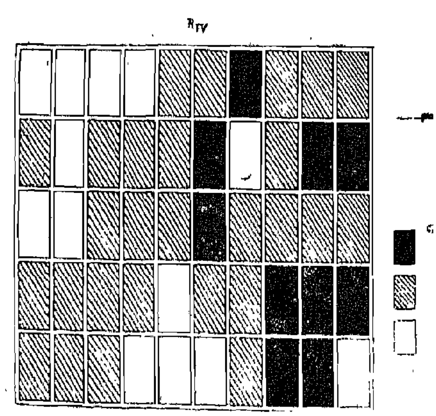


Fig 4

2nd Year

Indicating the plants showing first symptoms of disease and progressive spread of the same

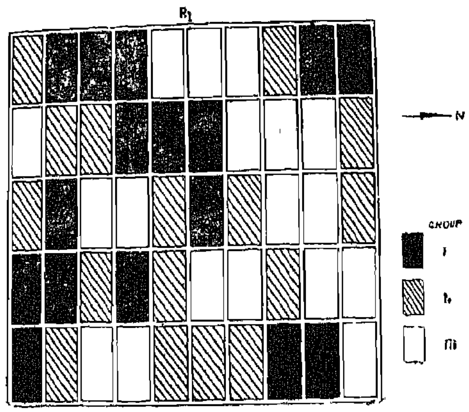


Fig 5

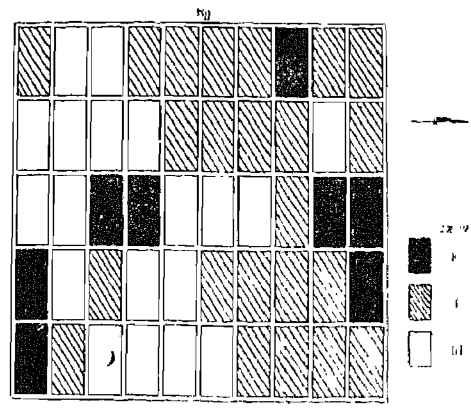


Fig. 6

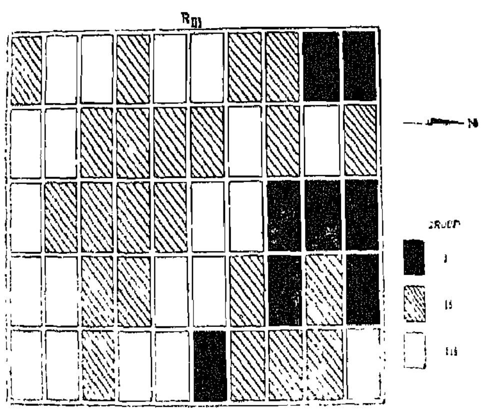


Fig. 7

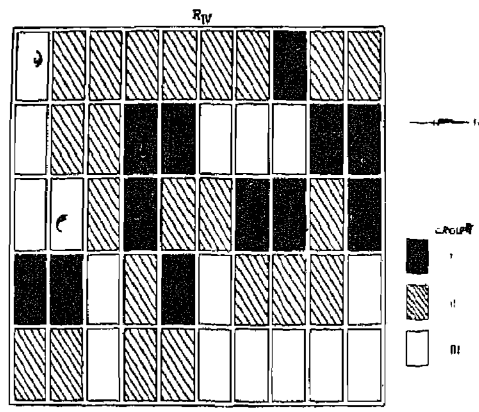


Fig. 8

For study of progress of the disease in a particular plant, four plants were selected at random in each plot. Altogether sixteen plants were used. They were tagged. In each tagged plant, each haulm arising from an individual sprout in a tuber was also separately marked. Plants were grouped according to the number of leaves, in which each shoot was considered as a single unit for purpose of noting progress of the disease. Sixteen shoots contained 5 leaves. Similarly 19, 34, 19 and 13 shoots contained 6, 7, 8, 9 and 10 leaves respectively. Observations were taken at 3 days interval after initial appearance of symptoms of early blight. Data were recorded at regular intervals on infection of haulm and leaf until majority of leaves were infected. In this study, presence of spot was taken as the criterion of infection.

RESULTS

Table Ia : Data on weekly average number of conidia trapped on aeroscopic slides minimum relative humidity, wind velocity, dew deposition and sunshine

Period	No. of conidia trapped daily/slide			Temperature (daily) 0°C			
	Minimum	Maximum	Average	Minimum	Average	Maximum	Average
December-73							
1st-7th	0.0	0.0	0.0	10.3	12.1	27.4	26 7
8th-14th	0.0	0.0	0.0	10.2	13.8	25.9	23.2
15th-21st	0.0	3.0	0.25	7.7	9.7	25.3	24.6
22nd-28th	0.0	3.0	0.50	6.7	8.7	25.3	23.8
January-74							
1st-7th	0.0	4.0	1.46	9.0	9.9	25.4	24.9
8th-14th	0.0	6.0	2.14	7.2	9.6	27.6	25.7
15th-21st	0.0	8.0	0.75	5.3	8.2	26.7	23.3
22nd-28th	0.0	8.0	2.82	7.9	9.9	27.7	26.0
February-74							
1st-7th	0.0	16.0	5.46	7.0	10.2	31.8	27.1
8th-14th	0.0	10.0	6.71	4.2	7.4	27.8	24.2
15th-21st	0.0	19.0	10.17	11.5	12.9	32.2	29.8
22nd-28th	3.0	52.0	17.53	11.7	15.3	35.7	32.7
March-74							
1st-7th	2.0	52 0	19.53	14 6	18.3	35.8	32.8
8th-14th	4.0	22.0	16.39	15.8	17.2	37.2	35.6
15th-21st	0.0	21.0	12.53	17.7	20.2	36.4	35.5
22nd-28th	0.0	13.0	5.17	17.7	19.8	33.5	30.3

as well as maximum temperature, minimum temperature, maximum and hours from the period of December, 1973 to March, 1974 in the first year

Relative humidity (daily) in %				Wind velocity (km/hr)			Dew deposition (mm) average	Sun-shine hours average
Maximum	Average	Minimum	Average	7 AM-5PM Av.	5 PM-7AM Av.	Average		
84	83.7	37	51.8	5.09	1.05	2.73	0.268	9.6
86	83.4	50	54.4	8.08	3.99	5.69	0.350	7.0
86	83.8	45	45.8	3.68	1.72	2.53	0.338	9.4
86	84.3	44	48.4	3.90	2.19	2.90	0.278	9.7
87	84.0	44	49.6	4.84	0.66	2.40	0.237	9.6
86	83.8	42	46.8	7.17	2.04	4.16	0.225	9.6
86	83.7	44	49.1	6.70	0.70	3.20	0.160	9.5
86	84.3	40	45.7	7.75	1.07	3.87	0.135	9.6
87	83.8	35	37.4	10.16	2.62	5.76	0.088	9.5
88	86.6	30	38.7	8.78	1.74	4.68	0.012	9.2
86	85.1	34	38.6	7.56	0.98	3.74	0.022	9.5
90	86.4	35	36.4	7.61	2.45	4.60	0.042	9.9
89	84.7	27	32.4	8.26	2.31	4.80	0.055	9.3
90	85.7	26	29.8	9.13	4.66	6.51	0.061	10.1
86	83.1	25	31.8	6.93	4.01	5.22	0.020	9.3
90	85.1	32	52.3	8.33	4.20	5.92	0.040	7.2

Table 1b : Data on weekly average number of conidia trapped on aeroscopic slides minimum relative humidity, wind velocity, dew deposition and sunshine

Period	No. of conidia trapped daily/slide			Temperature (daily) 0°C			
	Mini-mum	Maxi-mum	Ave-rage	Mini-mum	Ave-rage	Maxi-mum	Ave-rage
December-74							
1st-7th	0.0	0.0	0.0	8.6	10.1	27.4	26.5
8th-14th	0.0	0.0	0.0	7.5	10.4	28.4	25.5
15th-21st	0.0	9.0	2.42	7.5	10.9	28.1	25.5
22nd-28th	0.0	10.0	0 82	7.1	7.7	24.3	23.5
January-75							
1st-7th	0.0	6.0	1.0	7.2	10.3	27.7	24.9
8th-14th	0.0	4.0	2.07	7.7	10.1	27.4	25.3
15th-21st	0.0	8.0	3.39	6.7	7.8	27.1	24.2
22nd-28th	0.0	15.0	5.96	8.9	12.6	27.3	24.2
February-75							
1st-7th	0.0	34.0	11.4	11.5	13.9	28.8	26.6
8th-14th	0.0	29.0	11.21	12.3	14 2	29.8	28.6
15th-21st	0.0	22.0	16.96	9.1	14.4	30.6	27.3
22nd-28th	2.0	35.0	20.0	12.1	14.5	32.2	29.2
March-75							
1st-7th	7.0	40.0	24.0	16.4	18.0	34.4	32.7
8th-14th	3.0	52.0	17.53	17.5	20.3	35.7	32.8
15th-21st	0.0	29.0	16.28	16.0	17.4	34.5	32.8
22nd-28th	0.0	23.0	12.14	15.5	20.6	37.6	34.6

as well as maximum temperature and minimum temperature, maximum and hours from the period of December 1974 to March 1975.

Relative humidity (daily) in %				Wind velocity (km/h)			Dew deposition (mm) average	Sun-shine hours average
Maximum	Average	Minimum	Average	7 AM-5PM Av.	5 PM-7AM Av.	Average		
84	82.4	42	47.4	4.34	0.55	2.12	0.202	9.7
86	84.8	39	49.8	4.90	1.14	2.70	0.150	9.4
86	84.6	40	44.0	3.00	0.73	1.67	0.169	8.9
84	82.8	42	45.7	2.45	0.63	1.37	0.212	9.8
86	84.7	42	48.4	5.72	1.44	3.22	0.168	8.8
85	84.4	40	43.3	5.93	0.36	2.68	0.147	9.5
86	85.0	38	39.8	4.88	1.15	2.70	0.167	9.7
86	84.7	40	52.0	5.80	1.38	3.22	0.147	7.6
86	83.7	44	48.6	4.19	0.93	2.28	0.182	7.8
86	84.7	37	40.1	6.37	1.29	3.40	0.225	9.2
88	83.7	33	44.7	7.90	1.94	4.42	0.263	9.1
88	85.8	34	39.3	5.20	1.61	3.10	0.130	9.6
86	84.6	28	35.7	6.61	2.84	4.41	0.127	8.9
91	85.7	28	40.0	6.44	3.09	4.48	0.083	8.3
88	85.7	20	24.7	4.40	2.31	3.18	0.088	9.8
84	82.7	20	32.6	7.08	4.63	5.65	0.085	8.8

In the initial stages, namely Ist and 2nd week of December, no conidia could be detected on aeroscopic slides. From the third week of December, a few conidia were trapped. A fair deposition of conidia could be noticed from the third week of January gradually attaining the peak in 4th week of January to Ist week of March after which a sharp decline was noticed, though they could be observed till the end of March. Data recorded in two consecutive years were found to show similar trends.

A highly positive correlation coefficient between maximum temperature and number of conidia was noted (Table 1a, b,2). With increase in maximum temperature, there was a rise in airborne conidia of *A. solani.* In March, Ist yr. and 2nd yr. average number of conidia ranged from 5.17 to 19.53 and 12.14 to 24.0 when the average maximum temperature was between 30.3°C to 35.6°C and 32.7°C to 34.6°C respectively which indicated that higher maximum temperature was conducive for conidial movement and deposition.

Table 2. Values of correlation coefficient in relation to different weather factors.

Weather factors	Degrees of freedom	'r' value
Maximum temperature	38	+0.789**
Minimum temperature	38	+0.779**
Maximum relative humidity	38	+0.79 **
Minimum relative humidity	38	−0.04
Wind velocity	38	+0.72 **
Dew deposition	38	+0.56 *
Sun shine hours	38	−0.14

*Significant at 5% level, **Significant at 1% level.

There was a statistically significant positive correlation also between minimum temperature and prevalence of airborne conidia. With rise in minimum temperature, rise in conidial population was noticed. In the first season of observation (December, 1973 to March, 1974) minimum number of conidia were found to be 0.25 (average) in the 3rd week of December when the minimum temperature was 9.7°C. From 3rd week of February when minimum temperature began to rise the conidia deposition also was observed to increase till the 1st week of March. Similar observations were recorded in the second year.

From the data recorded in the cropping season of two years on the deposition of airborne conidia a highly significant positive relationship between rise in conidial population with maximum relative humidity was noticed.

Non-significant negative correlation coefficient was observed botween the minimum relative humidity and prevalence of airborne conidia.

Highly significant correlation was obtained between the wind velocity and deposition of airborne conidia of *A. solani* Increase in wind velocity contibuted to greater deposition of conidia. Field studies also indicated greater prevalence of disease from February onwards when progressively greater wind velocity was recorded.

Significantly positive correlation coefficient was observed between the dew deposition and prevalence of conidia. From the data it was found that from the first week of February, the minimum dew deposition was recorded thereafter gradual increase was noticed, up to 2nd week of March in the 1st year. Similarly, from the 2nd week of January to 3rd week of February, in second year there was gradual increase in dew deposition. In these periods conidial deposition increased with increasing amount of dew deposition with progress of disease.

No definite conclusion could be derived from sunshine hours and deposition of airborne conidia in the given period of time.

Attempts were made to estimate the combined effects of all these factors i.e. maximum temperature, maximum relative humidity, wind velocity and dew deposition, on the flight on conidia of *A. solani.*

It was observed that all these four factors together were responsible to the extent of 80% for deposition, and the flight of conidia on aeroscopic slides.

From the partial correlation studies it was observed that the role of maximum temperature, maximum relative humidity, wind velocity and dew deposition were important, no doubt, in the flight of the airborne conidia of *A. solani*, but the maximum temperature played the major role and wind velocity to some extent.

Large number of conidia were always recorded on the slides exposed during the night (Table 3). Hirst (9), Pady (13), Pady *et al.* (14), Corbaz (4), Gemawat and Prasad (6) have reported maximum flight of conidia of *A. solani* during day.

Maximum number of conidia were observed during the 1st week of March. When the number of conidia in the day were 504 and 451, average night temperature was 25.9°C and 30.0°C, day relative humidity 68.2 and 65.5 per cent, wind velocity i the day 8.26 km/h and 6 61 km/h and in night 2.31 km/h and 2.84 km/l respectively.

Table 3 : Data on differential deposition in day and night of conidia of *A. solan* and on the temperatures, relative humidity and wind velocity during day and night for the period of Dec. 73 to March 74 and Dec. 74 to March, 75.

Period	Conidia trapped weekly (total of 4 slides)			Temperature in °C (average)		Relative humidity (%) (average)		Wind velocity in km/h average	
	Day	Night	Difference	Day	Night	Day	Night	Day	Night
Column: 1	2	3	4	5	6	7	8	9	10
Dec. 73									
1st-7th	0	0	0	26.5	20.7	62.5	74.5	5.09	1.05
8th-14th	0	0	0	23.7	21.0	62.9	74.3	8.09	3.99
15th-21st	5	2	3	23.8	20.4	58.7	76.0	3.68	1.72
22nd-28th	11	3	8	24.5	20 3	60.6	77.0	3.90	2.19
Jan. 74									
1st-7th	27	14	13	25.0	19.5	60.8	76.0	4.84	0.66
8th-14th	55	6	49	25.7	18.6	58.7	75.2	7.17	2.04
15th-21st	21	0	21	25.2	16.9	59.5	73.5	6.70	0.70
22nd-28th	81	0	81	25.2	17.1	57.8	74.7	7.75	1.07
Feb. 74									
1st-7th	137	16	121	22 0	18.2	50.8	67.3	10.16	2 62
8th-14th	168	20	148	21.4	17.6	49.3	67.5	8.78	1.74
15th-21st	247	38	209	26.5	21.4	50.7	71.1	7.56	0.98
22nd-28th	405	86	319	30 0	25.7	47.0	65.7	7.61	2.45
March 74									
1st-7th	504	42	462	30.1	25.9	48.9	68.2	8.26	2.31
8th-14th	310	149	161	23.5	27.1	42.3	66.0	9.13	4.66
15th-21st	250	101	149	32.1	27.7	49.5	62.3	6.93	4.01
22nd-28th	93	51	42	27.9	26.5	63.4	73.8	8.33	4.23

..Contd.

Column 1	2	3	4	5	6	7	8	9	10
Dec. 74									
1st-7th	0	0	0	26.6	22.5	60.6	73.6	4.34	0.55
8th-14th	0	0	0	25.4	20.6	63.5	74.9	4.90	1.14
15th-21st	42	26	16	25.7	21.3	56 2	74.5	3.00	0.73
22nd-28th	13	10	3	22.8	20.3	58.2	75.1	2.45	0.63
Jan. 75									
1st-7th	26	2	24	25.1	20 8	61.7	76.4	5.72	1.44
8th-14th	49	9	40	25.6	20.7	56.7	72.9	5 93	0.36
15th-21st	75	20	55	25.5	18.8	58.3	70.2	4.88	1.15
22nd-28th	125	42	83	26.2	22.5	64 5	78.0	5.80	1.38
Feb. 75									
1st-7th	238	81	157	28.2	23.1	64.7	77.3	4.19	0.93
8th 14th	252	62	190	27.2	25.3	54.9	73.7	6.37	1.29
15th-21st	378	97	281	28 5	24.7	55.6	70.7	7.90	1 94
22nd-28th	397	163	234	30.9	26 3	48.5	69.8	5.20	1.61
March 75									
1st-7th	451	221	230	34.0	30 0	52.8	65.5	6.61	2.84
8th-14th	393	97	226	32.9	31.5	51.9	68.0	6.44	3.09
15th-21st	328	128	200	33.9	31.5	39.5	56.7	4.40	2.31
22nd-28th	290	50	240	35.7	31.2	46.5	54.6	7.08	4.63

From the data presented in Table 4, it was evident that conidia trapped in the slides during the day showed greater percentage of viability in both the years. Differences in some cases were perceptible.

In the first year of study, symptoms of early blight were first noted on 5th January in one replication (R II) and in other on 8th of January. In the second year of study, symptoms of early blight disease were first noted on 24th January in all the replications.

Table 4. Data on number of non-viable conidia of *A. solani* trapped during the period on Dec. 1973 to March 1974 and Dec. 1974 to March 1975.

Total number of conidia trapped on four aeroscopic slides/week

Period	7 A.M.—5 P.M. (days)					5 P.M.—7 A.M. (night)				
	Total	Viable number	Viable %	Non viable number	Non viable %	Total	Viable number	Viable %	Non viable number	Non viable %
Column:1	2	3	4	5	6	7	8	9	10	11
Dec. 73										
1st-7th	0	—	—	—	—	0	—	—	—	—
8th-14th	0	—	—	—	—	0	—	—	—	—
15th-21st	5	5	100.00	0	0.00	2	0	0.00	2	100.00
22nd-28th	11	7	63.60	4	36.40	3	2	66.60	1	33.40
Jan. 74										
1st-7th	27	18	66 60	2	33.30	14	9	64.28	5	35.72
8th-14th	55	37	67.30	18	32.70	6	6	100.00	0	0.00
15th-21st	21	10	47.70	11	52.30	0	0	0.00	0	0.00
22nd-28th	81	38	46.90	43	53 10	0	0	0.00	0	0.00
Feb. 74										
1st-7th	137	91	66.40	46	33.60	16	5	31.20	11	68.80
8th-14th	168	118	70.20	50	29.79	20	10	50.00	10	50.00
15th-21st	247	197	79.80	50	20.20	38	26	68.40	12	31.60
22nd-28th	405	316	78.00	89	22.00	86	63	73 25	23	26.70
March 74										
1st-7th	504	376	74 60	128	25.40	42	32	76.10	13	23.90
8th-14th	310	230	74.10	80	25.90	149	88	59.10	61	40.90
15th-21st	250	175	70.00	75	30.00	101	66	65 30	35	34.70
22nd-28th	93	58	62.30	35	37.70	51	31	60.70	20	36 00
Total	2314	1676	72.42	638	27.57	528	338	64 00	120	36.00
Dec. 74										
1st-7th	0	0	—	0	—	0	0	—	0	—
8th-14th	0	0	—	0	—	0	0	—	0	—
15th-21st	42	24	57.10	18	42.90	26	15	57.60	11	42.40
22nd-28th	12	7	53.80	6	46.20	10	3	30.00	7	70.00

...Contd.

Column 1	2	3	4	5	6	7	8	9	10	11
Jan. 75										
1st-7th	26	17	65.30	9	34.70	2	2	100.00	0	0.00
8th-14th	49	36	73.40	13	26.60	9	7	77.70	2	22.30
15th-21st	75	53	70.60	20	29.40	20	15	75.00	5	25.00
22nd-28th	125	86	68.80	39	31.29	42	32	76.10	10	23.90
Feb. 75										
1st-7th	238	143	60.00	95	40.00	81	40	49.30	41	50.70
8th-14th	252	138	54 70	114	45.30	62	45	70.50	17	27.50
15th-21st	378	270	71.40	108	28.60	97	67	69.10	30	30.90
22nd-28th	397	258	64.90	139	35.10	163	121	74.20	42	25.80
March 75										
1st-7th	451	250	55.40	201	44.60	221	150	67.80	71	32.20
8th-14th	393	228	58.00	165	42.00	97	57	58.70	40	41.30
15th-21st	328	180	54.80	148	45.20	128	73	57.00	55	43.00
22nd 28th	290	182	62.70	108	37.30	50	36	72.00	14	28.00
Total	3057	1872	61.20	1185	33 80	1008	663	66.00	345	34 00

For study of the spread of disease, the various symbols used to denote progressive. appearance of the disease were.

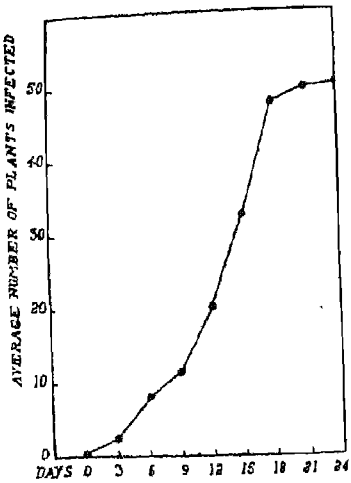
Group	Symbol		Dates of observation
I	1st Year	A+B	5th, 8th and 11th January
	2nd Year	A+B	24th and 27th January
II	1st Year	C+D+E	14th, 17th and 20th January
	2nd Year	C+D	30th January and 2nd February
III	1st Year	F+G+H	23rd, 26th and 29th February
	2nd Year	E+F	5th and 8th February

A picture of movement of disease in the field was thus obtained.

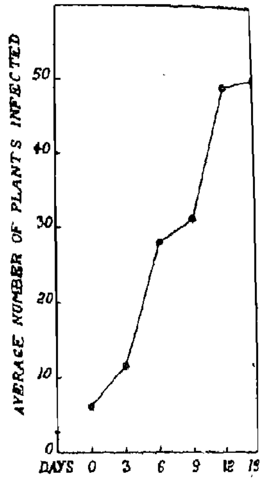
From the observations, it may be concluded that the disease appeared in a few plants first and subsequent spread in the field was limited to the surrounding plants. Distribution was local and limited.

In the first year of study, the disease appeared early and all plants were infected within 18 days of first appearance of the disease (Fig. 9). The spread of disease was comparatively slow in the initial stages and abrupt rise was noted after 9-12 days. In the second year, infection was fairly late (24th January in the second year as compared to 5-8th January in the first year) but progress of the disease was very rapid (Fig. 10).

Graphical representation of spread of the disease in relation to period



←Fig. 9 Fig. 10→



In the second year, reason of comparatively late appearance might be contributed to lower temperature in the earlier part of the season prior to appearance of the disease, and consequently less disposition of conidia (Table 1a, b).

Graphical representation of progress of infection in the first year (Fig. 9) shows a typical logarithmic curve illustrative of Van der Plank's (1963) model of epidemics of disease as exemplified by the $W_t = W_o e^{rt}$, where W_t = disease at a given time, W_o = initial inoculum, r = progress of infection, e = base of natural logarithm, t = time. An expotential function was noted in this case, disease increased proportional to the amount of the disease present at the moment. In the second year, logarithmic nature was discernible (Fig. 10) but not very clearly demonstrable as in first year. On the other hand, a somewhat linear relationship was noticed though the graph tended to be logarithmic in the end.

The leaves which were nearest to the soil namely 1st, 2nd and 3rd showed more infection than the leaves which are situated above (Table 5,6). The observations were most pronounced in plants having large numbers of leaves which provided better microclimatic conditions.

DISCUSSION

Results of the study show that with a rise of maximum and minimum temperature to some extent conidial flight was more i e. from the third week of January. Appearance and subsequent spread of the disease also started from the same time, thereby a close relationship between rise in conidial production and flight; and appearance and spread of the disease could be observed. It also points out the

Table 5. Progress of early blight disease on potato plant (Leaf study).

Plant size	Position of leaf from the base	Number of leaves infected (days after 1st detection of infection) 1st date	3days after	6days after	9days after	12days after	15days after	18days after	21days after	24days after
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
5 leaved	1st L*	5	8	8	11	15	15			
plant	2nd L	7	10	11	12	15	16			
(16)	3rd L	6	9	13	14	14	16			
	4th L	5	7	11	14	14	16			
	5th L	2	3	5	14	14	16			
6 leaved	1st L	5	7	11	12	16	17	18		
plant	2nd L	10	12	14	16	19	19	19		
(19)	3rd L	5	10	13	16	16	19	19		
	4th L	3	10	13	14	18	19	19		
	5th L	4	8	12	17	17	19	19		
	6th L	1	3	6	8	15	18	19		
7 leaved	1st L	15	15	19	22	27	31	31	39	40
plant	2nd L	15	26	31	33	41	43	43	45	45
(45)	3rd L	17	26	36	37	45	45	45	45	45
	4th L	9	20	31	37	42	45	45	45	45
	5th L	7	15	27	35	44	45	45	45	45
	6th L	3	6	11	25	37	43	45	45	45
	7th L	1	5	8	17	34	37	41	44	45
8 leaved	1st L	15	22	27	29	32	32	32	32	
plant	2nd L	11	19	27	31	33	34	34	34	
(34)	3rd L	7	16	22	26	31	34	34	35	
	4th L	4	9	22	26	31	34	34	34	
	5th L	6	12	20	28	32	33	34	34	
	6th L	1	5	13	19	26	33	34	34	
	7th L	1	4	5	11	18	30	32	34	
	8th L	1	2	3	7	17	29	33	34	
9 leaved	1st L	7	11	11	11	13	13	17		
plant	2nd L	11	12	13	14	16	16	19		
(19)	3rd L	10	15	16	16	18	19	19		
	4th L	3	13	18	18	19	19	19		

...Contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(10)	(11)
	5th L	3	9	13	16	18	19	19	
	6th L	1	2	8	12	15	18	19	
	7th L	1	2	4	8	13	16	19	
	8th L	1	1	2	6	9	15	19	
	9th L	1	1	1	3	7	14	19	
10 leaved									
plant	1st L	4	5	7	8	10	11	11	12
(13)	2nd L	3	4	7	8	11	12	13	13
	3rd L	7	10	12	12	12	13	13	13
	4th L	3	8	12	12	12	13	13	13
	5th L	1	4	9	12	13	13	13	13
	6th L	1	3	7	9	11	13	13	13
	7th L		1	4	9	12	13	13	13
	8th L		1	2	4	7	9	11	13
	9th L			2	4	7	8	9	13
	10th L			1	1	4	5	7	13

* Each haulm or shoot considered as single plant. First leaf or lower leaf are generally defoliated at later stage. Figures within the bracket indicate number of plants observed. L=indicates leaf.

Table 6. Distribution of early blight infection among leaves of potato (observation on plants produced by 4 tubers of each replication).

Position of leaf on a shoot (from base)	Number of infected leaves on 1st date of infection									
	1st year					2nd year				
	R-I	R-II	R-III	R-IV	Total	R-I	R-II	R-III	R-IV	Total
1st	11	2	4	5	22	8	15	6	3	32
2nd	5	4	8	4	21	3	3	8	6	20
3rd	3	4	3	4	14	3	4	3	6	16
4th	0	3	2	1	6	2	1	0	3	6
5th	2	0	1	3	6	0	0	2	1	3
6th, 7th, 8th, 9th, 10th *										

R=indicates replication. *No infection was noticed in young (6th to 10th) leaves.

necessity of commencement of prophylatic spraying from second to third week of January and continuance of the same till mid to late February should the conditions demand it to continue. The appearance of conidia with rise in day temperature are in conformity with fiindings of Hirst (9), Pady (13) and Harrison et al. (8) who recognized a characteristic day time or dry air conidia with components that become more common with rising temperature. That conidia of *Alternaria solani* are typically dry air conidia, are borne by the facts revealed from the present study that more conidia were found to be deposited during day time than in night and conidia trapped during day time showed greater viability. The latter observation is of particular significance from epidemiological stand point, as the conidia liberated and disseminated during day time and lodged on the plant surface in the afternoon have more chance of germination and establishment within the host tissue in the night when availability of moisture from the dew deposition would be more and longer period for completion of the process of establishment of infection.

Spread of the disease was found to be confined to surrounding plants and it might be presumed that conidial flight was limited. Under the circumstances, wind velocity which help conidial flight would be expected to play an important role and this was found to be so from data collected and partial regression analysis of the data.

Study of spread of the disease showed that the infection was more near the base which suggests that (i) primary infection might come from soil, (ii) infection was more pronounced on leaves attaining maturity, and (iii) micro-climatic conditions near the base were more favourable for infection. Observation of Chattopadhyay and De (3) also have clearly showed that the primary infection comes from the soil.

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STUDIES ON THE POWDERY SCAB OF POTATOES III. CHEMICAL AND CULTURAL CONTROL

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ABSTRACT

When potato was taken in rotation with wheat or pea-wheat, the disease incidence was reduced from 37% (potato-potato) to 29.4 and 21.7% respectively, but the infection increased to 45% when potato followed pea only. Potato yield increased about 3 times when it followed pea, and decreased about 2½ times after wheat. There was no difference in yield when potato followed pea-wheat or potato-pea-wheat with control (potato-potato) but disease incidence substantially reduced.

Soil treatment with Brassicol (75% PCNB) reduced the tuber infection to a great extent when healthy tubers were sown in infested soil. Use of healthy Agallol-3-treated tubers and soil amendment with saw dust or saw dust plus additional nitrogen did not reduce the disease incidence.

INTRODUCTION

The powdery scab disease of potatoes caused by *Spongospora subterranea* (Wallr.) Lagerth. is common in the temperate regions of the world. In India it has been found in the higher Himalayas (above 2,500 M) and Nilgiri hills (1). The incidence of the disease has beed recorded upto 25% in Himachal Pradesh (3). The disease reduces the market value of the produce. The pathogen not only infects the tubers but also predisposes them to late blight (2) and can transmit (6,8) potato mop-top virus rendering the tubers unfit for seed purposes.

Chemical seed treatment and stem cuttings are known to reduce/eradicate seed inoculum (4,5,7,8,9). No information is available on control of the disease in field through soil amendment and crop rotation. Also organo mercurial treatment of tubers may provide a protective effect to the progeny tubers. These aspects were studied and results are reported herein.

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MATERIALS AND METHODS

To carry out the experiments, a permanent block having high natural inoculum, was selected at Potato Development Farm, Khadrala-(3000m asl) in Himachal Pradesh. The experiments were laid out in randamized block design with four replications each with plot size 2.5m x 2.0m. The soil was tilled after every crop taking care not to mix the soil of one plot with another. The seed rate, planting and other cultural operations were followed for each crop as recommended for the region. Healthy tubers of variety Kufri Jyoti were used as seed. The disease incidence, intensity and yield were recorded at the harvest of the potato crops. For calculation of disease index, the infected tubers were graded as per 0-5 scale, (0—No infection, 1—upto 5% surface area infected, 2—6 to 10% surface area infected, 3 - 11 to 25% surface area infected, 4—26 to 50% surface area infected and 5 above 50% surface area infected) The total value for all the tubers was summed up and then divided by the total number of tubers obtained in a replicate.

The treatments were crop rotation (Table 1), saw dust soil amendment, Brassicol application and tuber treatment with Agallol-3 (Table 2). Saw dust alone or saw dust plus additional nitrogen was applied in the soil one month earlier to potato planting to allow its proper decomposition. Brassicol (75% PCNB) was applied in the ridges along with fertilizers at the time of planting.

RESULTS AND DISCUSSION

1. *Crop rotation :* In case of control i.e. potato followed by potato, disease incidence was 37.0 per cent. The incidence decreased from 37.0 to 29.4 and 21 7 respectively when potato was taken in rotation with wheat (2 yrs) or pea-wheat (3 yrs) (Table 1).

Table 1. Effect of crop rotation on the incidence of powdery scab.

	Crop rotation	Period (years)	% tuber infection	Yield (q/ha)
1.	Potato-Potato	2	37.0	4[illegible].1
2.	Pea-Potato	2	45.0	136.8
3.	Wheat-Potato	2	29.4	18.4
4	Potato Pea-Potato	3	45.4	136 8
5.	Pea-Wheat-Potato	3	21.7	45.1
6.	Potato-Pea-Wheat-Potato	4	27.0	45 1
	SE (±)			26.3
	CD (0.05)			82.9

Table 2. Effect of tuber and soil treatment on the incidence of powdery scab in the field.

Treatments	1974 %tuber infection	1974 Disease index	1974 Yield (q/ha)	1975 %tuber infection	1975 Disease index	1975 Yield (q/ha)	1976 %tuber infection	1976 Disease index	1976 Yield (q/ha)
1. No tuber treatment +no soil treatment	9.7	2.3	118.7	33.2	2 0	93 06	13.42	1.3	382.29
2. No tuber treatment +soil amendment with saw dust @25q/ha	18.74	3 2	59.3	24.0	0.80	77.78	13.40	1.3	326.73
3. No tuber treatment +soil treatment with saw dust (25q/ha)+ additional nitrogen (30 kg/ha)	19.96	3.32	124.3	41.1	1.00	125.00	12.40	1.2	324.58
4 No tuber treatment +soil treatment with Brassicol (75%PCNB) @30kg/ha.	20.0	2.97	134.0	21.2	1.21	157.99	7.80	0.8	348.12
5. Tuber treatment with Agallol -3(0.5% solution for 10mints)+no soil treatment.	15.6	1.1	132.0	29.0	0.29	157.64	13.60	1.3	369.04
6 Tuber treatment with Agallol-3(0.5% soln. for 10 mints.)+soil amendment with saw dust (25q/ha).	11.47	1.58	151.7	29.2	0.29	161.11	14.20	1.1	328.85
7. Tuber treatment with Agallol -3(0.5% soln. for 10 mints)+soil amendment with saw dust (25q/ha)+additional Nitrogen (30kg/ha)	18.2	2.11	173.7	26.5	1.14	104.86	14.20	0.7	328.62
8. Tuber treatment with Agallol-3(5% soln. for 10 mints)+soil treatment with Brassicol (75% PCNB 30 kg/ha)	11.7	2.15	174.3	26.4	0.26	106.95	5.20	0.2	295.29
SE±	1.9	0.68	38.8	3.93	0.33		3.1	0.2	
C.D(0.05)	5.4	2.0	113.7	11.89	0.99		9.11	0.7	

When potato followed pea (2 yrs) the infection increased from 37.0 to 45.0%. Increase in yield was more when potato followed pea though the disease incidence had increased substantially. The infection decreased when potato followed wheat but the potato yields also decreased markedly from 45.1 q/ha to 18.4 q/ha (Table 1). On the other hand, when potato was taken in rotation with pea-wheat (3 yrs) or potato-pea-wheat (4 yrs) the percentage of tuber infection was found to be the lowest without any decrease of the yield over control (potato-potato).

An enhanced potato crop yield in the case of pea-potato or potato-pea-potato rotations can be attributed to the fact that pea fixes soil nitrogen. Similarly it also adds up extra organic matter and thereby the soil population of the pathogen, *S. subterranea*, increases causing high degree of tuber infection as also noted by Wild (10). Apparently if pea is followed by wheat (before potato), the extra nitrogen fixed by pea is consumed by wheat and hence the following potato crop yields less even though the rate of infection is also fairly low (Table 1).

2. *Soil amendment anu tuber treatment :* In the first year all the treatments were found ineffective (Table 2) but in 1975 and 1976 tubers treated or untreated with Agallol-3 did not affect the disease position. But when the soil was treated with Brassicol both the disease index and infection reduced in comparison to the control or other treatments (Table 2). Soil amendment with saw dust or saw dust plus additional nitrogen could slightly reduce the infection ovor control though insignificantly.

The effect of tuber treatment has not been pronounced in this experiment as the seed tubers selected for planting were all initially healthy and therefore, the tuber borne inoculum had no part to play for subsequent infection. The inoculum present in the soil was solely responsible to produce the infection in the tubers harvested.

From the above mentioned data it was clear that even though the soil treatment with PCNB can reduce the disease incidence, it can not eliminate the pathogen from soil in 3 continuous years as well as causes yield depressions. Further, due to its high cost it can not be recommended for general use by the farmers.

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EFFECT OF FUNGICIDAL TREATMENT, CUTTINGS AND SEED SIZE ON SEED PIECE DECAY, GROWTH AND YIELD OF POTATO

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ABSTRACT

Studies conducted to evaluate the effect of number of seed pieces cut, seed size and fungicidal treatment on decay and yield of potato indicated that there was higher degree of decay in untreated seed pieces, whereas plant stand and yield was higher in Dithane-M-45 treated sets. Size of seed piece and number of cuttings did not influence the yield and yield attributes of crop. The yield was higher from whole tubers planted crop and best results were obtained from tubers of 50 g or higher weight. Extra large tubers (105 - 110 g and 140 - 150 g) planted at double spacing (40 cm) resulted in similar yield as by 50 g tubers planted 20 cm apart.

INTRODUCTION

The prevalent potato varieties have a tendency to produce large sized tubers and therefore the production of seed size tubers is very little. The use of large size tubers as seed thus becomes uneconomical on account of higher seed rate and seed cost. This has necessiated cutting of large sized tubers into desired smaller pieces as planting material. These cut pieces, however, get easily exposed to the attack of fungal and bacterial pathogens thereby causing partial or complete seed piece decay and consequent poor plant stand in the early October sown crop which is most optimum planting time in this region. Information on the number of seed pieces to be made from each large tuber so as to obtain higher economic yield is so far not available, therefore, present studies were carried out to evaluate the effect of seed cuttings, seed size and fungicidal treatment on the seed piece decay, growth and yield of potato.

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MATERIALS AND METHODS

The experimental trials were laid out in the Vegetable Research Farm of Haryana Agricultural University during 1980-81 and 1981-82 crop seasons. Commercial potato variety Kufri Chandramukhi was selected for these studies as it bears large sized tubers with high yield potential. Tubers of three sizes were selected, viz. (a) 75 g tuber cut into two piece (37.5 g a piece); (b) 110 g tuber cut into three pieces (37 g a piece) and (c) 150 g extra large tuber cut into two (75 g a piece), three (50 g a piece) and four (35-37 g a piece) pieces. In each treatment, one set was treated with Dithane M-45 (2 g/l) and the other was left untreated. Whole tuber of corresponding weights i.e. 37,50,70-75, 105-110 and 140-150 g were planted without treatment as controls. The last two controls were planted at double spacing i.e. 40 cm tuber to tuber. Whereas plant spacing in all other treatments was 20 cm. The experiment was planted in the 1st week of October in a plot size of 2.40 x 1.65 m during both the years. The soil of the experimental field was sandy loam with 8.6 pH and average temperature at 5 cm depth at planting was 31.6°C. The experiment with 14 treatments was laid out in randomized block design with three replications and all recommended cultural practices were followed during the course of experimentation. Pooled analysis of two years' data was done and average data presented is of the two years results. The economics of potato production was calculated on the basis of production cost of Rs. 3600/- per hectare without the cost of seed.

RESULTS AND DISCUSSION

The data (Table 1) revealed that treatment of cut seed with Dithane M-45 reduced seed piece decay, irrespective of size and resulted in significantly higher plant stand as compared to corresponding untreated cut seed sets. The plant stand under 75 g tuber cut into two pieces, improved from 47.67 per cent in control to 70.33 percent in Dithane M-45 treated plots. However, the number of cuts per tuber or seed piece size did not influence seed decay. The whole tubers had significantly higher plant stand under all sizes as compared to cut tubers. Dithane M-45 has been reported to be by far the best treatment to prevent seed decay in cut tubers (3, 7). Similarly Dithane M-45 treatment of cut tubers resulted in improvement in the height of plants and number of stems per hill. Plants from whole tubers also had better weight and more number of stems per hill which improved with the increase in tuber size. The size of cut tubers and Dithane M-45 treatment did not have any influence on the number of tubers per hill but in whole tubers the number increased significantly with the increase in tuber size which is directly related to the number of stems per hill.

Table 1. Effect of cutting, seed size and fungicidal treatment on plant stand, height of plant, number of stems/hill and number of tubers/hill in potato (*Solanum tuberosum* L.) cv. Kufri Chandramukhi.

Treatment (Tuber wt./No. of pieces)	%plant stand		Height of plant (cm)		No. of stem plant		No. of tuber/hill	
	T	U *	T	U	T	U	T	U
75 g/Two	70 36	47.67	44.60	29.89	3 29	2 49	5 53	4 22
110 g/Three	71.00	61.10	42.91	39.59	3 39	2 85	4 93	4 53
150 g/Two	78.69	66 62	52.06	45.51	4.01	3.21	6.27	5.72
150 g/Three	80.08	59.25	44.99	40.70	3 28	2.85	5.73	5.52
150 g/Four	70 90	57.86	43 58	38.66	2 85	2 30	4.76	4.45
35-37 g/Whole		85.64		46.29		2.99		4.67
50 g/-do-		80.07		49.96		3.40		6.63
75 g/-do-		84.76		55.09		3.85		6.68
105-110 g/ -do-		100.00		54.36		4.59		10.14
140-150 g/ -do-		92.22		59.78		5.73		11.14
C.D at 5%		12.78	5 58			0.09		0.91

*T=Treated and U=Untreated.

The results further revealed that yield per hectare was also significantly higher in Dithane M-45 treated cut seed as compared to corresponding untreated controls of various seed sizes (Table 2). In whole tuber planted crop the yield increased with increase in seed size and 105-110 g and 140-150 g seed sizes planted at double the normal spacing (40 cm) did not adversely affect the productivity. Allen (2) from Cambridge reported little advantage in using large sized whole tuber, as yield from half size tubers was similar to the whole size tubers of corresponding weight. This observation stands in contrast to the present investigations because of temperate climate of Cambridge (England) where the soil temperatures are lower resulting in similar yields from cut and whole tuber as a result of less seed piece decay. Under our conditions at the time of planting the maximum and minimum soil temperatures at 5 cm depth were 40.9 and 22.2°C, respectively.

It was further observed that cutting extra large tubers into two, three and four pieces (Table 2) did not give economic yields as compared to whole tubers.

Table 2. Effect of seed cutting, seed size and fungicidal treatment on the economics of potato production (Rs./ha).

Treatment Tuber Wt/ No. of Pcs.	Seed rate (q/ha)		Total yield (q/ha)		Gross income (Rs./ha)		Cost of cultivation (Rs./ha)		Net Income (Rs./ha)		Cost of production (Rs./q)		Return per rupee investment (Rs.)	
	T	U*	T	U	T	U	T	U	T	U	T	U	T	U
75 g/Two	33.63	33.63	215.86	129.28	17268.8	10336.0	9458.21	9220.8	7812.55	1115.20	43.80	71.36	1.82	1.12
104 g/Three	33.63	33.63	222.43	163,63	17794.4	13088 8	9456.21	9220.8	8338.19	3868.00	42 51	56.35	1.88	1.41
150 g/Two	68.18	68.18	286.57	245.57	22925.60	19645.6	15226.0	14748.7	7699.54	4896.84	53.15	60.05	1.50	1.33
150 g/Three	45.45	45.45	230.59	165.06	18447.2	13268.8	11430.15	11112.0	7017 05	2156.80	49.56	66.99	1.61	1.19
150 g/Four	33.63	33.63	206,18	144.35	16494.4	11548.0	9456.21	9220.8	7031.19	2327 2	45.86	3 87	1.74	1.25
35-37 g/Whole		33.63		221.12		17689.6		8980.8		8708 8		40.61		1.96
50 g/ -do-		45.45		278.23		22258.8		10872.0		11386.8		39 07		2.04
75 g/ -do-		68.18		308.03		24642.4		14508.8		10133 6		47.10		1.69
105-110 g/-do-		47.72		307.28		24582.4		11235.2		13347.2		36.56		2.18
140-150 g/-do-		68.18		322.84		25827.2		14508.8		11318.4		44.94		1.78
C.D. at 5%				53.62										

*T = Treated and U = Untreated.

Tuber cutting charges	Rs. 240/ha.,	Seed treatment	Rs. 07/q.,
Cost of seed	Rs. 160/q.,	Sale price of potato	Rs. 80/q.

Among the whole tubers 105-110g tubers planted 40 cm apart gave heighest economic returns (13347.2). Planting of 35 g whole tubers did not give good returns, thereby indicating that planting of whole tubers of 50 g and above would be profitable for better yield and returns than cut tubers even after treatment with Dithane M-45. Similar observations have been reported elsewhere (1, 5, 6). It has been reported by Bishop and Wright (4) that there is a positive correlation between seed size and yield of tuber.

Hence it can be concluded that for economic returns in autumn planted crop, the use of whole tubers above 50 g weight as seed is essential under North Indian plains where maximum and minimum temperatures range between 40.9 and 22.3°C at planting time. Treatment of cut seed piece with Dithane M-45 does not give economic yields, although it improves plant stand.

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STRAINS OF POTATO LEAFROLL VIRUS AND THEIR APHID TRANSMISSION

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ABSTRACT

Five symptomatically distinct and stable isolates of PLRV have been grouped into three strains, viz mild, moderate and severe on the basis of their reaction, mainly effect on height of *P. floridana* test plants. Use of their per cent aphid transmissibility and incubation period in the test host, as parameters for strain identification of PLRV have also been discussed.

INTRODUCTION

Strains of potato leafroll virus (PLRV) vary in their severity and virulence on potato varieties and other host plants. This fact has been used (5, 15) in differentiating the PLRV isolates into strains. Differences in aphid transmissibility from potato to potato and to *Physalis floridana* Rydb. and to and from *P. floridana* (4, 12) has also been investigated with this point in view. Webb *et al.* (13, 14). recognized five strains of PLRV depending on their varying virulenee/symptom severity on *P. floridana* Harrison (4) also reported similar symptom stab'lity on *P. floridana* with virulent and avirulent strains of PLRV. However, MacCarthy (7) observed extremely unstable symptoms with leafroll virus isolates transmitted from either potato or to and from *P. floridana* which might have been due to naturally occurring mixtures of PLRV strains which can be separated (3). Present investigation endeavoured to identify the PLRV strains from potatoes in Shimla-hills and Jullundhur on the basis of their reaction in *P. floridana*. The five isolates have been grouped in three strains following differences in growth of the virus-source and test plants as described by Chiko & Guthrie (3). A number of clones of *Aphis gossypii* and *Myzus persicae* were tried simultaneously to observe whether or not there is any difference in their aphid transmissibility.

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MATERIALS AND METHODS

The virus isolates of PLRV were selected from the different potato varieties/hybrids maintained at the Central Potato Research Station, Jullundur and/or Central Potato Research Institute, Shimla. They were maintained individually on *P. floridana* plants by regular subculturing through *Myzus persicae* (Sulz.) or *Aphis gossypii* (Glov.) in an insectproof glasshouse

Clones of *M. persicae* and *A. gossypii* were reared on cabbage and chilli plants, respectively, in individual plastic cages (8). Usually adult female apterae were allowed 24 h acquisition access on *P. floridana* virus-source plants with two weeks old infection of PLRV before transferring them to *P. floridana* test plants (18-22 days). Five viruliferous aphids/plant were allowed 24 h inoculation feeding followed by killing with 0.1% Metasystox spray. Adequate number of control test plants were exposed to equal number of aviruliferous aphids.

Each experiment consisted of 10 test plants per treatment, repeated atleast thrice using 5 aphids/plant unless otherwise stipulated. A number of virus source plants per isolate were infected through viruliferous aphids at 18-22 days stage and 15-25 days old infection in them was used by randomly picking one plant out of the lot available. In general, there was not much difference in their height yet only the mean height of the test/virus-source plants was recorded (Table 3).

RESULTS

Strains: The five selected isolates were originally from Up-to-Date, R1-2 (a late blight differential), Kufri Jyoti, Saco, Kufri Sindhuri and for the sake of convenience, their abbreviations have been used to depict isolates, viz. UTD, R1-2, K.J. and K.S. They have been grouped into mild, moderate, and severe strains of PLRV on the basis of their virulence on *P. floridana* plants as well as on potato varieties/hybrids (Table 1). Their effect on growth in height of *P. floridana* virus-source plants showing

Table 1. PLRV Strains : Symptom's intensity on potato and *Physalis floridana* plants.

Strain	Isolate (Potatovars./hybrid)	*P. floridana*	Remark
Mild	Up-to-Date/R1-2. Apparent stunting of height and leaves, severe rolling and brown purple pigmentation.	General chlorosis and slight to moderate stunting	Long incubation period in host (12-19 days).
Moderate	Kufri Jyoti. Mild stunting and severe rolling but mild pigmentation, pink-brown.	Interveinal chlorosis and moderate stunting.	Moderate incubation period in host (11-13 days).
Severe	Saco/Kufri Sindhuri. Extreme stunting of growth, severe rolling cut leaflets, brown/purple pigmentation and severe thickening of leaves.	Severe deformation and rolling of leaves, chlorosis and extreme stunting.	Short incubation period in host (7-10 days).

distinct symptoms (having 15-25 days old infection) was compared with the height of test plants that developed the virus infection and was found quite comparable. Plants of *P. floridana* infected with PLRV isolate KJ invoked marked interveinal chlorosis and moderate stunting. But isolate Saco and KS resulted in extreme stunting of growth, leaf chlorosis, deformation and rolling (Table 1, Fig. 1) These differences in the height and symptoms, mainly on *P. floridana*, clearly suggested them to be three distinct strains of PLRV. Slight differences in height observed (Fig. 1, Table 1) may be on account of the differences in test plants used either in their age and/or fluctuating environmental conditions.

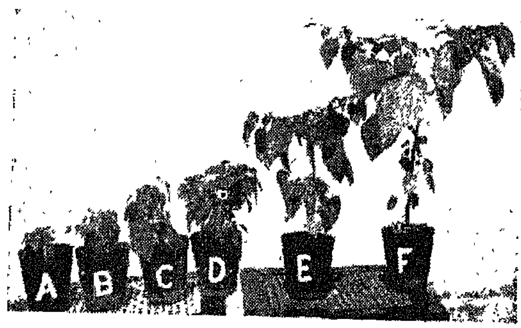

Fig. 1. Effect of PLRV strains on the growth (height) of *Physalis floridana* test plants :

A & B : Severe strain (K.S. & Saco isolates).
C & D : Moderete strain (K J. isolate).
E : Mild strain (UTD isolate). and
F : Healthy control.

Transmission o' PLRV isolates and symptoms : The results in Table 2 reveal that the different PLRV isolates could be transmitted with varying degree of efficiency by the aphid clones which ranged between 5-80% and 5-85% through *A. gossypii* and *M persicae* clones, respectively. The most efficient clone of *A. gossypii* was H.V. I followed by clones H,V. V. II & IV in descending order while clone H.V. II was the most inefficient and it could not transmit PLRV isolates UTD, R1-2 & KJ. Similarly *M. persicae* clone H. V. IX was the most efficient vector for all the PLRV isolates followed by H.V. V, I & III in descending order, though with certain similarities for some isolates. However, clone H.V. XII was quite inefficient yet superior over *A. gossypii* H.V. II. None of the plants under control ever got infected (Table 2).

Effect of number o, aphids/plant on transmission of PLRV isolates : This experiment was designed to observe the effect of varying inoculum potential on the test plant by

Table 2. Aphid transmissibility of PLRV isolates through *Aphis gossypii* and *Myzus persicae* clones.

Aphid clones	PLRV isolates/% transmission				
	Up-to-Date	R1-2	Kufri Jyoti	Saco	Kufri Sindhuri
A. gossypii					
H.V. I	40.0	50.0	65.0	75.0	80.0
H.V. II	0.0	0,0	0.0	5.0	5.0
H.V. III	30 0	40 0	45.0	55.0	65.0
H.V. IV	25.0	35.0	45.0	50.0	65.0
H.V. V	35.0	45.0	55.0	60.0	75 0
Control*	0.0	0.0	0 0	0.0	0.0
M. persicae					
H.V. I	30.0	40.0	35.0	55 0	60,0
H,V. III	25.0	35,0	50 0	50.0	55.0
H,V.'V	25.0	30.0	45.0	60.0	70 0
H.V. IX	30.0	45.0	55,0	75.0	85.0
H.V. XIII	5 0	10.0	10.0	25.0	35.0
Control**	0.0	0.0	0.0	0.0	0.0

Adult aphids of *H.V. I and **H.V. IX, respectively, were used by feeding them on virus-free 'host' plants to serve as control.

Table 3. Aphid (*M. persicae* H.V. IX* clone) transmissibility of PLRV isolates and their effect on the height of *P. floridana* test plants.

Virus isolate (strain)	Virus-source plant height (mm)	Aphids/plant	% Transmission	Test plant height (mm)	
				Mean	Range
Up-to-Date	165	1	0.0		
(Mild)		5	10 0	155	150-160
		10	20.0		
R1-2		1	10.0		
(Mild)	175	5	15.0	165	155-175
		10	25.0		
Kufri Jyoti		1	30,0		
(Moderate)	131	5	45.0	115	110-120
		10	50 0		
Saco		1	35.0		
(Severe)	110	5	50.0	82	78-86
		10	70.0		
Kufri Sindhuri		1	45.0		
(Severe)	100	5	65.0	75	68-82
		10	80.0		
Control (Healthy)	200	10	0.0	200	180-220

*Efficient vector clone.

varying the number of viruliferous aphids/plant (2). Although a higher rate of transmission was achieved up to a certain extent due to an increase in the number of viruliferous aphids/plant still they did not invoke different symptoms for the various PLRV isolates on *P. floridana* Further, the mild isolates (UTD & R1-2) had longer incubation period (13-18 days) as against (7-10 days) for the severe ones (Saco & KS) (Table 4).

Table 4. Incubation period of PLRV isolates in test plants (*P. flortdana*) on transmission through *A gossypii* H V. V* clone.

Leafroll isolate (Strain)	Incubation period in days		%transmission
	Ip 50**	Range	
Up-to-Date (Mild)	14	13-18	35.0
R1-2 (Mild)	13	12-19	45.0
Kufri Jyoti (Moderate)	11	11-13	55.0
Saco (Severe)	9	8-10	60.0
Kufri Sindhuri (Severe)	7	7-10	75.0

*Efficient vector clone.

**Ip 50=The minimum number of days recorded for symptom expression in atleast 50% of the total infected plants

DISCUSSION

We did not come across isolates with changing or unstable PLRV symptoms (7) probably because we filtered them a number of times before grouping into strains. Stability of present PLRV isolates in symptoms indicate that the 'pure' isolates of PLRV have stable symptoms in *P. floridana* as known earlier (3). But the fact that the severe isolates (Saco, K.S.) were more efficiently aphid transmitted is in contrast with that of low aphid-transmissibility of the severe isolates of PIRV found Chiko & Guthrie (3). Neverthelesss, a large degree of such variations have been reported earlier (8, 9, 10, 11).

Besides the symptoms and effect on growth, we found a relation between the aphid-transmissibility and incubation period of the presently delineated three strains. The mild strain isolates induced minimum growth retardation, had longer incubation period and poor aphid-transmissibility. On the other hand, the severe strain isolates resulted in extreme stunting, required shorter incubation period and registered maximum aphid transmissibility. But on the basis of reduction in plant height alone, it may not be possible to delineate the intermediate type of PLRV strains. Thus, we have delineated the KJ isolate as the moderate strain of PLRV by taking into consideration its moderate behaviour in tranmission through aphids and the incubation period. Our studies suggest that the other two factors alone or in combination with the effect of virus on plant height (3,12) should be considered important parameters for differentiating virus strains as has been reported for papaya and Ragi (*Eleusine*) mosaic (non-persistent) viruses (1, 6).

ACKNOWLEDGEMENT

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POTATO YIELD DEPRESSIONS DUE TO CURRENT YEAR INFECTION WITH VIRUSES Y AND LEAFROLL[1]

M.N. SINGH, B B. NAGAICH[2] AND H.O. AGRAWAL[3]

ABSTRACT

Field experiments were conducted for 3 years, i.e. from 1977 to 1980 to study the yield losses incited by PVY and PLRV in potato varieties The yield losses caused by PVY and PLRV varied from 13.90 to 20.12% and 7.45 to 15.74% in autumn crop and 44.03 to 57.18% and 38.83 to 60.04%, respectively, in spring crop, The losses were more in potato varieties Kufri Sindhuri followed by Kufri Chandramukhi and least in Kufri Jyoti in both the crops easons.

INTRODUCTION

Virus and allied diseases are generally a major problem on potato *(Solanum tuberosum* L.) production. Amongst these potato viruses Y (PVY) and leafroll (PRLV) seriously affect the potato yields in India. The yield losses caused by PLRV have been reported to vary from 29 to 98% in different countries (8, 9 1, 12). The losses caused by PVY and PLRV in India have been reported by different workers to vary from 20 to 82% and 25 to 75%, respectively, depending upon the varieties (16, 15, 4, 6, 10, 11). The data on losses in three present day potato cultivars due to PVY and PLRV are reported in this paper.

MATERIALS AND METHODS

Virus-free seed of the three commercial potato varieties namely, Kufri Chandramukhi, Kufri Jyoti and Kufri Sindhuri, which are early, medium and late in their maturity, respectively, was planted in replicated plots in randomized block design. Each plot, measuring 10 x 4.8m, was planted with 400 tubers. Manurial application

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was done @ 20 kg N, 80 kg P and 80 kg K/ha. The inter and intra row distance was 20 and 60 cm, respectively. The tria's were conducted during three autumn crops 1977-78, 1978-79 and 1979-80 and two spring crops 1978 and 1980. The spring crop in 1979 was badly damaged by hail-stroms and hence no observations could be recorded. No pesticides were applied in and around the field.

For each of the the experimental plots, atleast 2 known infected tubers each of PVY and PLRV were mixed in the tuber lots before planting to allow their random location for spread of the two viruses by aphids under natural conditions.

The losses in potato yield due to PVY (mild or severe mosaic) and PLRV (mild/severe symptoms) infections was determined separately by taking yields of individual diseased plants of each category (pegged before hand) as compared to at random healthy control plants in a particular plot. The yield losses were calculated on the basis of the following formula from the data recorded for an equal number of healthy and diseased plants.

$$\% \text{ Loss in yield} = \frac{H-D}{H} \times 100 = L(100) = \text{per cent loss at } 100\% \text{ incidence}$$

Where H and D are the average yields per plant of healthy and diseased ones respectively. This gives the percentage loss in yield on 100% infection basis. Percent loss at p% disease incidence was calculated by

$$L(p) = \frac{L(100)}{100} \times p = \text{percentage loss at } p\% \text{ disease incidence.}$$

RESULTS

Yield depressions due to potato virus Y and leafroll infection. During the course of study many species of aphids were observed but *Myzus persicae* (Sulz.) and *Aphis gossypii* Glov.) were higher than the critical level, i.e. 20 aphids per 100 compound leaves, which were found responsible for spreading the PVY and PLRV in the field in both the crop seasons.

The data gathered indicate that the per cent loss in yield due to PVY was almost of similar magnitude in different years for a given variety. The three varieties viz, Kufri Jyoti, Kufri Chandramukhi and Kufri Sindhuri, however, had different degrees of yield depression, viz. 13.90, 16 45 and 20.12%, respectively, due to PVY and 7.45, 11.93 and 15.74%, respectively, due to PLRV. Significantly more loss in yield due to PVY was observed in variety Kufri Sindhuri followed by Kufri Chandramukhi and Kufri Jyoti during all the three autumn crops. The data also revealed the highly significant differences in the yield of healthy and PLRV diseased plants during all the three years in varieties, viz Kufri Sindhuri and Kufri Chandramukhi. However, such significant differences in yields of healthy and PLRV infected plants could be observed in Kufri Jyoti only during 1977-78

The percentage losses in yield due to PVY and PLRV were almost similar in spring crops but were higher due to PVY in all the three potato varieties in autumn crop (Fig. 3).

However, the yield despression due to PVY and PLRV was observsd 44.03, 57.50, 57.18% and 38.83, 61.54, 60.04% in varieties Kufri Jyoti, Kufri Chandramukhi and Kufri Sindhuri, respectively, in spring crop. Further, the per cent loss in yield due to PVY and PLRV in Kufri Sindhuri and Kufri Chandramukhi was not significantly different but was lower in variety Kufri Jyoti. Based on the actual yield losses determined from the field data, losses were estimated (projected) for the higher degrees of incidence in nature for autumn (Fig. 1) and spring (Fig. 2) crops individually. The trend of per cent losses due to PVY and PLRV in all the three autumn crops and in both the spring crops was similar for all the three varieties.

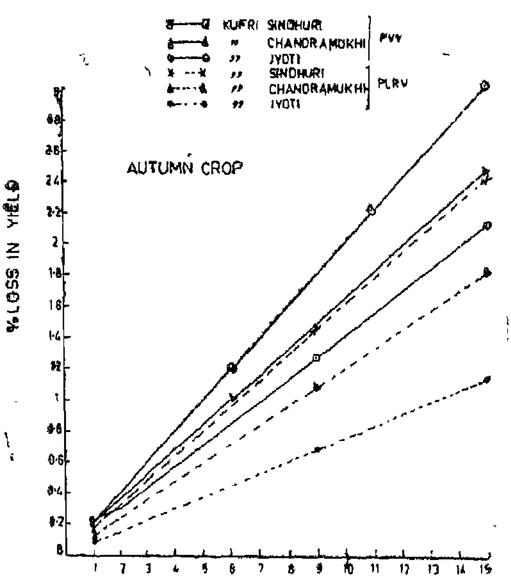

FIG 1 ESTIMATED YIELD DEPRESSIONS DUE TO PVY AND PLRV

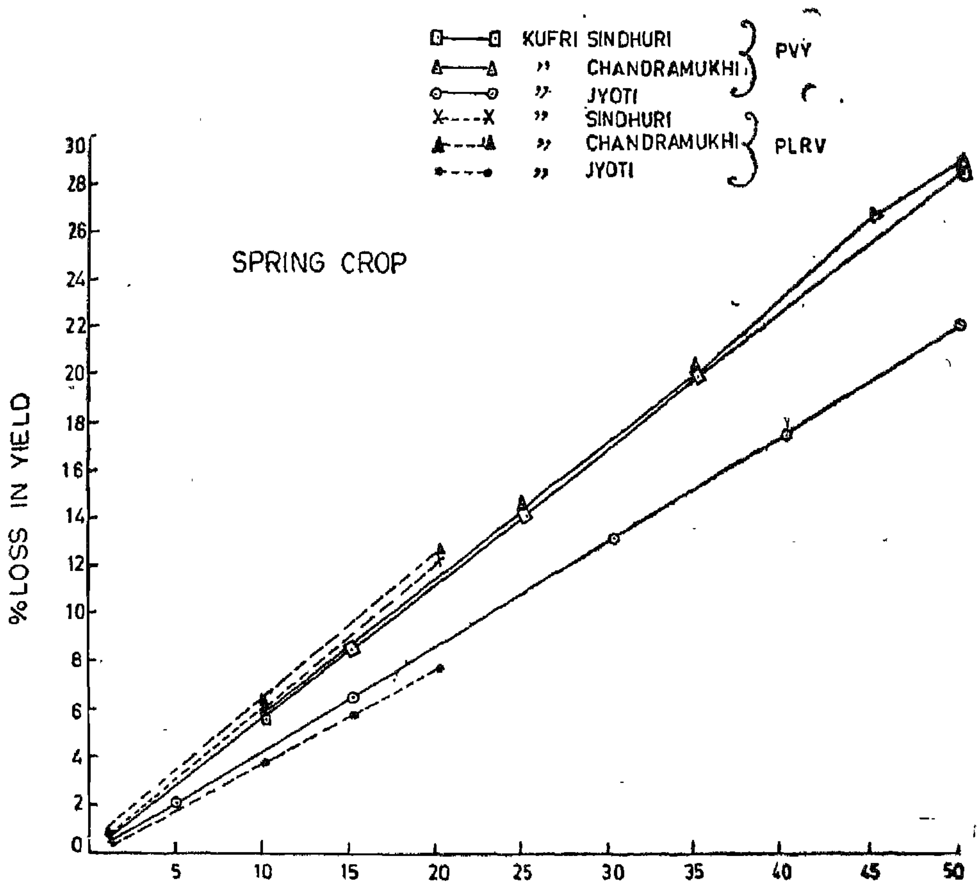

FIG.2 · ESTIMATED YIELD DEPRESSIONS DUE TO PVY AND PLRV

DISCUSSION

The actual data (Fig. 3) and the yield losses projected for higher incidence (Fig. 1-2) are in close agreement with the previous reports (7, 10, 11, 15).

A linear correlation was observed between the increase in disease incidence and the per cent yield loss in both the crop seasons.

Variations in the yield losses of potato due to individual infections of PVY and PLRV were observed to be markedly less in autumn than in the spring season. Further, the yield depressions were prominent in varieties Kufri Sindhuri followed closely by Kufri Chandramukhi and least in Kufri Jyoti in both the seasons. This may be because the population of aphids were definitely more in spring crops than

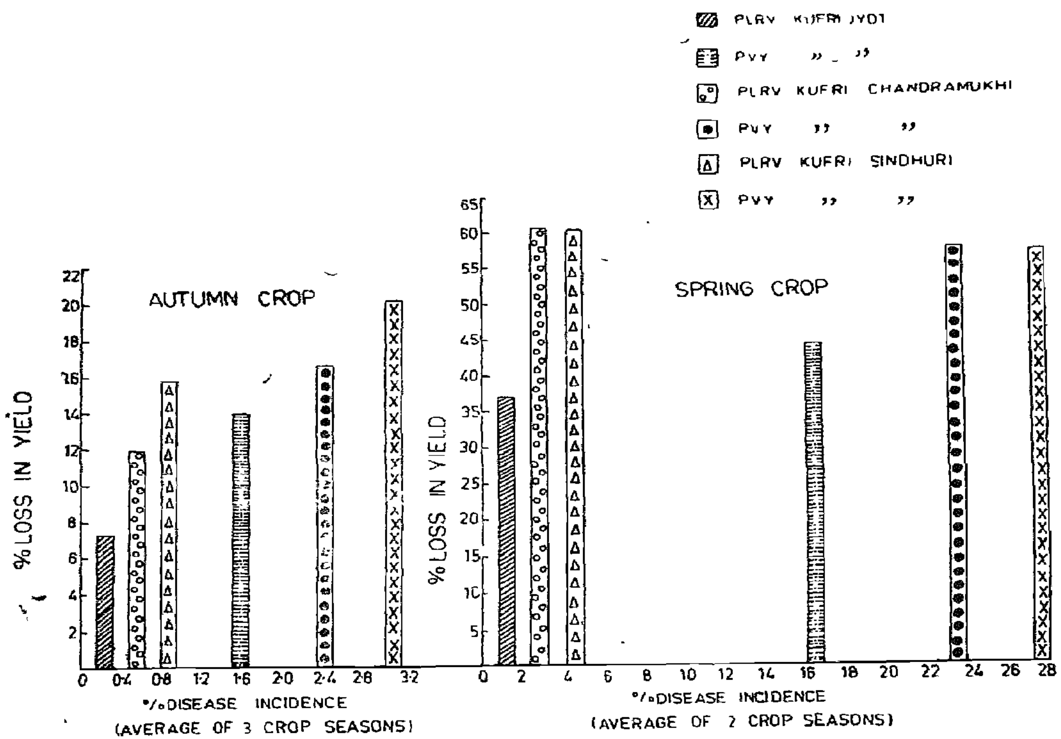

FIG. 3 : ACTUAL YIELD DEPRESSIONS DUE TO PVY AND PLRV

the autumn crops. Also, the higher temperatures during spring favour symptom severity, virulence of the viruses and aphid fecundity. The variety Kufri Sindhuri had supported the maximum fecundity of aphids followed by Kufri Chandramukhi and Kufri Jyoti. The findings corroborate the observation of Bos (3) that the high vector population may also adversely effect crop yield even without transmitting viruses.

The losess in yield are very much related to the incidence of the disease in the variety and the influenced in a particular season because both the environmental factors and virulence of the virus interact in causing yield losses. The present data strongly support the findings of Harper *et al.* (5), Kiliick (7), Rasocha (13) that the yield losses due to PLRV varies with the severity of symptoms. Arenz and Hunnius (2) and Singh (14) also noted that the yield losses caused by PVY and PLRV are very much related to severity of the disease symptoms in a particular season/potato variety.

Furthermore, it was observed that the per cent loss in yield due to PLRV was quite high in comparison to PVY though the natural incidence of PLRV was usually very low than that of the PVY in all the three varieties in both autumn and spring crops. It may be because the plants infected with PLRV are known to have less number of stems and total number as well weight of the tubers produced per hill (7). Very high degree of yield losses have been registered for PVY and PLRV infections by Nagaich (10), Khurana (6) and Singh and Khurana (15). However, they worked out yield losses on the basis of absolute infection verses healthy controls under pot culture conditions at Shimla. Since the present data refer to the actual yield losses on the basis of disease in fields, they coorborate the findings of Chattopodhyay and Das (4) who observed the incidence of rugose mosaic from 0.14 to 14.5% and that of leaf roll from 0.14 to 1·7% causing 20 to 70% and 41 3 to 73.3%, losses in yield, respectively.

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EFFECT OF ADJUVANTS ON ANTISERA TITRE OF PARTIALLY PURIFIED POTATO VIRUS X

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ABSTRACT

Rabbits were immunized intramuscularly with PVX antigen emulsified in Freund's complete adjuvant and liquid paraffin as against the control (antigen without adjuvant). Both the adjuvants were found effective over the control. Freund's adjuvant increased the antisera titre more than that with liquid paraffin and maintained high antibody level for longer period.

INTRODUCTION

The efficiency and reliability of seed testing increases with the use of high titre antisera. The antibody response of antiserum can be enhanced by proper selection of immunizing animal (7) using highly purified form of antigen, adopting different routes and methods of immunization (1) or immunizing the animals with adjuvants (4,8). For last several years, Central Potato Research Institute, Shimla has been actively engaged in producing antisera of PVX for tuber indexing and testing the seed crop at its various regional stations. The antisera are also supplied to different State Agricultural Departments and Universities, neighbouring countries like Nepal, Afghanistan, etc. for research & seed production programmes. In order to increase the production of PVX antiserum, adjuvants, which are known to stimulate production of antibodies, their protection and distribution in the animal body have been in use for some time. Since different adjuvants show varying antibody response with different plant viruses (4), this study was undertaken to determine the effect of two adjuvants on the titre of antisera using partially purified PVX as the antigen.

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MATERIALS AND METHODS

Potato virus X was increased in *Datura stramonium* L. plants in a glasshouse. One hundred gm of infected leaves packed in a polythene bag were frozen overnight at -20°C. Leaves were than thawed and macerated in a waring blender adding 50 ml of 0.1M (pH 7.0) sodium phosphate buffer and 200 mg each of sodium sulphite and ascorbic acid as reducing agents. Clarified extract was obtained by adding and shaking the contents with an equal volume of other and separated by means of a separating funnel. The virus was precipitated by saturating the extract with ammonium sulphate. The precipitate was concentrated and separated by low speed certifugation (3000 rpm) for 30 minutes and suspended in saline (0 85% NaCl). The suspension was again centrifuged at 2000 rpm for 15 minutes and the supernatant was taken as the antigen to inject the rabbits.

Twelve healthy rabbits free from virus antibodies were selected for the studies. Antigen was injected intramuscularly into the rabbits at thighs. A total of three injections were given to each rabbit weekly. Emulsions of equal volumes of the antigen and the adjuvants were prepared by repeatedly sucking-in and ejecting the solution with the syringe having a short 18-gauge needle (6). Three groups each of 4 rabbits were immunized with 1ml of antigen emulsified with equal volume of Freund's complete adjuvant (6), 1 ml of antigen with 1 ml of thick liquid paraffin and with 1 ml of antigen only (control), respectively. The rabbits were first bled one week after the last injection and subsequently at weekly or weeks interval. Antisera obtained from all the 4 rabbits of each group were pooled, adsorbed with the sap of healthy host plants for the purpose of neutralizing the plant protein-antibodies and examined for the titre by making two fold dilutions. Chloroplast agglutination method, with the sap of PVX infected *D. stramonium* plants as antigen, was used for determining the titre.

RESULTS AND DISCUSSION

Rabbits immunized with partially purified PVX with adjuvants produced antisera showing different antibody response. Maximum titre (1:2048) was observed with Freund's adjuvant followed by 1:256 with liquid paraffin as against 1:64 in the control (Fig. 1). The maximum antibody level reached the peak after 5 weeks of the initial injection and thereafter did not change upto 8th week. The liquid paraffin was only able to increase the antibody production by 4 times as against the control and this level was reached by 4th week after the initial immunization.

Freund's adjuvant has been found to be the best by different workers (4, 5, 8) for other viruses also. Govier (2) working with PVX obtained high titre antisera

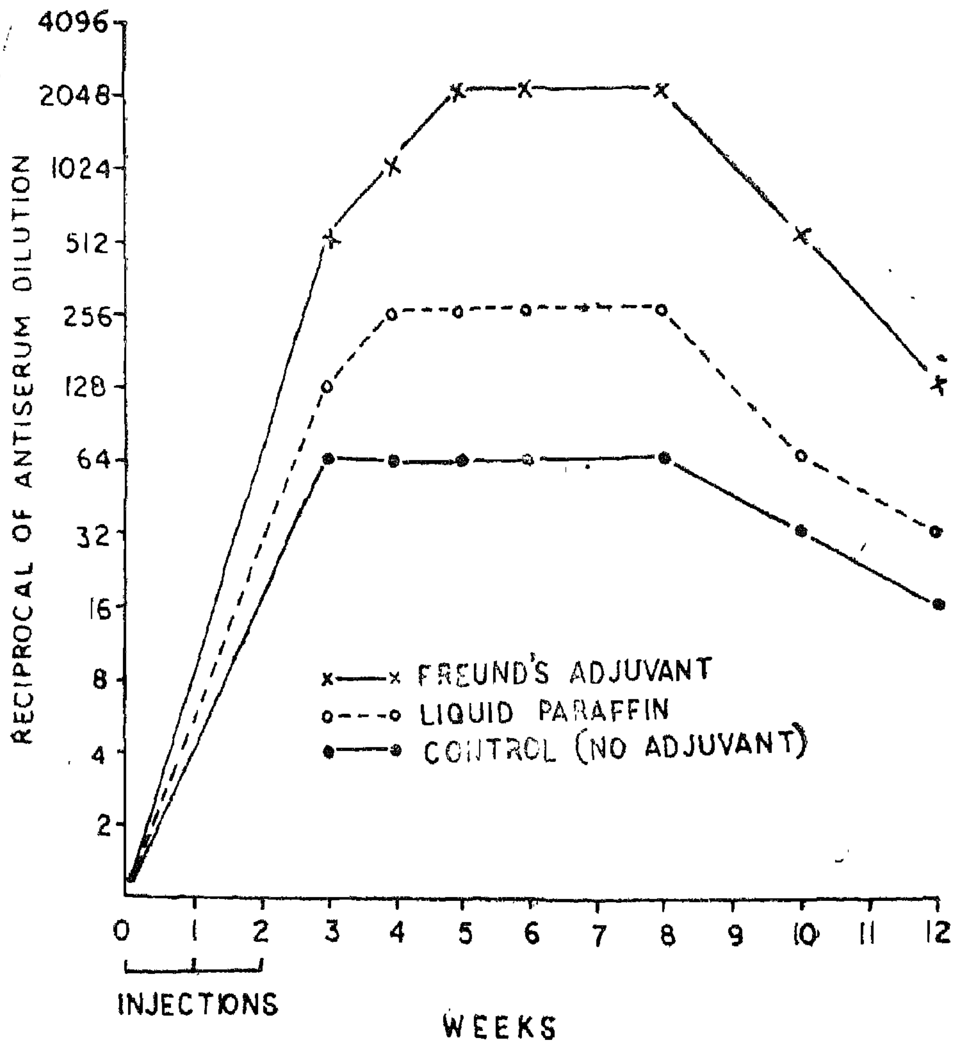

FIG. 1. EFFECT OF ADJUVANTS ON THE ANTISERUM TITRE OF POTATO VIRUS X

from the rabbits injected intramuscularly with a single dose of virus emulsified with Freund's adjuvant. Maximum antibody level reached after about 4 weeks. In our studies, however, 3 doses of 1 ml each of the antigen were given in all cases to make sure that a reasonable titre is obtained in the control for comparison (three 1 ml doses each of the partially purified antigen had been necessary to produce an antiserum). The titre of the antiserum obtained was 1:2041 in our case and it was low as compared to that of 1:4096 obtained by Govier (2). This variation in the titres may be due to several factors e.g. immunization technique (1), antibody producing capacity of the animal (8), purification methods (9) or concentration of the antigen (3), etc.

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J. Indian Potato Assoc. 9(2,3 & 4) : 140-144, 1982. SHORT NOTE

SOME NEW SYMPTOMS ON POTATO TUBERS INDUCED BY *FUSARIUM OXYSPORUM*

B.P. SINGH[1], R.P. RAI[2] AND V.C. SHARMA[3]

Surveys of freshly harvested potatoes in the fields at Central Potato Research Station, Modipuram, Daurala & Jalandhar revealed the occurrence of unusual disease symptoms. Studies relating to their cause, incidence, distribution pattern on the tuber surface and pathogenicity tests were carried out and the results are reported herein.

For three consecutive years (1977-78, 1978-79 & 1979-80) the disease incidence and intensity of tuber spots were recorded on different commercial varieties and advanced hybrids from various fields of Modipuram and Daurala Stations. The disease was rated on 0—6 scale, and the disease intensity was calculated as under :

$$\text{Disease intensity} = \frac{\text{Sum of individual ratings}}{\text{Number of tuber assessed}} \times \frac{100}{6}$$

A lot of 100 infected tubers from each variety/hybrid was sorted out at the time of harvest, and visual observations were made to study the distribution pattern of tuber spots on the tuber surface in regard to two ends of tubers and lenticels.

Pathogenicity tests were carried out under laboratory and glasshouse conditions. In laboratory, surface sterilised tubers were inoculated with test pathogen by using pinprick method and incubated at 27±1°C for a week. With a view to study the nature and development of the disease(s), as occurs in fields, the same was done by creating similar conditions in glasshouse by seeding the sterilised soil in 25 cm earthen pots with the test pathogen employing two varieties, Kufri Sindhuri and

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Kufri Chandramukhi. Appropriate controls were also maintained. Each treatment contained 8 earthen pots having one plant in each. Development of the disease was recorded at three different stages viz.—a) Prior to tuber initiation, b) After tuber initiation (Harvest of this observation was burried in soil after surface bruising, and c) At maturity—i) Which were disturbed at the time of second observation with a view to inflict injury on tubers, and ii)—Undisturbed plants (no injury).

For reproducing skin-necrosis symptoms, mature healthy tubers of Kufri Chandramukhi were given superficial bruisings with sterile sand-paper and burried in pathogen infested soil and incubated at $27 \pm 1°C$.

Symptomatology : Diseases on tubers manifested in the form of brown spots of varying shapes and sizes which were either circular to oval or irregular from p in head size to 1.5 cm diam. The raised spots had buldging in the centre very much looking like intact or ruptured pustules of powdery scab (Fig. 1). Some spots were just flat or sunken (Fig. 2). Spots with rupture/crackings in the centres surrounded by loose fringe (Fig. 3) were also common.

Second type of symptoms manifested in the form of dark brown to black necrotic patches measuring up to 2.0 cm diam. (Fig 4) and the tuber skin was hard and dry. Necrosis was confined only up to 3 mm depth and underneath flesh was healthy.

Occurrence : Initially tuber spot was recorded at CPRS, Modipuram and Daurala, later it was observed in other parts of U.P. and Punjab. The incidence and intensity of the disease were recorded on 24 varieties and hybrids during different cropping years. The maximum incidence was up to 26.6% while the highest intensity was up to 10.3%. The amount of disease greatly varied in the same variety/hybrid within same location or different locations possibly due to different levels of inoculum present in soil.

Distribution Pattern : Tuber spots were usually found associated with lenticels, this is perhaps because the pathogen has no inherent mechanism to penetrate the tuber skin directly and therefore, enters through lenticels. A very strong affinity was also observed between the tuber spots and heel-end of tubers. Most of the varieties/hybrids examined showed that tubers had spots located on or around the heel-end, only few varieties/hybrids had very few spots on rose-end.

Fig. 1. Tuber showing raised spots similar to that of powdery scab lesions

Fig. 2. Tuber showing sunken spot.

Fig. 3. Tuber having spots with cracks in the centre surrounded by loose fringe.

Fig. 4. Tuber showing large irregular necrotic patch.

Cultural Characters of the Fungus : Average growth rate of colony was 5 8 mm on PDA. Aerial mycelium remained off-white with purple tinge, initially floccose, becoming felted in old cultures. Conidia both micro and macro, chalamydospores both intercalary and terminal abundantly found in one week old cultures. Microconidia were oval to cylindrical measuring 2-10$\times$2-4μ, macroconidia fusoid, curved to cylindrical, up to 7 septate measuring 8-40$\times$2-10μ, chlamydospores 2-16μ diam. The isolate was indentified as *Fusarium oxysporum* Schlecht. at CMI, Kew (IMI-246010).

Pathogenicity : Fungus could establish in tubers of both the varieties within 48 h of their inoculation and spots were visible after 72 h. In variety Kufri Chandramukhi, spots enlarged to 5-10 mm diam. whereas in Kufri Sindhuri these were of 2-4 mm diam. within a week.

Fungus did not infect the roots, stolons or stem at any stage of plant growth. Minute spots appeared on mother tubers of Kufri Chandramukhi after one month of planting (prior to tuber initiation). Spots became quite prominent at second observation. At final harvest typical spots were observed on tubers of both varieties under test. Injured tubers developed more disease than uninjured ones, thus bruising was congenial for further spot development. Results indicated that lenticels provided natural avenues for penetration of the pathogen.

Second type of symptoms, i.e. necrotic patches developed on tubers burried in the infested soil and were similar to the one found in nature.

Studies reported above clearly show that variable types of symptoms could be produced by *F. oxysporum* under different sets of conditions of inoculation. The symptoms were categorised mainly into two types, tuber spot and necrotic patches. Although *F. oxysporum* is known to cause different disease symptoms on tubers like dryrot (1), stem end vascular discolouration (2) and Corky-rot (3) but so far there are no reports describing raised tuber spots and necrotic patches as reported in the present paper.

ACKNOWLEDGEMENTS

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J. Indian Potato Assoc. 9 (2, 3 & 4) : 145-147, 1982.

SHORT NOTE

COMPACT-POT METHOD IN POTATO TUBER INDEXING FOR VIRUSES AND MLO's IN GLASSHOUSE

A.K. SOMANI, K.S. VASHISTH AND A K. VERMA[1]

Production of virus and MLO tested nucleus seed stocks at Central Potato Research Institute, Shimla is the base of the certified seed potatoes of the commercial varieties in our country. It has two steps : tuber indexing in glasshouse and its multiplication in the field. The procedure developed at CPRI is as follows : Four tubers (as one clone) are taken from an apparently healthy plant. One eye from each tuber is planted separately in small pots in glasshouse. The counterparts are kept in cold storage. The plants raised from these single eyes are individually tested serologically for contagious viruses X and S, biologically on leaves of 'A 6' for viruses Y and A, histochemically using phloroglucinol test for leaf roll virus and visually for mycoplasmal diseases. If any one plant of a clone is found infected with any of the viruses or MLO's, all the four plants of the clone are rejected along-with their counterparts in cold storage. The counterparts of the healthy plants are grown in the field as stage I.

The availability of the glasshouse space is a limiting factor in nucleus seed production programme. The present method of indexing in glasshouse can be suitably modified to overcome this limitation to a great extent.

In the compact-pot method (C.P. method) instead of planting the eyes separately in 4 pots (11 x 9 x 5 cm), these were planted in a big pot (sized 16 x 0 x 10 cm) on 4 equidistant sites designated as A,B,C and D (Fig. 1), about 4 cm away from the periphery in the usual manner. Comparison for efficiency of indexing was made between the 54 clones each raised in small pots and big pot (compact pot). Two eyes were taken from each tuber and one planted in a small and another in compact pots. Adequate distance was maintained among pots to avoid contact transmission of viruses X and S.

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For keeping 54 clones in small pots and compact pots, the glasshouse bench space required was 4.56 and 2.28 sq m, respectively. (Fig. 2). Plants' growth was normal in both types of pots. The cost of 216 small pots was Rs. 54.00 but for 54 compact pots it was Rs. 27.00.

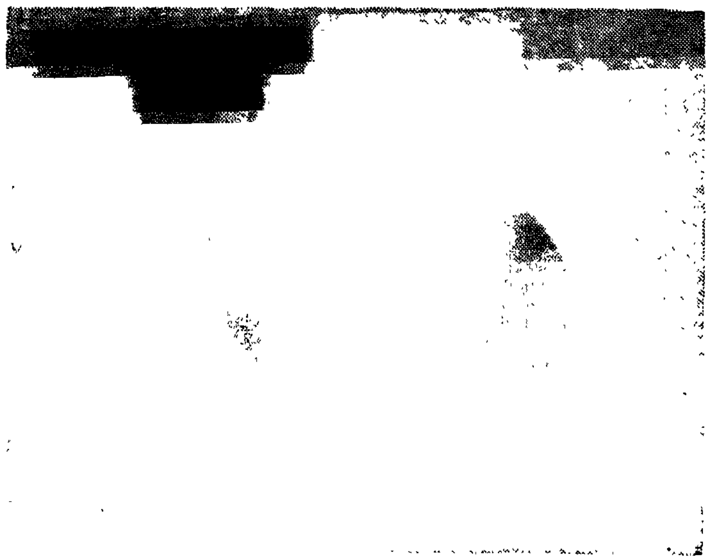

Fig. 1. A close up of compact pot.

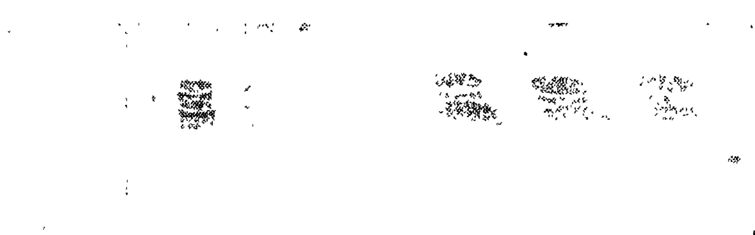

Fig 2. Comparison of space occupied by the traditional and improved (C.P.) pots for indexing

In the improved method, using the same glasshouse space, just double the number of clones can be indexed, viz. by conventional method 54 clones are indexed in 4.56 sq m space while by the improved method in the same space 108 clones can be indexed. Thus glasshouse space utilization is increased by 100 per cent. The method also cuts on the cost on pots by 50 per cent. Operations such as filling of pots, irrigation and the handling of clones were also found to be more convenient.

Uuequal distribution of viruses among the eyes of a tuber is well known (1). Since the plants of a clone remain in close contact with each other in the improved method, the chances of escaping the detection of contact transmitted viruses (X and S) are reduced to a minimum.

ACKNOWLEDGEMENTS

We are thankful to Dr. S.B. Lal, Sr. Scientist, for his inspiration. The help rendered by Dr. O.M. Bambawale is gratefully acknowledged.

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J. Indian Potato Assoc. 9 (2, 3 & 4) : 143-149, 1982. SHORT NOTE

POTATO VIRUS X INHIBITOR FROM NEEM LEAF EXTRACT

R.B.S. SANGAR AND M.K. DHINGRA[1]

Several plant extracts have been found to carry inhibitory properties against different viruses (1, 2, 3, 7). In some cases the chemical inhibitors have been identified and their properties studied in detail (1, 6, 7). Inhibition of infectivity of potato virus X (PVX) has been studied both by plant extracts (1, 4, 5) and their chemical inhibitors (1, 6). This paper describes the inhibitory properties of neem *(Azadirachta indica* Juss.) leaf extract on PVX.

Tender neem leaves were ground mixing one ml. of water for every gram of leaf tissue, extract squeezed through muslin cloth, centrifuged at low speed for 30 minutes and stored at —20°C. PVX inoculum was prepared by macerating young PVX infected leaves of *Datura stramonium* in ratio of 1 gm : 1 ml of water and diluted 1:5 with tap water. Serial dilutions of the inhibitor and the virus inoculum were mixed together and young *Capsicum pendulum* seedlings were inoculated after 5 minutes for assaying the infectivity. Inoculations were made mechanically on the leaves predusted with carborundum powder. Three plants each with six leaves were employed for each assay.

Different combinations of the virus inoculum and the neem leaf extract in the proportion of 1:0.5, 1:1, 1:1.5 and 1:2 were made to study their effect on virus inhibition. Complete inhibition was observed at the ratio of 1:2 i.e. 1 ml of virus inoculum and 2 ml of neem leaf extract. The neem leaf extract was heated at 50, 60, 70, 70, 80, and 90°C in a water-bath for 10 minutes, cooled immediately under running tap water and mixed with the inoculum in the ratio of 1:2 and assay plants inoculated with the mixture. The inhibitor heated even up to 90°C continued to inhibit the virus. It also remained effective at room temperature (18-22°C) for 40 days and up to 60 days when stored at -20°C. The inhibitor was also not affected at a pH range of 5.8 to 8.0.

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Spraying the neem leaf extract on upper surface of the leaves of the test-plant was found effective in completely preventing virus infection (made at 0, 2, 4, 6 and 8 hr after spraying) up to 4 hr but its efficacy decreased gradually by increasing the interval between treatment and inoculation. The neem leaf extract exhibited no phytotoxicity.

From above studies, it is clear that the inhibitor in aqueous neem leaf extract is thermostable, resists storage and a wide range of pH. It showed loss of activity with lapse of time between treatment and inoculation. Most of the properties of this inhibitor are similar with those reported earlier (1, 4, 5).

ACKNOWLEDGEMENTS

We are grateful to Dr. B.B. Nagaich, ex-Director and Dr. G.S. Shekhawat, Head of the Division for providing the facilities and going through manuscript, respectively.

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J. Indian Potato Assoc. 9(2, 3 & 4) : 150-152, 1982. SHORT NOTE

ELIMINATION OF POTATO AUCUBA MOSAIC VIRUS FROM POTATO BY HEAT-TREATMENT AND MERISTEM TIP CULTURE

M.K. DHINGRA, R.B.S. SANGAR AND R.A. SINGH[1]

Limasset and Cornuet (3) demonstrated that the concentration of tobacco mosaic virus (TMV) gets lower in tobacco leaves as they approach the plant tip and no virus was usually detected in the apical meristematic portion. Morel and Martin (6) used meristem culture technique to obtain virus-free dahlia plants from the virus-riddled ones. Since then a number of workers (8) used this method to free the potato plants from PVX, PVY, PVS, PLRV, etc. Varying degree of incidence of potato Aucuba mosaic virus (PAMV) is known in some old Indian potato varieties (7). Recently, PAMV has gained importance in the plains of India and it may assume serious proportion in future if the diseased stocks are continued to be used by the farmers. Since there is no such published report of freeing potatoes from PAMV, we were prompted to find out the efficacy of this technique for freeing plants of var. Kufri Kuber from PAMV and the results obtained are reported here.

The culture medium 'A', recently reported by Dhingra *et al.* (1), was used. The pH of the medium was adjusted to 5.8 and dispensed into culture tubes, plugged with cotton and autoclaved at 15 lbs pressure in a pressure cooker for 15 min.

The meristems were excised from infected tuber sprouts. Virus-infected tubers were pre-sprouted and maintained for 6—8 weeks at 30 $\pm$ 30°C under artificial light. The sprouts were washed with tap water, dipped in 90% ethonol for a few seconds and rinsed 2-3 times in distilled sterile water. Soon after this they were transferred to a 20% Polar's bleech solution for 5-10 min. and rinsed again 4-5 times in sterile water. Apical meristems (0.3—0.4 mm. approx.) with two leaf primordia were aseptically dissected under the binocular microscope on a clean-air bench and then

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transferred on to the nutrient medium. The culture tubes were maintained at 24$\pm$ 20°C under fluorescent light ca. 1800-2000 lux (16 hr photoperiod).

When the plantlets were 3-5 cm. long, they were transferred from the tubes to small pots containing sterilized soil and compost manure. The potted plantlets were covered with a glass beaker for maintaining high humidity for about one week. Thereafter the plantlets were indexed biologically on *Capsicum annuum* L. and *C. pendulum* Willd. for detecting PAMV (and/or PVX) as well as other indicator plants 'A6', *Chenopodium amaranticolor*. Plantlets that were found to be virus-free were maintained in an insect-proof glasshouse and were rechecked for confirming their freedom from PAMV as well as other viruses like PVX, PVS(M), PVY after 30-45 days.

Table 1. Development of healthy plantlets on medium 'A' from potato variety Kufri Kuber infected with PAMV.

PAMV isolate	Number of			% virus-free plantlets
	Apical meristems	Plantlets produced	Healthy plantlets	
$PAMV^4$	40	29	20	69
$PAMV^6$	40	33	25	76

It can be seen from the table that out of total 80 meristems (in two trials) excised from the sprouts infected with PAMV isolates, viz. 4 & 6, a total of 20 and 25 healthy plantlets could be produced, respectively. Such a success of the technique may be attributed to the presence of different chemicals in the medium or lack of the virus in apical meristems or pre-treatment of sprouts at higher temperature and light for a longer time or their combined effects. This type of observations on inactivation/elimination of viruses have also been reported earlier (1,2,4, 5).

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J. Indian Potato Assoc. 9(2, 3 & 4) : 153-156, 1982.

SEXUAL DIMORPHISM IN THE PUPAE OF THE POTATO TUBER MOTH

USHA CHAUHAN AND L R. VERMA[1]

ABSTRACT

Male and female pupae of *Phthorimaea operculella* (Zeller) differ from each other in many morphological characteristics. Body length and weight of female pupae is greater than the males. Male pupae also differ from the female pupae in respect to shape and position of genital opening, position of posterior-most abdominal spiracle and shape of the caudal margin of the tenth abdominal segment.

INTRODUCTION

Potato tuber moth, *Phthorimaea operculella* (Zeller) is a serious pest of potato in all the potato growing countries of the world such as U.S.A., Australia, Israel, New Zealand, Africa and India (1,2,11,12,). Although the biology of this moth has been studied in detail (3,4,5,6,9,10), but so for no studies were made on differentiating sex in the pupal stage. Such studies are important in order to find out the sex ratio in the population, for understanding the basic mechanism of insect behaviour and reproduction.

MATERIALS AND METHODS

The culture of this pest was raised under controlled laboratory conditions and pupae were collected from the culture pots, washed with water and then dried over the filter paper. All observations were made under dissecting stereomicroscope.

RESULTS AND DISCUSSION

The main distinguishing morphological characteristics of the male and female pupae are shown in Fig. 1.

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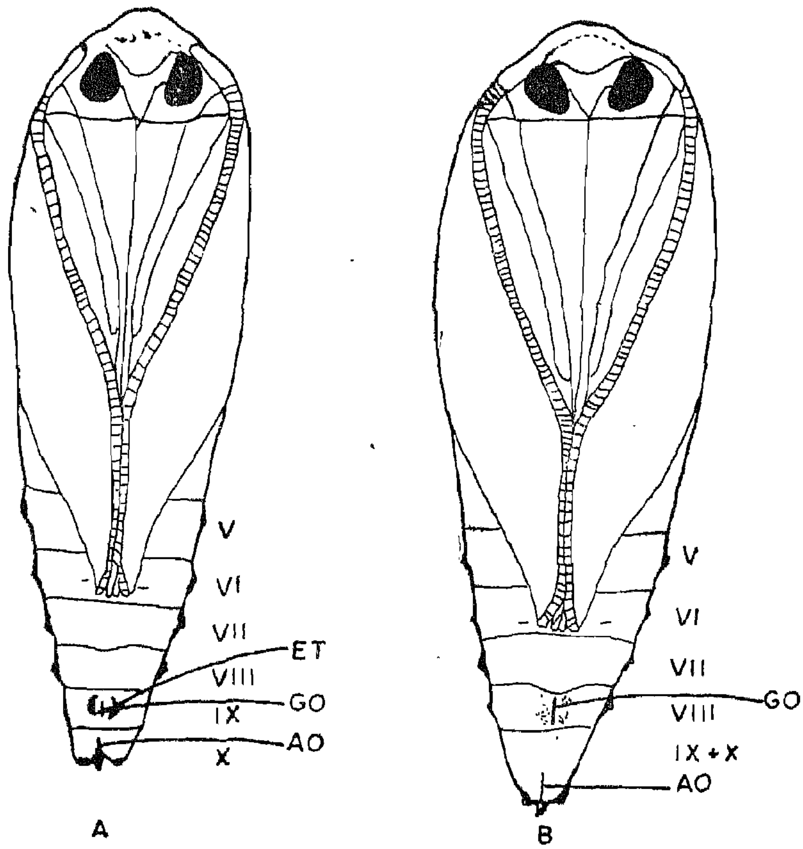

Fig. 1

Phthorimaea operculella : Ventral view of male (A) and female (B) pupae showing elevated tubercle (ET), genital opening (GO) and anal opening (AO). X20.

The mean body length and weight of the female pupa are 2 5 and 6.8 per cent greater than the length and weight of male pupa, respectively. The genital opening (futtre ostium bursae) of female pupa is present on the ventral side of the 8th abdominal segment, whereas, the genital opening of male is present on the ventral side of 9th abdominal segment. Female genital opening is a slit like structure and is longer than the male genital opening. Elevated tubercles are present on either side ef the male genital opening but these structures are absent in the female pupa. The posterior most spiracle and the genital opening in male pupa are present on 8th and 9th abdominal segments, respectively, but in the female pupa both are present on the 8th segment. The caudal margin of 10th segment in the female pupa ends bluntly but in male pupa it is divided by anal opening into an inverted V shaped structure. Similar observations on sexual dimorphism at pupal stage were also reported in other species of moths such as *Rhyacionia frustrana* (Comstock) ; *Rhyacionia rigidana* (Fernald) ; *Rhyacionia subtropica* (Miller) ; *Rhyacionia neomexicana* (Dyer) and *Agrotis segetum* (Schiffer Mueller) (7, 8, 13). However, in the present investigation, sexually dimorphic antennal length, presence of coloured patches in particular abdominal segments and the number and shape of exposed segments beyond the wing pads have not been observed and reported by the other authors in the above mentioned species (7, 13).

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J. Indian Potato Assoc. 9 (2, 3 & 4) : 157-158, 1982. SHORT NOTE

NEW RECORD OF APHIDS INFESTING SEED CROP OF POTATO

R.K. KASHYAP AND A.N. VERMA[1]

Haryana is one of the leading states of India producing seed-potatoes. With a view to study the pattern of population build-up of aphids in seed potato growing areas of the state, a survey was conducted in the months of December and January during the year 1981-82. During the course of survey, the aphid species infesting this crop were collected for authoritative determinations. Both nymphs and adults of the aphids from only well establiseed colonies, were collected in glass vials containing 70 per cent alcohol.

A total of seven aphids species were found to infest potato crop in Haryana which were : *Aphis craccivora* Koch. ; *A. gossypii* complex, *A. fabae* complex, *Myzus persicae* Sulz., *Rhopalosiphum nymphaeae* (Linn.), *R. rufiabdominalis* (Sasaki) and *Tetraneura nigriabdominalis* (Sasaki). Of these, the most predominant aphid species attacking potato crop in this state were, however, *A. gossypii*, *A. craccivora* and *M. persicae* (4).

Occurrence of *R. nymphaeae* on potato (from Shahbad, District Kurukshetra, Haryana) has been reported for the first time. This species has earlier been found to infest apricot (2); aquatic plants (1, 3) and plum (2, 5).

Tetraneura nigriabdominalis has been found infesting potato crop in India (Hissar, Haryana) for the first time. In earlier literature, *Tetraneura* sp. has been reported to infest potato crop in Korea (6).

R. nymphaeae and *T. nigriabdominalis* have not so far been recorded to infest any crop in Haryana.

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The authors are thankful to Dr. D. Raychaudhuri, Department of Zoology, Calcutta University, Calcutta for identification of aphid specimens and to the Chief Seed Certification Officer, Karnal for providing facilities for conducting the survey.

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Edited by B.B. Nagaich, G.S. Shekhawat, S.C. Verma, & P.C. Gaur

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