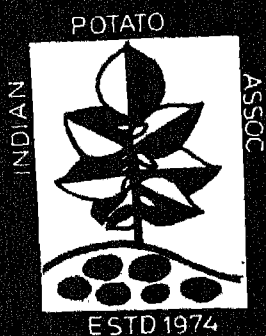


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3. Burton, W.G. 1963. In the growth of the potato, Ivins, J.D. and F.L. Milthoipe, Ed. pp. 17-40, Butterworths, London.

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(Issued in July, 1990)

C O N T E N T S

Page No.

- | | |
|--|----|
| 1. Potato response to zinc as influenced by genetic variability-UC Sharma and JS Grewal. | 1 |
| 2. Effect of soil moisture level on root growth in four potato varieties-R. Ezekiel | 6 |
| 3. Disease monitoring on potato crop in Punjab from 1980-83-AK Verma, AK Somani, OM Bombawale and VC Sharma. | 10 |
| 4. Efficacy of different methods of fertilizer application to potato-SS Saini and VS Kushwah. | 16 |
| 5. Studies on the levels and their methods of application of potassium to potato in sandy loam soil-KS Krishnappa. | 20 |
| 6. Stimulating effect of N on the uptake of P and K compared with P and K fertilization-RC Sharma and HC Sharma. | 24 |
| 7. Field performance of seedling tubers in three successive clonal generation-PC Pande, MS Kadian and MD Upadhya. | 30 |
| 8. Rooting capacity and vigour in relation to seed size in potatoes-AK Sharma, VN Banerjee and R. Bhargava. | 34 |
| 9. Population buildup of aphid vectors in potato in eastern UP-SMA Rizvi and HM Singh. | 38 |
| 10. Yield potential and stability of potato hybrids in NW plains of India-GS Kang and RK Birhman | 41 |
| 11. Efficacy of herbicides for weed control in potato in Meghalaya hills-SS Lal | 48 |
| 12. Control of bacterial wilt of potatoes by agronomic practices-GS Shekhawat, VK Bahal, V. Kishore, RBS Sangar, RL Patel, BK Dey, SK Sinha and AK Pani. | 52 |
| 13. Mortality of potato seedlings and its control-BP Singh, SK Bhattacharyya, SK Saxena and BB Nagaich. | 61 |

14.	Population trend of <i>Myzus persicae</i> on different stages of potato crop in Karnataka-TP Trivedi and KD Verma.	65
15.	Use of meristem-tip culture for producing virus free potatoes-MJ Hossain, AL Khan and MM Rashid.	67
16.	Effect of ascorbic acid on potato yield-VN Banerjee and Rakesh Bhargava.	70
17.	Prevalence and distribution of tuber diseases of seed potatoes in Western Uttar Pradesh-MD Jeswani and VC Sharma.	72
18.	Managing <i>Fusarium</i> wilt of potato by adjusting date of planting-BP Singh, SK Bhattacharyya, SK Saxena and BB Nagaich.	75
19.	Studies on the effect of Cytozyme on potato yields-VN Banerjee	78
<i>Papers presented in the group discussion held at SKUAST in September, 1988</i>		
20.	Major pest problems of potato in UP hills and their management-Gajendra Singh.	79
21.	Threatening diseases and pests of potatoes in Jammu and Kashmir-FA Zaki and M. Amin Masoodi	83
22.	Potato production in UP hills-Constraints and future strategies-PL Gautam, Ranvir Singh and J. Kumar.	87
23.	Potato diseases and pests and their management in the hills of Himachal Pradesh-GS Shekhawat.	94
24.	Fertilizer use in potato crop in North-Western hills of India-Present status and future strategies-JS Grewal.	102

POTATO RESPONSE TO ZINC AS INFLUENCED BY GENETIC VARIABILITY*

U.C. Sharma¹ and J.S. Grewal²

Abstract : Field and pot experiments were conducted on alluvial soils at Kartarpur (Punjab), to evaluate the response of eight potato cultivars/hybrids to zinc application at the rate of 0 and 8 kg/ha. Under field conditions, significant and highest yield response (19.5%) to zinc was recorded in Kufri Alankar followed by Kufri Chandramukhi (15.4%) and Kufri Sheetman (14.6%). In pot culture, besides above three cultivars, V.B.8, Kufri Sindhuri, Kufri Jyoti also showed some response to zinc, Kufri Chamatkar and SLB/Z-569 did not respond both in the field and pot studies. Zinc increased Zinc concentration in leaves and tubers and its uptake by the tubers. The dry matter content of the tubers was not affected by zinc application.

INTRODUCTION

Potato is the most important tuber crop in North-Western Indo-Gangetic plains, where it is grown during winter under short day conditions. The importance of zinc in potato production has increased in the recent years because its application along with major nutrients is needed for optimum yields of high yielding potato cultivars (1,2). However, the zinc requirements of potato is likely to differ with the cultivar grown, depending upon its capacity to exploit native soil zinc and translocation of absorbed zinc to the sites of physiological activity. The studies conducted with some cultivars of cereals, i.e. rice, wheat, maize and pigeon pea revealed that the response to zinc application differ with their yielding capacity and other genetical character (5,6,9). In recent past several high yielding potato cultivars have been released for cultivation in different agroclimatic regions of the country and some hybrids are in the pipeline but there is no information about differential behaviour of these varieties to zinc application. The information about cultivars/hybrids reaction under zinc stress conditions would be useful to potato growers and also to breeders in evolving suitable cultivars for zinc deficient soils. Therefore, the study was undertaken to find out zinc requirements of released potato cultivars and promising hybrids.

MATERIALS AND METHODS

Field and pot trials were conducted during second week of October 1977-78 and 1978-79 in zinc deficient sandy loam alluvial soils of Kartarpur (Punjab) belonging to soil group Ustochrepts (Table 1). The treatments in the field and pot experiments consisted of 8 promising potato cultures viz. Kufri sheetman, Kufri Alankar, Kufri Sindhuri, Kufri Chamatkar, Kufri Jyoti, V.B. 8, SLB/Z 569 and Kufri Chandramukhi at two levels of zinc, i.e. 0 and 8 kg Zn/ha in the field experiments and 0 and 8 ppm in pot experiments as zinc sulphate. The field experiment was conducted in a randomized block design with 16 treatments and 4 replicates. The crop received a basal application of 150 kg, N, 40 kg P and 80 kg K/ha through calcium ammonium nitrate, single superphosphate and potassium chloride, respectively. Half dose of nitrogen and full phosphorus and potassium along with zinc was applied

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at planting while rest of nitrogen was applied at the time of earthing up, i.e. 30 days after planting. All other cultural and plant protection operations were done as per recommended practices.

Table-1 Physico-chemical characteristics of the soils.

	1977-78	1978-79
1. Texture		
Sand (%)	72	72
Silt (%)	23	22
Clay (%)	5	6
2. AV. P_2O_5 (Kg/ha)	10.5	10.2
3. AV. K_2O (Kg/ha)	85	92
4. Organic carbons (%)	0.29	0.28
5. pH	7.3	7.4
6. Conductivity	0.24	0.23
7. DTPA extr. Zn (ppm)	0.32	0.29

Leaf samples (4th leaf from top) were collected after 60 days of planting. Crop was harvested at maturity and tuber yield recorded. Tuber sample were also collected for determination of zinc content. Available soil zinc was extracted with DTPA (4). The other physical and chemical soil analyses were carried out as per standard procedures (3).

RESULTS AND DISCUSSION

The cultivars/hybrids greatly differed in their response to zinc application (Tables 2 and 3). Application of zinc significantly increased the tuber yield of cultivars Kufri Alankar, Kufri Chandramukhi and Kufri Sheetman under both field and pot conditions during both the years of study. The highest yield response (19.5%) was recorded in Kufri Alankar followed by Kufri Chandramukhi (15.4%) and Kufri Sheetman (14.6%), as calculated from the pooled yield data for both the years. The cultivar/hybrids which showed maximum response to zinc application were rated as most susceptible and the ones with less response as less susceptible to zinc stress. On the basis of per cent tuber yield response under field condition the relative susceptibility of potato cultivars/hybrids to zinc stress can be rated as Kufri Alankar > Kufri Chandramukhi > Kufri Sheetman > Kufri Sindhuri > V.B. 8 followed by SLB/Z-569, Kufri Jyoti and Kufri Chamaikar which were least susceptible. A perusal of the yield response indicated that in general, the short duration culture/ hybrids were most susceptible to zinc stress and, as such, highly responsive to zinc application as compared to long duration varieties. This may be due to the fact that during their comparatively short period of growth, the availability of native soil zinc could not keep pace with zinc needs of these fast bulking cultivars and thus zinc application was needed to these cultivars for high yields. On the contrary long duration cultivar/hybrids could exploit more native soil zinc for their growth and development. The applied zinc did not show any significant effect on the dry matter content of tubers in any cultivar/hybrid.

Table-2. Effect of zinc application on the yield of potato cultivars/hybrids under field conditions (q/ha)

Cultivars/hybrids	1977-78		1978-79		Pooled over years		Yield response (%)
	Zn-0 kg/ha	Zn-8 kg/ha	Zn-0 kg/ha	Zn-8 kg/ha	Zn-0 kg/ha	Zn-8 kg/ha	
Kufri Sheetman	156	181	171	194	164	188	14.6
Kufri Alankar	196	233	162	194	179	214	19.5
Kufri Sindhuri	147	148	169	179	158	164	3.8
Kufri Chamatkar	154	156	170	166	162	161	0.0
Kufri Jyoti	189	184	152	163	171	174	1.8
V.B. 8	137	137	122	130	130	134	3.1
SLB/Z-569	173	161	191	204	182	183	0.5
Kufri Chandramukhi	164	201	179	195	172	198	15.1
Mean	165	175	165	178	165	177	7.3
CD (0.05)							
Zinc		8		4		9	
Cultivars/hybrids		15		8		16	
Zinc X cultivars/hybrids		22		12		24	

Table-3. Effect of zinc application on the yield of potato cultivars/ hybrids (g/pot)

Cultivars/hybrids	1977-78		1978-79		Pooled over years		Yield response (%)
	Zn-0 kg/ha	Zn-8 kg/ha	Zn-0 kg/ha	Zn-8 kg/ha	Zn-0 kg/ha	Zn-8 kg/ha	
Kufri Sheetman	163	185	206	241	185	212	14.6
Kufri Alankar	159	222	257	338	208	280	34.6
Kufri Sindhuri	206	208	257	305	232	257	10.8
Kufri Chamatkar	147	150	252	245	200	198	0.0
Kufri Jyoti	138	185	292	272	215	229	6.5
V.B. 8	122	162	208	233	165	198	20.0
SLB/Z-569	115	139	261	230	188	185	0.0
Kufri Chandramukhi	150	168	258	293	204	231	13.2
Mean	150	177	249	270	200	224	12.0
CD (0.05)							
Zinc		9		9		10	
Cultivars/hybrids		14		20		15	
Zinc X cultivars/hybrids		23		28		21	

The chemical analysis of leaves and tubers (Table 4) distinctly revealed that their zinc content was significantly increased due to zinc application. This was due to improvement in zinc supply to plants which resulted in higher tuber yield. The increased zinc concentration might have an indirect effect on nitrogen and phosphorus utilization and rate of photosynthesis, resulting in the increase of tuber yield. The average zinc concentration in leaves and tubers ranged between 29.0 to 36.6 ppm and between 12.3 to 17.1 ppm respectively without zinc application and 43.6 to 56.8 ppm and 14.6 to 17.8 ppm respectively with zinc application at the rate of 8 kg/ha. The interaction between cultivars and Zn was significant. This clearly indicates that cultivars/hybrids differed appreciably in their ability to extract and absorb native soil zinc and translocate it to the sites of physiological activity under conditions of zinc stress. The pattern of tubers yield of the cultivars/hybrids after zinc supplementation also reflected that cultivars/hybrids differed greatly in their zinc requirement, besides, capacity to exploit soil zinc and to translocate it to the physiological active sites. Similar genetic variability to zinc response had been reported in cereals (5, 7, 9) and in legumes (8). Further cultivars/hybrids differed markedly in their zinc uptake by tubers which mainly depended with the cultivar/hybrid and the zinc level (Table 4). This is in agreement with other workers (5, 9).

Table-4. Effect of zinc application on zinc content in leaves and tubers and zinc uptake by tubers of different cultivars/hybrid

Cultivars/hybrid	Zn in leaves (ppm)		Zn in tubers (ppm)		Zn uptake by tubers (g/ha)	
	Zn-0 kg/ha	Zn-8 kg/ha	Zn-0 kg/ha	Zn-8 kg/ha	Zn-0 kg/ha	Zn-8 kg/ha
Kufri Sheetman	31.1	56.3	13.2	15.6	40.7	56.1
Kufri Alankar	33.3	52.9	12.3	14.6	60.9	67.6
Kufri Sindhuri	32.9	54.2	13.0	15.6	38.4	45.6
Kufri Chamatkar	33.6	51.8	16.1	16.7	49.9	52.4
Kufri Jyoti	36.6	43.6	15.1	16.7	57.0	63.6
V.B. 8	43.6	46.1	15.6	16.5	42.4	45.0
SLB/Z-569	29.0	55.2	17.1	17.8	57.9	62.2
Kufri Chandramukhi	36.1	56.8	15.2	17.0	49.9	70.1
Mean	34.5	52.1	14.7	16.3	49.6	57.8
C.D. (0.05)						
Zinc		3.8		1.4		5.5
Varieties		7.6		2.8		10.9
Zn X Var.		10.7		4.0		15.5

The cultivar/hybrids differed greatly in their uptake of zinc, maximum being 70.1 g/ha by Kufri Chandramukhi with the application of zinc and minimum being 38.4 g/ha by Kufri Sindhuri when no zinc was applied. However, the zinc uptake increased in all the varieties due to zinc application although with varying degress. Highest per cent increase was recorded in Kufri Chandramukhi (49.4%), followed by Kufri Sheetman (37.8%), Kufri Sindhuri (18.8%), Kufri Jyoti (11.6%), Kufri Alankar (11.0%), SLB/Z 569 (7.4%), V.B. 8 (6.1%) and Kufri Chamatkar (5.0%).

Thus the response of potato cultivar/hybrids to the zinc application depended to a great extent on the ability to exploit native soil zinc and translocate it to the leaves besides differential zinc requirement of the cultivars/hybrids. Further the differential behaviour regarding zinc response in potato cultivars/hybrids may be attributed to variation in root volume and its length. Cultivars/hybrids susceptible to zinc deficiency have been reported to have limited root volume (10).

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EFFECT OF SOIL MOISTURE LEVEL ON ROOT GROWTH IN FOUR POTATO VARIETIES

R. EZEKIEL¹

Abstract : *Root growth of four potato varieties under three soil moisture levels was studied in sand culture. Varieties differed significantly in root weight and root length. There was no significant difference in the primary adventitious root diameter until 60 days after emergence. There was a significant reduction in root weight and the total length of primary adventitious roots in 50% moisture replacement treatment.*

INTRODUCTION

Varietal differences in root growth have been recorded in potato (8) and other crops (15). One of the principal environmental factors affecting root growth is soil moisture. Many workers have studied root growth in relation to soil moisture levels. Some have found greater root growth under dry growing conditions while others reported better growth under good moist conditions (3). An experiment was carried out in pots to study the pattern of root growth in four popular potato varieties and the extent to which this was affected by moisture level.

MATERIALS AND METHODS

The experiment was carried out at the Central Potato Research Station, Modipuram (U.P) during the 1984-85 season. Scooped single eyes of four varieties viz., Kufri Chandramukhi, Kufri Lauvkar, Kufri Jyoti and Kufri Lalima were planted in earthen pots containing 16 kg of fine sand. The inner surface of the pots was lined with polythene sheet to prevent excessive water loss through the sides. The pots were watered daily to ensure uniform germination and only one stem per pot was retained. Subsequently, differential watering was given to replace 100% (T_1) 75% (T_2) and 50% (T_3) moisture loss due to evapotranspiration. Water loss due to evapotranspiration was determined by weighing the whole pot. Once a week Hoagland's nutrient solution (4) was added in the amount of water applied that day. The pots were kept under natural conditions. During the growth period, the maximum temperature was 22°C to 27°C and the minimum temperature was 6°C to 14°C. The relative humidity ranged from 50% to 63%.

Observations were taken 20, 40 and 60 days after emergence, on two plants from each treatment for each variety. After removing the shoot, the pots were inverted and the contents transferred into a plastic trough. The roots were washed and loose roots were collected on a musli cloth. Eight primary adventitious roots, taken randomly from each treatment, were used for measuring the root diameter using a stereoscopic microscope fitted with an ocular micrometer. Root diameter was measured at about 1 cm from the point of origin. The roots were oven dried at 85°C and the dry weights were taken. Using dried root samples root length per plant was determined following the method of Newman (9) and Tennant (14).

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RESULTS AND DISCUSSION

There was no significant difference in the primary root diameter among the varieties upto 40 days after emergence. Significant differences in root diameter were observed 60 days after emergence and Kufri Jyoti showed maximum thickness (Table-1) which confirms the earlier observation (8). Reduction in root diameter with a decrease in plant or soil water potential has been reported (5, 10), but no significant difference in root diameter due to decrease in moisture level could be observed here.

Table-I Root diameter (mm) at three moisture levels

Variety	Moisture level				SE	CD
	100%	75%	50%			
20 days after emergence						
Kufri Chandramukhi	0.76	0.81	0.78	T	0.08	NS
Kufri Lauvkar	0.63	0.71	0.83	V	0.03	NS
Kufri Jyoti	0.78	0.97	0.82	TxV	0.03	NS
Kufri Lalima	0.69	0.78	0.79			
40 days after emergence						
Kufri Chandramukhi	1.42	1.37	1.71	T	0.16	NS
Kufri Lauvkar	1.88	1.39	1.42	V	0.08	NS
Kufri Jyoti	1.65	1.71	1.03	TxV	0.08	NS
Kufri Lalima	1.31	1.37	1.62			
60 days after emergence						
Kufri Chandramukhi	1.82	1.94	1.88	T	0.10	NS
Kufri Lauvkar	1.31	1.94	1.59	V	0.03	0.06
Kufri Jyoti	2.28	2.39	2.34	TxV	0.03	NS
Kufri Lalima	1.94	1.88	1.71			

Amongst the varieties, Kufri Lalima had the maximum root growth. The root dry weight changed significantly with moisture stress and varieties differed in their response. In Kufri Lauvkar and Kufri Jyoti, the root weight was more in T_2 but this increase was not observed in the other two varieties (Fig. 1). The root weight decreased in T_3 in all the four varieties. The total root length was greatest in Kufri Lalima. The length of primary adventitious roots was more in T_2 , but decreased in T_3 (Fig. 2).

Varities differed significantly in root weight and length (Nagarajan *et al.* 8). The four varieties studied here differed in their pattern of root growth. Kufri Lalima had the most extensive root system (Fig. 1 and 3) and the increase in the total length of primary adventitious roots was 22.7 cm/day. Kufri Lalima should be more efficient in water and nutrient uptake for its better root system. It is already known to be a high yielder (7).

Bennett and Doss (1) observed that the amount of roots and the rooting depth varied with the species and soil moisture level. Total weight of roots was found to be greater at low moisture level. But several other workers (2, 6, 12) have observed greater root weight at higher soil

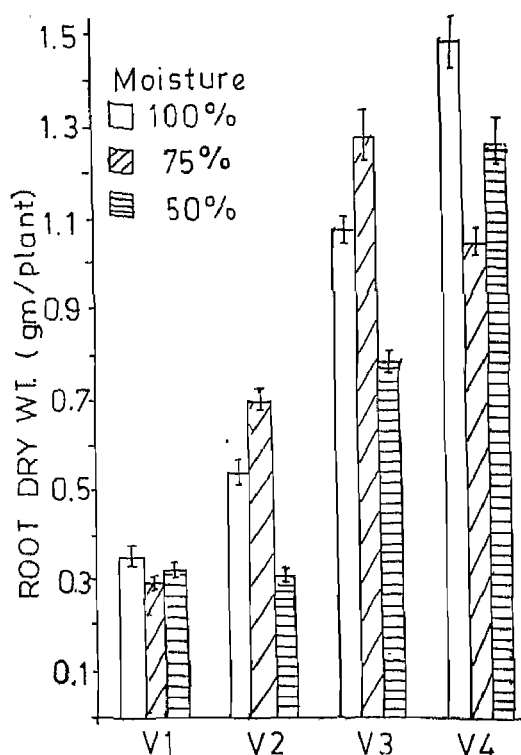


Fig. 1 : Effect of soil moisture level on root dry weight in four potato varieties. V₁ : Kufri Chandramukhi, V₂ : Kufri Lauvkar, V₃ : Kufri Jyoti, V₄ : Kufri Lalima. (40 days after emergence). Vertical bars denote standard error of the mean.

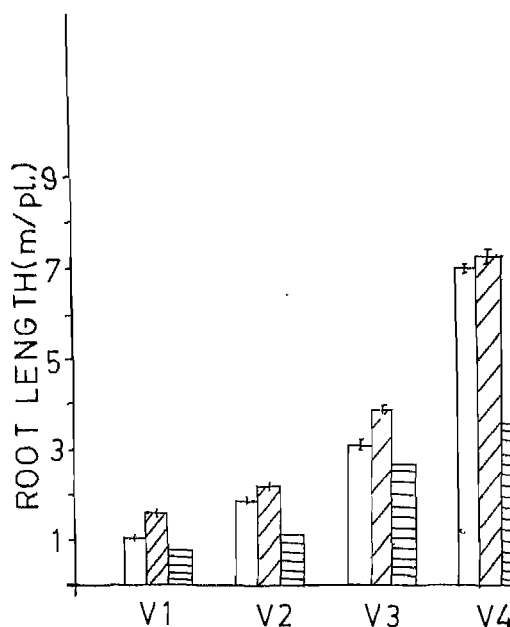


Fig. 2 : Effect of soil moisture level on root length in four potato varieties. V₁ : Kufri Chandramukhi, V₂ : Kufri Lauvkar, V₃ : Kufri Jyoti, V₄ : Kufri Lalima. (40 days after emergence). Vertical bars denote standard error of the mean.

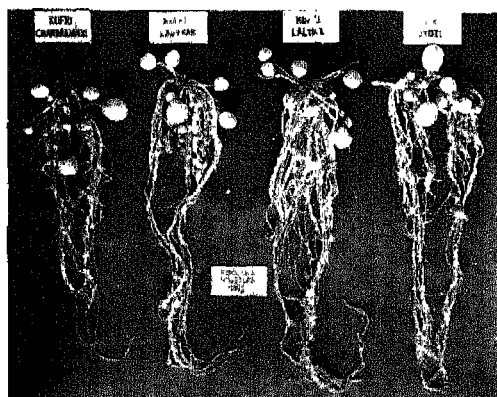


Fig. 3 : Varietal differences in potato root system. (40 days after emergence)

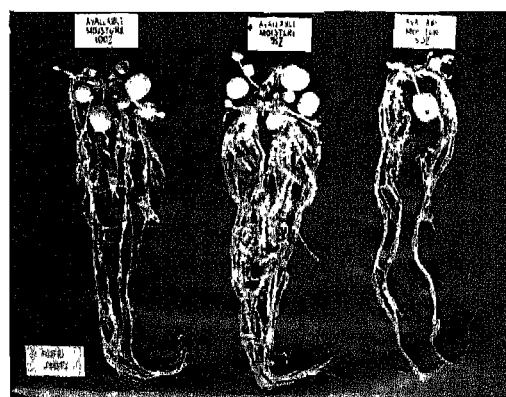


Fig. 4 : Effect of soil moisture level on potato root system (Variety: Kufri Jyoti). (40 days after emergence)

moisture level and reduced root growth at low moisture levels. Roots length has been found to decrease at low moisture level (11, 13). The results presented here indicate that root weight and root length decreased at 50% moisture level. This is in consonance with the general finding that root growth is reduced at low moisture level. Soil water stress reduces the growth of new roots and the ability to supply water to the plant (13). Total root length was less in T_1 compared to T_2 (Fig. 4). The root weight was also less in T_1 in two of the four varieties. The reduced root growth in T_1 was probably due to poor aeration (6, 10). But this response was variety-dependent.

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DISEASE MONITORING ON POTATO CROP IN PUNJAB FROM 1980-83*

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Abstract : A four year survey in Punjab from 1980-83 revealed that Mild mosaic (MM) and severe mosaic (SM) had an average incidence of respectively 5.35 and 2.50% on seed crops as compared to 14.95 and 4.92% on ware crops. Leafroll and MLO's were absent. Black scurf was the most ubiquitous disease on tubers with incidence from 35.9 to 59.7% on seed and from 15.0 to 60.4% on ware potatoes. Common scab has spread further to almost all the potato growing areas in Punjab with incidence above 10%. Soft rot and dry rot were less prevalent and appeared mostly in association with lateblight infected tubers. Late blight escaped regular detection every year on foliage but was found present on the cold stored tubers.

INTRODUCTION

Punjab is the leading seed potato producing state in India on which a number of other states viz. West Bengal, Maharashtra, Karnataka, Gujarat, Madhya Pradesh etc. depend for their quality seed requirement. Since transmission of most of the potato diseases takes place through seed (5) and various viral diseases degenerate the seed stocks (4) it is important to keep a continued vigil on the prevalence and spread of various diseases in seed crop in Punjab. A systematic monitoring of diseases on potato crop in Punjab began in 1972 and the information is available upto 1979 (6). The present paper reports the disease status on potato crop from 1980-83 in Punjab.

MATERIALS AND METHODS

Survey of standing potato crop was confined mostly in main potato growing districts of Punjab viz. Jalandhar, Hoshiarpur and Kapurthala which contribute about 80% of the potato cropped area. There are 322 cold stores in Punjab, of which 105 were in Jalandhar, 62 in Hoshiarpur and 17 in Kapurthala districts (2). The cold stores/field survey was confined to these districts only.

The number of potato fields and tuber samples examined from freshly harvested or cold stored stocks during 1980-83 are given in table 1. Standard procedure was adopted for survey of standing crops. Fields at every 10 km representing all the Tehsils of Jalandhar district and some parts of adjoining districts were observed at 40-60 days old stage of the crop. Viral and MLO diseases were recorded using the potato certification procedure (1). A minimum of two counts (100 plants each) per acre and thereafter one count for each additional acre or part thereof were taken randomly. A maximum of 10 counts per field were recorded. Average incidence of all the counts of one field were taken as one sample. For recording late blight, 5 counts of 100 plants each taken randomly over an area of an acre or fraction thereof comprised the sample. Survey was carried out upto December only.

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Table-1: Potato fields and tuber samples examined during survey

Year	Potato fields		Freshly harvested		Cold stored tubers		
			fields/heaps		No. of cold stores	No. of samples	
	seed	ware	seed	ware		seed	ware
1980	33	30	21	7	42	111	64
1981	15	16	36	6	43	79	51
1982	60	17	66	28	68	68	90
1983	37	36	33	7	56	202	47

Autumn harvested potatoes in farmers fields were examined from December to March for tuber diseases. A minimum of 4 counts comprising of 100 tubers each drawn randomly from 4 places in a field of one acre or its produce limited to 10 counts per field or heap constitute a sample.

In cold stores both seed and ware potatoes were stored together. The ware potatoes were examined earlier as these are taken out from June to September for marketing. The seed potatoes were examined during September to October when they are taken out for planting. A minimum of 4 counts subject to a limit of 10 counts of 100 tubers each drawn randomly from a lot of 10 quintals or less of potatoes comprised the sample from a cold store.

Disease prevalence denotes the per cent fields or samples found infected, where as the incidence indicates the per cent infected plants or tubers out of a count of 100 plants or tubers. In deriving mean disease incidence, the samples found disease free were not taken into account as these were reflected in percent disease prevalence.

RESULTS AND DISCUSSION

Main varieties grown in the region were kufri Chandramukhi and Kufri Jyoti. Other varieties grown were Kufri Badshah, Kufri Bahar, Kufri Sindhuri and mix varieties.

Health standards of seed crop was better than those of ware crop so far as the MM and SM were concerned (Table 2). Though all the observed fields of both seed and ware crops had MM, the incidence ranged from 4.2-6.9% over the 4 years on seed crop compared to 9.8-21.5% in ware crop. The number of fields showing SM in seed crop ranged from 46.7% in 1981 to 81.1% in 1983 showing increasing trends whereas on ware crop almost all fields carried the disease. The incidence of SM was low on seed crop (1.8-4.9%) as compared to that on ware crop (3.5-9.6%). No trend of disease increase or decrease was evident for incidence of MM and SM from 1980-83. Severe mosaic was usually absent in the fields of progressive growers who sincerely rogued out the SM infected plants from their seed fields. Potato leaf roll (PLRV) was not found except in one field during 1982. On enquiring, it was found that the seed source was Shimla hills.

No mycoplasmal disease such as purple top roll, marginal flavescence and witches broom were observed. In earlier years from 1972-79 also these diseases were reported to be absent in Punjab (6). Possible reasons for the absence of PLRV and MLO's in Punjab could be transmission of PLRV and

MLO's is of persistent nature which requires sufficient time for their acquisition and transmission. Due to heavy use of insecticides in potato crops in the region, the aphids and jassids are killed before getting sufficient time for acquisition and transmission. Another reason could be that source of seed in the region is local i.e. free from PLRV and MLO's infection.

Table-2. Disease situation in standing potato crop

Diseases	Years	Disease prevalence average %		Disease incidence average %		Disease incidence in seed and ware samples average %	
		seed	ware	seed	ware	1 year	4 year
Mild mosaic	1980	100.0	100.0	5.8	12.2	8.9	
	1981	100.0	100.0	4.5	21.5	13.3	
	1982	100.0	100.0	6.9	16.3	9.0	9.6
	1983	100.0	100.0	4.2	9.8	7.0	
Severe mosaic	1980	50.5	80.5	1.8	3.9	3.0	
	1981	46.7	100.0	4.9	7.6	6.8	
	1982	78.3	100.0	1.8	4.7	2.6	3.8
	1983	81.1	100.0	1.5	3.5	2.6	
* Late blight	1980	0.0	0.0	0.0	0.0	0.0	
	1981	0.0	0.0	0.0	0.0	0.0	
	1982	16.7	11.2	5.4	2.6	4.9	1.2
	1983	0.0	0.0	0.0	0.0	0.0	

* During 1980 and 1981, it appeared very late in the season after completion of foliar disease surveys.

Late blight was observed only in 1982 with 16.7% prevalence in seed and 11.2% in ware crops. Incidence ranged upto 50% in one of the field of the seed crop but in ware crops it was upto 5% only with average incidence 5.4 and 2.6%, respectively. However during 1980 and 1981 late blight appeared very late in the season after completion of disease surveys. But during 1983 it did not appear at all. Occurrence of late blight was therefore, sporadic in autumn crop. Early blight was observed only in light intensity in a few fields of the autumn potato crop. No bacterial leaf spots and wilts were found. Ozone injury was encountered in nearly all the potato fields in varying intensity from 1982 onwards. A thorough survey report on the extent of prevalence of ozone injury in Punjab is available (3).

The status of tuber diseases is presented in table 3. The black scurf was the most ubiquitous disease on freshly harvested and cold stored potato stocks. There was no appreciable difference in the disease prevalence amongst seed and ware potatoes. The four years average incidence of seed and ware was 39.4% in fresh produce and 45.4% in cold stored material (Table 3). Low incidence of black scurf in freshly harvested tubers than cold storage is because the freshly harvested tubers were from early harvested crop mainly, while cold stored tubers included both early and late harvested crop when the prevailing higher temperature favour black scurf. It was observed that black scurf incidence was always higher in small farmers stocks or the farmers who did not treat their seed stocks properly.

Table-3. Disease situation on potato tubers

Disease	Year	Average disease prevalence %				Average disease incidence %				Average disease incidence in seed and ware samples			
		Freshly harvested produce		Cold stored produce		Freshly harvested produce		Cold stored produce		Freshly harvested produce		Cold stored produce	
		seed	ware	seed	ware	seed	ware	seed	ware	seed	ware	1 year	4 years
Black scurf	1980	95.2	85.7	99.1	98.4	51.7	23.3	59.7	37.5	45.1	37.5	51.6	
	1981	91.7	100.0	97.4	63.3	35.1	19.3	39.0	60.4	32.7	39.4	45.2	45.4
	1982	100.0	100.0	100.0	100.0	41.9	60.5	52.1	35.7	47.5		42.8	
	1983	100.0	100.0	100.0	100.0	36.1	15.0	40.3	49.9	32.4		42.1	
	1980	33.3	14.3	53.1	34.8	1.2	1.0	6.6	1.5	1.0		5.2	
Late blight	1981	0.0	16.7	20.2	11.7	0.0	2.0	0.5	0.9	2.0		0.6	
	1982	59.1	39.3	77.9	75.6	2.2	1.3	1.7	1.9	2.0	2.1	1.8	3.0
	1983	78.8	42.9	89.1	79.4	3.4	1.6	4.0	6.2	3.2		4.5	
	1980	38.1	85.7	34.2	28.1	15.5	8.6	21.0	4.6	12.4		15.7	
Common scab	1981	66.7	33.3	18.9	41.1	11.6	12.6	8.7	9.3	11.7	10.2	9.1	10.3
	1982	31.8	7.1	41.2	32.2	15.1	5.6	16.3	5.9	14.3		11.0	
	1983	21.2	28.6	37.1	44.7	2.8	0.1	5.1	5.6	2.2		5.3	
	1980	19.1	28.6	18.0	20.3	0.6	0.1	3.3	1.0	0.4		2.4	
Soft rot	1981	16.7	33.3	46.8	35.3	0.7	0.6	0.4	0.6	0.7	0.8	0.5	2.2
	1982	53.2	50.0	76.5	82.2	1.3	0.8	1.8	3.4	1.2		2.7	
	1983	24.2	14.3	84.6	89.4	0.8	0.1	2.7	4.3	0.7		3.0	
	1980	0.0	0.0	39.5	28.1	0.0	0.0	0.8	1.4	0.0		1.0	
Dry rot	1981	0.0	0.0	44.3	33.3	0.0	0.0	0.2	0.3	0.0	0.0	0.2	0.9
	1982	0.0	0.0	73.5	72.2	0.0	0.0	1.6	1.5	0.0		1.5	
	1983	0.0	0.0	51.0	59.6	0.0	0.0	0.8	0.8	0.0		0.8	

Common scab was also highly prevalent disease found in 18.9 to 66.7% of seed samples and 7.1 to 85.7% in ware potato samples during individual years in fresh harvest and cold stored tubers (Table 3). A average incidence of common scab on both seed and ware crop was above 10% during the 4 years. Till 1979 it was reported to be restricted to a few pockets (6) but now it was widespread in the State. High incidence of common scab in small farmers stocks might be due to no tuber treatment or improper treatment.

In tubers, late blight was observed during all the 4 years while in standing crop it was found only during 1982 autumn resulting in record of high prevalence and incidence during 1983 surveys of tubers. During the first two seasons it appeared very late and therefore, escaped notice in foliar diseases surveys but was found in subsequent tuber surveys. Also the tubers of cultivar Kufri Jyoti were found susceptible while its foliage in field was resistant to late blight. It was found upto 79.7% in seed samples and 89.4% in ware potato samples with incidence upto 65 and 75%, respectively (Table 3). Four years average incidence was 2.1 and 3.0% in tubers of freshly harvested and cold stored samples, respectively.

Dry rot was found 50.2% samples of cold stored material but was absent in freshly harvested tubers. Four years average incidence was 0.9% (Table 3).

Soft rot prevalence was also quite high (upto 89.4% samples) but the incidence was low (Table 3) except for a few individual samples. In some samples, the incidence was very high due to late storage in cold store, exposure to the sun, rain or hail storm. Four years average incidence was 0.8% in freshly harvested tubers and 2.2% in cold stored material.

It was observed that late blight infected tubers were more prone to dry and soft rot development and these usually appeared concomitantly on individual tubers.

The seed health standards reflected from foliar incidence of MM and SM (combined) appears to be a little above the prescribed limits of getting good seed health standards (1). The quality of the seed crop, therefore needs to be improved further from the existing levels. The incidence of viruses on ware crops is quite high which may be directly or indirectly reduce the quantitative aspects of potato productions through providing inoculum for seed crop and through degeneration. Black scurf and common scab are important diseases in Punjab and increased attention needs to be paid for their proper management. Late blight is of sporadic occurrence on foliage but the tuber infection showed that it is carried every year through infected seed in the next crop season.

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EFFICACY OF DIFFERENT METHODS OF FERTILIZER APPLICATION TO PATATO*

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Abstract : Field experiments were conducted on loamy alluvial soils at Morena/Gwalior during Rabi 1980-81 and 1981-82 to compare the different methods of fertilizer (NPK) application to potato cv. Kufri Chandramukhi. Tuber yields of same magnitude were recorded by broadcasting and placement methods of fertilizer application. Split application of N, 1/2 at planting and 1/2 at earthing or 2/3 at planting and 1/3 at earthing, did not influence total as well as seed size tuber yield significantly. Split application of N in two equal doses, especially for raising a seed crop, is advocated.

INTRODUCTION

Potato is very intensive input demanding crop and its cost of cultivation works out to over Rs. 15,000/-ha (3). To bring down this cost to make potato cultivation more remunerative, one way is to reduce the cost of fertilizer application through its judicious use and right method of application. Many workers reported better utilization of fertilizers by furrow/band placements (1, 4, 5, 8, 9). Divergent views are also available in the literature that NPK application by broadcast gave higher yield than by application below seed tubers and on one side or on both sides (2). Sahota and Singh (6) reported that broadcasting of P, K and FYM was as effective as localized fertilizer placement. In alluvial soil of Jalandhar (Punjab), application of N by broadcast gave similar yield to that of furrow placement (7). Previous studies have been conducted in a fragmented way taking one or two nutrients at a time and very little information is available in respect of the application of three nutrients (NPK) together.

With this in view and the feed back from the farmers, who prefer to apply the fertilizers by broadcast, field experiments were conducted at Morena/Gwalior (MP) to compare the effectiveness of broadcast and placement methods of fertilizer application in potato cultivation.

MATERIAL AND METHODS

Field experiments were conducted at the Central Potato Research Station, Morena/Gwalior (MP), for two seasons 1980-81 and 1981-82. The soil of experimental fields was alluvial type, having pH 7.5-8.6, EC 0.25-0.33 m mhos/cm, organic carbon, 0.76-0.81%, available phosphorus, 12.7-15.2 kg and available potassium 80-100 kg/ha. Fertilizers were applied at the rate of 120 kg N + 35 kg P + 84 kg K/ha. Nitrogen was applied in two split doses at the time of planting and earthing. Full dose of P and K was applied at planting. All the three nutrients were applied mixed together in the form of ammonium sulphate, di-ammonium phosphate and muriate of potash. The treatments were :-

T₁ — Broadcasting 1/2 N + full P&K at planting + 1/2N at earthing. T₂ — Broadcasting and mixing in soil, 1/2 N + full P&K at planting + 1/2 N at earthing. T₃ — Placement at ground level, 1/2 N + full P&K at planting and 1/2 N at earthing. T₄ — Furrow placement, 1/2 N + full P&K at planting

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and 1/2 N at earthing. T₅ — Broadcasting 2/3 N + full P&K at planting and 1/3 N at earthing. T₆ — Broadcasting and mixing in soil, 2/3 N + full P&K planting and 1/3 at earthing. T₇ — Placement at ground level, 2/3 N + full P&K at planting and 1/3 N at earthing and T₈ — Furrow placement, 2/3 N + full P&K at planting and 1/3 N at earthing.

Randomised block design was adopted with four replications. Net plot size was 36.0 m² in 1980-81 and 26.4 m² in 1981-82. After fertilizer treatments ridges with tractor drawn ridger were formed 60 cm apart and seed tubers of cv. Kufri Chandramukhi were dibbled on them manually at a spacing of 20 cm. Planting was done on 29th October in the first year and 10th November in the second year of experimentation. Operations, viz. one hoeing/weeding and earthing up, were carried out as per recommendations. The crop was harvested at 75 days of planting in both the years and the yields were recorded in five grades, viz. up to 25, 26-50, 51-75, 76-100 and > 100 gm tubers.

RESULTS AND DISCUSSION

Effect on total yield : The data revealed that different methods of fertilizer application gave yield of same magnitude (Table 1). It indicates that broadcasting of fertilizer is as effective as localised application. In fact, in broadcasting method during the process of ridge making, the fertilizers is drawn into the ridges and is placed in the root zone simulating the condition of placement of fertilizers in potato. With broadcasting while there is no reduction in yield, the cost and time of application is reduced and the planing is speeded up considerably. That is the main reason that the technique is widely acceptable to the farmers, particularly in Punjab.

Table 1 : Effect of methods of fertilizer application on total tuber yield.

Treatment	Yield q/ha		
	1980-81	1981-82	Mean
T ₁	272	269	271
T ₂	280	275	278
T ₃	271	264	268
T ₄	279	274	277
T ₅	287	255	271
T ₆	268	281	274
T ₇	273	273	273
T ₈	271	273	274
Mean	275	270	
S.E.m ±	10.2	11.5	
CD (0.05)	NS	NS	
CV%	7.4	8.5	

Methods of fertilizer application

Splitting of N into $1/2 + 1/2$ and $2/3 + 1/3$ also did not influence the yield. However, in order to avoid masking of viral diseases symptoms in seed crop of potato, initial heavy doses of N should be avoided. At the same time, there should be sufficient N in the initial stages of crop growth to help it in the early build up of crop canopy. Hence, split application of N ($1/2$ at planting + $1/2$ at earthing up) is advocated for raising potato seed crop.

Effect on grades of tubers : Like total yield, seed size tuber yield also remained unaffected by various methods of fertilizer application (Table 2). Seed size (26-100 gm) tuber constituted 90.8% of the total yield.

The proportion of different tuber grades in total produce was not affected much by different methods of fertilizer application. The tubers in the grades of up to 25, 26-50, 51-75, 76-100 and > 100 gm weight formed 5.6, 39.6, 34.10, 17.1 and 3.5 per cent of total produce, respectively (Table 3).

It can be concluded from the present study that NPK fertilizers can be applied together safely to potato crop at planting in alluvial soils by broadcast method which is comparatively a cheaper and speedier method. Splitting of N, application in $1/2 + 1/2$ or $2/3 + 1/3$ gave same yield. Hence, it is better to apply N in two equal doses on potato seed crop in order to avoid masking of viral diseases symptoms.

Table 2 : Effect of methods of fertilizer application on yield of seed size tubers (26-100 gm)

Treatment	Yield q/ha		
	1980-81	1981-82	Mean
T ₁	247	247	247
T ₂	252	251	251
T ₃	243	244	244
T ₄	250	251	250
T ₅	262	233	248
T ₆	242	259	251
T ₇	249	250	250
T ₈	237	250	244
Mean	248	248	
S. Em $\pm$	9.3	10.9	
CD (0.05)	NS	NS	
CV %	7.5	8.8	

Table 3 : Effect of methods of fertilizer application on percent yield of different tuber grades (pooled data for two years).

Treatment	Tuber/grades (gm)				
	Up to 25	26-50	51-75	76-100	> 100
T ₁	4.98	36.68	33.48	19.13	3.73
T ₂	6.43	42.47	33.68	14.42	2.99
T ₃	5.83	41.38	34.95	14.53	3.31
T ₄	4.78	39.08	31.95	19.42	4.76
T ₅	5.35	37.53	33.32	20.41	3.39
T ₆	5.43	38.80	33.60	18.95	3.24
T ₇	6.11	41.20	36.18	14.12	2.38
T ₈	6.11	37.73	35.70	16.03	4.41
Mean	5.62	39.60	34.10	17.12	3.52

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STUDIES ON THE LEVELS AND THEIR METHODS OF APPLICATION OF POTASSIUM TO POTATO IN SANDY LOAM SOIL

K.S. Kirshnappa¹

Abstract : Application of K fertilizer significantly increased the tuber yield. The yield increased progressively with the increasing levels of K upto 100 kg/ha and on the production of large, medium and small sized tubers. Band placement of K was superior to broadcasting in increasing the tuber yield and increased the uptake of K by the potato plant.

INTRODUCTION

Potassium requirement in sandy loam soils is considered necessary along with N and P fertilizers for higher yields of potato crop (3, 5, 6). The optimum dose of nutrient largely depends on soil type, cultivar and other agroclimatic conditions. Earlier studies revealed that band placement/furrow placement was superior to broadcast in increasing the potato yield in acidic soil (8, 10). Keeping these in view, field trials were conducted to determine optimum level of K and its method of application to potato in sandy loam soil.

MATERIALS AND METHODS

Two field trials were conducted during 1981-82 and 1982-83 at the University of Agricultural Sciences, Bangalore, in sandy loam soil with four levels of K (0, 50, 100 and 150 kg/ha) in the form of muriate of potash and three methods of application to potato (Kufri Jyoti). K was applied as broadcast, single and double band placement. The twelve treatments were distributed in a factorial RBD with four replications. A basal dose of 100kg/ha each of N and P in the form of urea and single superphosphate were applied to all the treatments. Before planting the soil samples of the experimental plot were taken and analysed for different characteristics as outlined by Jackson (2). The available NPK nutrients of the experimental field during 1981-82 had 214.6, 12.9 and 252.4 kg/ha respectively, with organic carbon of 0.51% and with pH 6.0. While during 1982-83, it had 219.5, 10.6 and 263.3 kg NPK/ha respectively with organic carbon 0.59% and with pH 6.2.

In broadcast the fertilizer was evenly distributed on the soil just before planting. In single band placement the fertilizer was applied on one side of the tuber about 5 cm away in a 8 cm deep furrow formed by hand tools. While in double band placement the method was similar to single band placement but the furrows were made on both sides of the tuber and fertilizer was applied in the furrows. At harvest tubers were divided into four grades based on their weight i.e. large, above 75 g; medium, 50-74g; small, 26-49 g; and very small below 25g. The uptake was calculated by multiplying the dry matter yield with K concentration of different plant parts. The two years data were pooled and analysed statistically.

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RESULTS AND DISCUSSION

Emergence : The emergence of seed tubers was 92 to 96% in different treatments revealing that K fertilizer has no effect on emergence of seed tubers. This could be due to low salt index of the potassic fertilizer. The results are in agreement with the findings of Pushkarnath (7) and Verma and Grewal (10).

Tuber yield : Application of K increased the tuber yield significantly upto 100 kg K/ha (Table 1). The absence of K response beyond 100 kg/ha can be attributed to medium K status of the experimental field soil. The results revealed that in these soils application of 100 kg K/ha along with N and P was optimum. Krishnappa and Muddappa Gowda (6) and Anand (1) had also reported that potato did not respond beyond 100 kg K/ha in sandy loam soil.

Band placement was superior to broadcasting in increasing the tuber yield. However, single placement and double band placement were at par (Table 1). Higher tuber yield in band placement can be attributed to better utilization of applied K by the sparse root system of the potato plant.

Table-1. Tuber yield (q/ha) as affected by different levels of K and their method of application.

K levels (kg/ha)	Broad- casting	Band placement		Mean
		Single	Double	
0	225.4	235.6	229.8	230.8
50	264.6	302.1	313.5	293.4
100	287.2	315.3	327.2	309.9
150	289.5	314.7	328.4	310.9
Mean	266.7	291.9	299.7	—
C.D. (0.05) for levels/methods			17.0	
C.D. (0.05) for levels X methods			34.1	

In broadcast, applied K was exposed to a greater soil surface and might not have been available near the active root zone of the plant. Better utilization of K by the potato plant when applied through furrow or band placement than broadcast had also been reported by Pushkarnath and Patil (8), Jackate (4) and Verma and Grewal (10). Therefore, for an efficient use of K fertilizer in these soils it should be applied by band placement near the seed tubers so that the roots could easily absorb it.

Gradewise tuber yield : Application of K had a marked effect on the yield of large, medium and small sized tubers, but had no effect on very small sized tubers (Table 2). The yield of large and medium sized tubers was increased progressively with the increasing levels of K. However, the differences between 50, 100 and 150 kg K/ha in the production of large, medium and small sized tubers being non-significant. Similar results has also been reported by Anand (1). These results revealed that the increased yield due to K application was mainly the function of the size of the tubers.

Table-2. Gradewise tuber yield (q/ha) as affected by different levels of K and their methods of application.

Treatments K levels (kg/ha)	Gradewise tuber yield			
	Large	Medium	Small	Very small
0	52.6	79.1	84.3	14.3
50	139.1	100.2	40.6	13.5
100	154.7	98.5	43.9	12.8
150	151.8	102.2	44.7	12.2
Methods of application				
Broadcasting	103.6	72.7	74.0	16.4
Single band placement	125.2	99.9	52.7	14.1
Double band placement	127.4	93.2	63.4	15.7
C.D. (0.05) for levels/methods of application	16.9	16.1	11.6	NS

NS = Non-Significant

It is evident from the data in Table 2 that the band placement was superior to broadcasting in the production of large, medium and small sized tubers, But the methods of application had no significant effect in the production of very small sized tubers. The increased yield of large, medium and small sized tubers can be attributed to rapid bulking which resulted in the increased tuber yield.

Uptake of K : Significant differences were observed in the uptake of K amongst different levels of K and their method of application and their interactions (Table 3). Marked increase of K uptake was observed upto 100 kg K/ha. Application of 100 and 150 kg K/ha were at par in the uptake of K. The increased uptake could be due to increased availability of nutrients and increased absorptive area. Anand (1) and Rajanna (9) have also reported increased uptake of K by the potato plant to varying levels of K in sandy loam soil.

Table-3 Uptake of K (kg/ha) as affected by different levels of K and their method of application

K levels (kg/ha)	Broad- casting	Band placement		Mean
		Single	Double	
0	106.5	132.1	137.7	125.4
50	139.6	158.9	162.6	153.7
100	162.4	195.3	199.7	185.8
150	164.9	197.2	201.5	187.9
Mean	143.3	170.9	175.4	
C.D. (0.05) for levels/methods			6.6	
C.D. (0.05) for levels X methods			13.2	

The methods of application also significantly affected the uptake of K. The highest uptake by the plant was found when K was applied in double band placement. However, the difference between the single and double band placement being non-significant. The results revealed that application of K close to the active root zone of the plants was better utilized than when it is broadcast.

From the studies it is concluded that application of 100 kg K/ha was optimum and it should be applied in band placement for better utilization.

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STIMULATING EFFECT OF N ON THE UPTAKE OF P AND K COMPARED WITH P AND K FERTILIZATION*

R.C.Sharma and H.C. Sharma¹

Abstract : A field experiment was conducted on alluvial soil (Ustochrept) of Jalandhar (Punjab) during 1985-86 with four rates of application each of N, P and K with four potato cultivars (Badshah, Bahar, Lalima and Jyoti) to examine the effects of N on the nutrient uptake when compared with P and K application. Application of N increased not only the uptake of N but also that of P and K by tubers and the increase varied with cultivars. On the other hand, application of P and K did not affect N, P and K uptake of Badshah, Bahar and Lalima but increased the uptake of Jyoti marginally. The contribution of N to P and K uptake (averaged over cultivars) was 80 and 75% respectively whereas the contribution of P to P uptake was 2.5% and that of K to K uptake was 2.8%

INTRODUCTION

Earlier studies conducted on alkaline alluvial soil (Ustochrept) of Jalandhar (Punjab) showed that N application increased P and K uptake of potato (10). But how far, N application could compete with P and K fertilization in increasing P and K uptake, was not known. Whether the observed positive effects of N application on P and K uptake were affected by the cultivars, was also not known. Field experiment was, therefore, conducted to examine the effects of N on P and K uptake in different cultivars of potato and to compare the observed effect with those of P and K fertilization.

MATERIALS AND METHODS

Field experiment was conducted during 1985-86 on alluvial (Ustochrept) soil at the Central Potato Research Station, Jalandhar (Punjab). The soil was slightly alkaline (pH, 7.4) and sandy loam in texture. The values of organic carbon, alkaline KMnO_4 oxidizable-N, Olsen-P and $1\text{N NH}_4\text{OAc-K}$ were; 0.4%, 90mg, 18mg and 130mg/kg soil.

The treatments were formed by the combinations of 4 levels each of N (0,80,160 and 240 kg/ha), P (0, 22, 44 and 66 kg/ha) and K (0, 50, 100 and 150 kg/ha). The 4^3 design of Sharma and Sharma (6) confounding $\text{N}^{\text{I}}\text{P}^{\text{II}}\text{K}^{\text{III}}$, $\text{N}^{\text{II}}\text{P}^{\text{III}}\text{K}^{\text{I}}$ and $\text{N}^{\text{III}}\text{P}^{\text{I}}\text{K}^{\text{II}}$ (2) in blocks of 16 plots was adopted. The 16 of the treatments were accommodated in each block. Each fertilizer treatment was tried with four potato cultivars : Kufri Badshah, Kufri Bahar, Kufri Lalima and Kufri Jyoti. For brevity, the word "Kufri" has been omitted henceforth. Each cultivar was allocated to four lines of two m length in a plot. Thus, there were 16 experimental lines in a plot.

Half of the dose of N as ammonium sulphate whereas full dose of P and K as single superphosphate and muriate of potash was applied at planting at 5cm depth in furrows and mixed with the soil. The crop was planted in 3rd week of October at 60 x 20cm spacing. Plant emergence was recorded periodically till full emergence. Remainder dose of N was applied at earthing-up when the crop was about 30 days old. The crop was grown under irrigated conditions. Tuber yield was recorded at maturity and samples were collected for chemical analysis. N was determined by the rapid chromic acid method

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of Sharma & Sud (11). P and K were determined in traicid digest with the help of cholorimeter and flamephotometer (4). The relative contribution of nitrogen to different plant parameters was worked out by the following formula of Sharma and Sharma (7). Likewise, the contributions of phosphorus to P and K uptake were worked out.

$$\text{Percent contribution of nutrient (N)} = \frac{\text{sum of squares due to N levels}}{\text{Total sum of squares} - \text{Sum of squares due to blocks (ignoring treatments)}} \times 100$$

Here, the contributions of nutrients to N,P and K are discussed while the yield and composition part have been reported elsewhere (8).

RESULTS AND DISCUSSION

Effect of N, P and K on N uptake : Application of N upto 240kg/ha increased the uptake though the increase varied with the cultivar (Table 1). On the other hand, application of P and K did not affect the N uptake. The contribution of N to N uptake was 75, 86, 91 and 91% in the case of Badshah, Bahar, Lalima and Jyoti respectively.

Table-1. Effect of nutrients on N uptake by tubers (kg/ha)

N rate (kg/ha)	Cultivars			
	Badshah	Bahar	Lalima	Jyoti
0	59	50	46	43
80	69	57	50	48
160	111	92	97	110
240	120	101	97	123
P rate (kg/ha)				
0	92	72	71	76
22	86	74	72	81
44	87	78	74	85
66	93	75	73	83
K rate (kg/ha)				
0	92	75	73	83
50	94	79	73	83
100	87	76	73	76
150	86	70	69	84
CD 5% for N,P,K rates	12	6	7	8

Effect of N rate on P uptake by tubers : Application of N increased P uptake and the increase varied with N rate (Table 2). The increase was noticed upto 160 kg/ha. The tuber yield also showed significant response upto 160 kg N/ha only. The response in terms of tuber yield in Badshah, Bahar, Lalima and

Stimulating effect of N on the uptake of P & K

Jyoti was 13.7, 15.5, 16.4 and 23.4 t/ha respectively (8). Application of 160 kg N/ha increased P uptake in Badshah, Bahar, Lalima and Jyoti by 8.8, 4.8, 8.2 and 9.4 kg/ha respectively. The contribution of N to P uptake, in quantitative terms, was 80, 72, 83 and 86% in Badshah, Bahar, Lalima and Jyoti, respectively (Table 4). The results showing higher contribution of N to P uptake in Lalima than Bahar are in agreement with the findings of Upadhyay and Sharma (12).

Table-2. Effect of nutrients on P uptake by tubers (kg/ha)

N rate (kg/ha)	Cultivars			
	Badshah	Bahar	Lalima	Jyoti
0	9.8	7.6	6.6	7.4
80	11.0	8.1	7.5	7.5
160	18.6	12.4	14.8	16.8
240	17.4	12.6	13.5	16.1
P rate (kg/ha)				
0	13.9	9.5	10.1	10.5
22	13.8	10.0	10.1	12.6
44	14.4	10.8	10.7	12.0
66	14.7	10.4	11.6	12.7
K rate (kg/ha)				
0	14.3	10.5	10.9	11.8
50	15.1	10.2	10.4	11.9
100	13.4	10.6	10.5	12.1
150	13.9	9.3	10.6	12.0
C.D. 5% for NPK rates	1.6	1.1	1.3	1.2

Effect of P on P uptake by tubers : Application of P, ranging from 0 to 66 kg/ha, did not increase P uptake of Badshah, Bahar and Lalima significantly (Table 2). But 22 kg P/ha did increase it in Jyoti by 2.1 kg/ha. The contribution of P to P uptake in Jyoti was worked out to be only 3.5%. P application did not affect tuber yield of any cultivar showing that P level of soil (18 ppm Olsen-P) was adequate to support the optimal yield.

A comparison of the effects of N on P uptake with those of P on P uptake clearly shows that N was more effective in increasing P uptake than the application of P itself. The results showing positive effect of N on P uptake are in agreement with the findings of Kamprath (5). Positive effect of N on P uptake might be attributed to increased root growth and increased physiological activity of roots to absorb P (3) and to increased P availability from the soil source by ammonium sulphate. Sharma *et al* (9) reported an increase in available P status of alluvial soil of Jalandhar (Punjab) with the application of N (ammonium sulphate).

Effect of N on K uptake by tubers : Application of 80 kg N/ha did not affect K uptake (Table 3). But 160 kg N/ha increased K uptake of Badshah, Bahar, Lalima and Jyoti by 35, 19, 43 and 52 kg/ha

respectively. Raising the dose of N from 160 to 240 kg/ha did not increase K uptake further. In quantitative terms, the contribution of N to K uptake of Badshah, Bahar, Lalima and Jyoti was 72, 56, 83 and 87% respectively (Table 4).

Table-3. Effect of nutrients on K uptake by tubers (kg/ha)

N rate (kg/ha)	Cultivars			
	Badshah	Bahar	Lalima	Jyoti
0	106	85	77	74
80	102	83	74	72
160	141	104	120	126
240	137	106	118	126
P rate (kg/ha)				
0	119	92	96	98
22	120	93	96	99
44	125	95	99	99
66	124	97	100	102
K rate (kg/ha)				
0	116	92	96	93
50	124	92	95	97
100	125	100	100	105
150	122	93	97	102
C.D. 5% for N,P,K rates	8	7	7	7

Table-4. Contribution of N, P and K towards nutrient uptake by tubers in different cultivars

Nutrient	Percentage contribution			
	Badshah	Bahar	Lalima	Jyoti
(N uptake)				
N	75	86	91	91
P	1.1	0.8	0.2	0.9
K	1.2	2.1	0.4	0.6
(P uptake)				
N	80	72	83	86
P	0.8	3.2	2.4	3.5
K	2.2	3.7	0.2	0.1
(K uptake)				
N	72	56	83	87
P	1.8	1.6	0.6	0.4
K	3.1	4.8	0.7	2.6

Stimulating effect of N on the uptake of P & K

Effect of K on K uptake by tubers : Application of 50 kg K/ha increased K uptake of Badshah by 8 kg/ha whereas 100kg K/ha increased K uptake of Bahar, Lalima and Jyoti by 8, 4 and 12 kg/ha respectively (Table 3). The increase was significant in Jyoti only. The increase in K uptake was mainly the reflection of tuber yield. Application of 100kg K/ha increased tuber yield by 0.5, 1.0, 1.8 and 2.5 t/ha in Badshah, Bahar, Lalima and Jyoti respectively (8). The contribution of K to K uptake in Badshah Bahar, Lalima and Jyoti was 3.1, 4.8, 0.7 and 2.6%, (Table 4). K applications ranging from 0 to 150 kg K/ha did not increase tuber yield of any cultivar significantly (8) showing that exchangeable K status (130 ppm) was adequate for sustaining optimum growth of potato.

The results show that N application was more effective in increasing K uptake when compared with K application. The enhancing/stimulating effect of N on K uptake might be attributed to increased root growth exploiting a given volume of soil more thoroughly. In the short term experiments, ammonium has been reported to inhibit K absorption (1). But in the present field studies, ammonium appeared to have nitrified as the soil environment was conducive to nitrification. Thus, the amount of N was more important than its form in the present investigation.

The stimulating effect of N on the uptake of P and K was similar to the pattern of contribution of N to N uptake. N contributed 76, 85, 86 and 87% to tuber yield in Badshah, Bahar, Lalima and Jyoti, respectively. The values of N, P and K uptake were positively correlated with tuber yield (Table 5).

Table-5. Simple correlations between tuber nutrient uptake and tuber yield

Attribute	Cultivars			
	Badshah	Bahar	Lalima	Jyoti
N uptake	0.66	0.65	0.63	0.73
P uptake	0.61	0.63	0.60	0.69
K uptake	0.55	0.53	0.52	0.67

Number of observations in each cultivar = 64

The results show that the stimulating effect of N on P uptake was larger than the corresponding effect of N on K uptake. The differences in the effects are explicable in terms of P and K composition, N increased the composition of P from 0.20 to 0.25% but decreased that of K from 2.24 to 1.99%.

From the results, it can be concluded that the application of N not only increase N uptake but also stimulates the uptake of P and K to the extent that the stimulation surpasses the effects of P and K fertilization. The results have far reaching implications as they explain the reason of getting no response to P and K application.

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FIELD PERFORMANCE OF SEEDLING TUBERS IN THREE SUCCESSIVE CLONAL GENERATIONS

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Abstract : *Tuber yield of TPS families remained statistically similar in all three successive clonal generations. Compared to first clonal generation (C₁) the seed tubers of second (C₂) and third (C₃) generations of hybrid and open pollinated TPS families gave higher percentages of marketable size tubers. The results demonstrate that TPS families evaluated had maintained their potential productivity upto the third clonal generation.*

INTRODUCTION

The major constraints for potato production in the developing countries are the high cost and poor quality of seed tubers. To some extent, these problems could be solved using an alternate cheap method of potato production from the true potato seed (TPS). International Potato Center and its eight Regional Offices located in developing countries are collaborating with national/country programmes in conducting adaptability trials with true seed of improved TPS families under different agro-ecological zones. Extensive studies on the use of TPS as a propagule for potato production has clearly indicated that either TPS seedling transplants or first generation seedling tubers could be successfully used for the production of ware crop in South and South-East Asia including China (1, 2). However, a question has consistently been asked, in response to TPS technology transfer, as to the possibility of using successive generation produce from seedling tubers as planting material if the farmer could store part of produce as seed. The objective of this study was to determine the extent of yield reduction of seed tubers from successive clonal generations derived initially from true seed.

MATERIALS AND METHODS

Seedling tubers of three open pollinated, TPS-2, TPS-3, TPS-7 and two hybrid families HPS-4/3, HPS-7/III derived from true seed grown in beds during 1984-85 crop season were used as a planting material for three successive clonal generations. Field trials were conducted at Central Potato Research Station, Modipuram at an elevation of 237 metres AMSL located 29°4' N latitude and 77°46' E longitude.

First year seedling tubers (C₁) of 20-40g size and same size foundation seed tubers of local cv. Kufri Bahar as a control were used for the trials. In subsequent generations, the seed tuber size for both TPS families and Kufri Bahar was between 40-60g. Every year the crop was planted between 15-30 October and dehaulked after 90 days of planting. Trials were laid in a randomized block design with four replications. The replicate size was 4.8x4.0m having 60 and 20cm inter and intra row spacings, respectively. Preplanting application of NPK fertilizers were applied in lines at the rate of 75:80:100 kg/ha. Additional 75 kg/ha of nitrogen was applied at first earthing-up. Insecticides and fungicides were applied as per the recommendations of Central Potato Research Institute to the farmers. Total

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KEY WORDS : True Potato Seed (TPS); clonal generation, seedling tuber.

yield and marketable yield (fraction > 20g) were recorded at harvest. Statistical analysis of the data were carried out and Duncan's Multiple Range Test was used to compare treatment means.

RESULTS AND DISCUSSION

Intragenotypic differences for tuber yield in three consecutive crop seasons were non-significant, although the first year crop was grown from seedling tubers (C₁) of TPS families and foundation seed tubers of Kufri Bahar (Table 1). These results show that the yield potential of TPS families, both hybrid and open pollinated, remained unchanged upto the third clonal generation.

Table-1 : Yield (t/ha) of TPS families and cv Kufri Bahar in three successive clonal generations

Genotype Family	Seasons			CD at P=0.05
	1985-86 (F ₁ C ₁)	1986-87 (F ₁ C ₁)	1987-88 (F ₁ C ₃)	
TPS-2 (OP)	26.3 bc	26.6 bc	28.0 a	NS
TPS-3 (OP)	22.0 c	25.1 c	28.8 a	NS
TPS-7 (OP)	33.8 ab	28.7 abc	34.6 a	NS
HPS-4/3	27.2 bc	29.1 abc	34.1 a	NS
HPS-7/III	34.3 ab	33.2 a	33.6 a	NS
Kufri Bahar (cv)	39.9 ab	31.1 ab	31.0 a	NS

Duncan's Multiple Range Test at P = 0.05

NS = Non-significant.

The yield differences among the genotypes were statistically significant, except when the crop was grown from C₃ tubers (Table 1). During the first year, Kufri Bahar gave maximum yield of 39.9 t/ha followed by HPS-7/III (34.3 t/ha) and TPS-7 (OP) (33.8 t/ha). The differences among these three were not significant. In the second season, the hybrid TPS family HPS-4/3 also reached the same yield level as the above two TPS families and Kufri Bahar. Yield performance of TPS-3 (OP) was the poorest in the first two clonal generations. Overall, the performance of hybrid HPS-7/III and TPS-7 (OP) for tuber yield was as good as of Kufri Bahar in all the three years.

From three years yield data it seems that the hybrid TPS families had a superiority over open pollinated, although TPS-7 (OP) was exceptional in the present study. In general, the productivity level of crop raised from seedling tubers originating from TPS have been higher than local cultivars in many field evaluation trials conducted in India and several other countries (1, 2, 3).

Percentage yield of marketable size tuber (fraction > 20g) produced by open pollinated families, TPS-3 and TPS-7 in three clonal generations and Kufri Bahar were similar (Table 2), whereas the TPS families HPS-4/3, HPS-7/III and TPS-2 (OP) gave higher marketable yields in second and third generations compared to first. First year when first clonal seedling tubers were used as planting material,

Performance of clonal generations of seedling tubers

Kufri Bahar produced the highest marketable yield over all TPS families (Table 2). These differences were marginally narrowed down in second clonal generation and finally, in the third season the marketable yields of TPS families were similar to Kufri Bahar.

The data on the average tuber weights presented in table 3, similarly indicate that the average tuber size of all the TPS families improved during the subsequent clonal generations and except for TPS-3 (OP), all the TPS families produced same average size tubers as Kufri Bahar in the third year crop harvest.

Table-2 : Marketable Yield (%) of TPS families and cv Kufri Bahar in three successive clonal generations.

Genotype Family	Seasons			CD at P=0.05
	1985-86 (F ₁ C ₁)	1986-87 (F ₁ C ₂)	1987-88 (F ₁ C ₃)	
TPS-2 (OP)	80.2 b	89.0 ab	88.2 a	2.3
TPS-3 (OP)	81.8 b	85.2 b	87.4 a	NS
TPS-7 (OP)	82.9 b	86.9 ab	89.0 a	NS
HPS-4/3	82.0 b	85.1 b	89.6 a	4.0
HPS-7/III	79.4 b	89.3 ab	85.9 a	3.7
Kufri Bahar (cv)	92.0 a	91.7 a	89.1 a	NS

Duncan's Multiple Range Test at P = 0.05

NS = Non-significant.

Table 3 : Average tuber weight (g) of TPS families and cv Kufri Bahar in three successive clonal generations

TPS families	1985-86 (F ₁ C ₁)	1986-87 (F ₁ C ₂)	1987-88 (F ₁ C ₃)
TPS-2 (OP)	33.0	31.7 ab	37.7 a
TPS-3 (OP)	—	27.3 b	29.3 b
TPS-7 (OP)	—	28.3 b	32.0 ab
HPS-4/3	—	27.7 b	35.0 ab
HPS-7/III	—	29.0 b	30.3 b
K. Bahar	38.7	35.3 a	37.0 a

Duncan's Multiple Range Test P = 0.05

The data presented bring out the fact that the total yields and average tuber size of TPS families generally improves at least upto the third clonal generation reaching the level of a cultivar like Kufri Bahar. Therefore, it is evident that the farmers using TPS for potato production could save seed tubers

for planting the next crop till the third clonal generation in agro-ecological areas like mid-western Indo-Gangetic plains of India.

Present results clearly demonstrate that the seedling tubers derived from the true potato seeds remain potentially productive at least upto the third clonal generation.

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ROOTING CAPACITY AND VIGOUR IN RELATION TO SEED SIZE IN POTATOES

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Abstract : Tubers of two potato cultivars namely *Desiree* and *Kufri Jyoti* were categorised into two grades viz. small (8-12g) and seed size (40-45g) were pre-chitted and sprouted and were planted in sand supplemented with Hoaglands macro-nutrient medium at monthly interval to evaluate the impact of seed size on root characteristics. Non-destructive sampling for different observations were made at fortnightly intervals while destructive samplings was done at 30 days interval. From the results of intergrade comparison it was found that plants grown from the small size tubers (8-12g) were taller than those grown from other grades. The seed size tubers (40-45g) performed better than small size tubers in root length, root volume and total biomass.

INTRODUCTION

Among the various inputs required for the cultivation and optimal yield of the potato crop, seed tubers is the most costly input. Therefore, the major thrust now-a-days is to identify the appropriate size of seed tuber from which optimal and economical yield can be obtained. Experiments were conducted to evaluate the impact of seed size in relation to growth and developmental features of aerial plant parts (3,4) dormancy period (1,5.) However, the impact of various seed size tubers on the rooting potential has rarely been studied. Therefore, in the present study an attempt has been made to evaluate the impact of seed size on root characteristics using two potato cultivars.

MATERIAL AND METHODS

The experiment was laid out in October, 1986 using two potato cultivars namely, *Desiree* and *Kufri Jyoti*. The seed tubers of both the varieties were categorised into two grades viz. small (8-12g) and seed size (40-45g). The pre-chitted and sprouted tubers of each category were planted in porcelain pots of about 20cm inner diameter filled with acid washed sand. The plants were irrigated with ordinary tap water and the pots were supplemented twice with Hoaglands macro-nutrient medium at monthly interval. Five replications of each grade of seed tubers were maintained.

Non-destructive samplings for measurements of maximum shoot height, number of shoots per plant, maximum root length and root volume as well as destructive sampling for quantification of fresh and dry weight of stem, root, leaves and tubers were recorded. Non-destructive sampling for different observations were done at 15 days interval, while the destructive sampling was done at 30 days interval. The weight of the sample were record after drying the samples for 48 hrs in oven maintained at 70°C. Root volume was measured by water displacement method. In this case the roots were immersed in the beaker filled with water upto the brim. The water displaced by the immersion of the roots were collected and the volume measured. The leaf area was measured with portable leaf area meter (LI-

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COR, USA, LI3000). In this case, the fully expanded leaf was kept on conveyor belt and was allowed to pass through the electronic sensor. The reading on the display unit was recorded.

RESULTS AND DISCUSSION

The results obtained during the course of present investigation are presented in Table 1. It reveals that in both the cultivars the plants obtained from smaller size tubers (8-12g) were taller than those

Table-1 Impact of different seed sizes on various morphological parameters during different stages of growth

Character	DAP	Desiree Small	Seed size	CD (0.05)	Kufri Jyoti Small	Seed size	CD (0.05)
Root Volume (cc)	45	9.2(1.1)	10.4(1.4)	NS	8.1(0.4)	10.8(0.8)	3.8
	60	7.0(0.7)	10.0(0.7)	2.2	9.1(1.3)	10.6(0.8)	NS
	75	6.7(0.8)	10.1(0.7)	3.8	8.8(0.3)	11.5(0.7)	2.8
	90	7.1(0.9)	12.7(0.7)	4.1	10.6(1.6)	12.6(1.5)	NS
Number of shoots per tuber	45	1.2(0.2)	2.4(0.7)	NS	1.8(0.2)	2.8(0.6)	0.7
	60	1.2(0.2)	2.4(0.7)	NS	1.8(0.2)	2.6(0.5)	0.7
	75	1.2(0.2)	2.0(0.7)	NS	1.8(0.2)	2.8(0.5)	NS
	90	1.2(0.2)	2.4(0.7)	NS	1.8(0.2)	2.8(0.5)	0.9
Fresh weight root (g)	60	6.0(0.2)	8.9(1.2)	2.8	2.7(0.4)	5.8(2.1)	NS
	90	2.7(0.2)	6.2(0.5)	1.5	4.6(0.9)	7.2(1.1)	NS
Dry weight root (g)	60	0.2(0.1)	0.3(0.3)	0.1	0.1(0.2)	0.24(0.1)	NS
	90	0.26(0.4)	0.47(0.3)	0.2	0.57(0.1)	0.76(0.9)	NS
Fresh weight shoot (g)	60	8.15	8.31	NS	6.69	8.84	NS
	90	11.76	15.92	4.0	13.47	22.67	7.6
Dry weight shoot (g)	60	0.65	1.21	0.4	0.58	1.26	NS
	90	0.71	1.28	0.3	1.1	2.32	1.03
Total biomass (g)	60	0.65	1.21	NS	0.58	1.01	NS
	90	0.71	1.28	2.0	1.26	2.32	2.0

(Figures in parenthesis are SEM)

obtained from seed size (40-45g). The maximum plant height in all the cases were recorded at 90 DAP. In contrast to this, the number of stems produced per tuber were higher in seed size tubers as compared to small size tubers. In var. Desiree the number of stems produced by small tubers were 1.2 and those by seed tubers was 2.4.

The largest root length was obtained either at 45 or 60 DAP in both the cultivars. This may be on account of the fact that the active root growth continues upto 60-75 DAP and thereafter it slows down (6). Intergrade comparison reveals that the root penetration is not significantly affected by seed size. However, significant differences in root volume was observed between the two category of seed used. In var. Desiree the volume recorded in roots obtained from seed size tubers was 10.0 cc at 60 DAP whereas the root volume at same day was 7.0cc in small size tubers. Similar differences were also recorded at different developmental stages in both the cultivars.

Significant differences between the grades were also recorded for other parameters, such as fresh and dry weight of root, shoot and total biomass (Table 1). Fresh weight of roots obtained from small & seed size tubers are 5.16g and 8.96g respectively in var. Desiree at 60 DAP. Similarly, the values are 4.56g and 7.16g for roots obtained from respective grades in var. Kufri Jyoti at 90 DAP. A comparison of total leaf area of the plant shows that it increases with the increase in seed size. In var. Kufri Jyoti, the plants obtained from small size seeds shows a total leaf area of 339.29 sqcm which increases by 74.4% in seed size tubers. Similar increase are also evident in terms of total biomass and shoot dry weight. Therefore, from the foregoing account, it can be inferred that increasing seed size upto 40-45g, results in the production of more vigorous plants.

The most important question which still remains unanswered is that why the larger seed size tubers produces voluminous roots. It has been reported that the number of sprouts produced from the seed tubers are proportional to the seed size. Thus, the larger size seed tubers produce more sprouts. This relationship may be accounted for the tuber buds complete for a restricted supply of nutrition (2), which results in the suppression of sprouting of lateral buds. The results of the present investigation also reveals that the number of stems per tuber increases with the increase in the seed size. For instance, in var Kufri Jyoti the average number of the stems arising from small tubers are 1.8 and from seed size tubers are 2.8. Similar results were also obtained for var. Desiree.

If we compare the number of stems produced per tuber, against root characteristics, they have a direct relationship. In var. Desiree the number of stems produced per tuber are 1.2 and 2.4 in small and seed size tubers respectively, and the root volume at 60 DAP in corresponding grades are 7.0 and 10.0 cc. If the root volume is calculated per stem basis, the results will be 5.8 and 4.2 cc respectively. Similarly, in var. Kufri Jyoti at 45 DAP will be 4.5 and 4.15 in small and seed size tubers respectively. This illustrates that the increase in the root volume is because of the increase in the number of stem per tuber. Similar results were also obtained in respect of other parameters viz. root dry weight, shoot dry weight, total biomass etc.

From the present experiment it can be concluded that quantitative increase in root parameters on increasing seed size (upto 40-45g) is due to the sprouting and development of more buds per tuber. However, the endogenous factors which control the production of more shoots still remains to be investigated.

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POPULATION BUILD UP OF APHID VECTORS IN POTATO IN EASTERN U.P.

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Abstract : *Aphid surveys conducted in Eastern Uttar Pradesh during the crop seasons 1982-83 to 1986-87 reveal that Aphis gossypii Glov. usually appears in the third week of November and reaches critical level in December end or first week of January, while the principal vector Myzus persicae (Sulzer) appears in the third week of December and reaches critical level by the end of the third week of January. These studies indicated that if haulms cutting is delayed farmers can get higher yields of quality seed potatoes.*

INTRODUCTION

The disease free potato seed produced in U.P. is insufficient to meet the entire requirement of this big state which presently producing 48% of total potato production of the country. The area under seed potato crop in eastern U.P. can be increased by identifying the pockets having longer aphid free period to meet the requirement of seed potatoes of that area. The practice so far is to cut the haulms in the first week or before 10th of January as per blanket recommendations of Seed Certification Agency of U.P. which adversely effected the late potato crop in this tract. Preliminary observations made during the crop seasons 80-81 and 81-82 revealed that the appearance and build up of the principal vector, *M. persicae* is late in this region. Keeping this information and farmer's concern in view regular aphid surveys were initiated during crop season 1982-83 and were continued till 1986-87.

The purpose of undertaking these studies was to see the aphid species associated with potato crop in this region, their time of appearance and crossing of critical levels i.e., 20 aphids/100 compound leaves, in order to determine the appropriate time of haulms cutting in seed crop.

MATERIALS AND METHODS

Weekly aphid counts were made on potato crop at the farm and also in the nearby areas of Faizabad in farmer's fields from November to February by counting aphids on randomly selected 34 plants (100 compound leaves) following the method suggested by Simpson¹

RESULTS AND DISCUSSION

Two aphid species viz., *A. gossypii* and *M. persicae* were observed colonising on potato crop. The weekly recorded data are being summarised in Table 1.

The data presented in table 1 reveal that *A. gossypii* usually appears earlier i.e. in third week of November and reaches critical level (20 aphid/100 compound leaves) either in the end of December or in the first week of January. However, principal vector of potato viruses, *M. persicae* appears slightly late (third week of December) and usually reaches critical level by the end of third week or in the fourth week of January. The average weekly temperature during the period of studies varied between 9.07° to 30.35° C and R.H. between 80.0-88.3 per cent. Though both the aphids have been reported

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Table-1 : Population of *Myzus persicae* and *Aphis gossypii* per 100 leaves on potato crop

Month	1982-83		1983-84		1984-85		1985-86		1986-87		Average of 5 years (1982-83 to 1986-87)		Temperature (°C) (average of 5 years)		R.H. % (average of 5 years)
	A	B	A	B	A	B	A	B	A	B	A	B	Minimum	Maximum	
Nov.	I	0	0	0	0	0	0	0	0	0	0	0	14.07	30.35	86.6
	II	0	0	0	0	0	0	0	0	0	0	0	12.97	29.67	85.4
	III	0	0	0	2	0	1	0	0	0	0	0.6	12.92	28.92	88.3
	IV	0	0	0	2	0	2	0	0	0	0	0.8	12.70	27.82	86.3
Dec.	I	0	0	0	3	0	6	0	0	6	0	3.0	11.85	26.60	86.0
	II	0	0	0	7	0	11	0	0	0	0	3.6	10.70	25.52	86.2
	III	0	0	3	11	2	16	0	5	0	1	6.4	10.42	25.17	85.4
	IV	6	7	5	23	2	26	2	18	1	3.2	19.2	10.40	23.37	86.5
Jan.	I	8	15	7	21	5	25	6	22	3	5.8	17.0	10.80	16.30	86.2
	II	10	18	8	25	10	46	12	28	9	9.8	25.4	9.40	21.40	86.2
	III	13	22	11	37	26	78	29	32	22	20.2	36.2	9.30	21.00	87.8
	IV	15	35	16	41	28	91	54	75	27	28.0	50.2	9.32	21.50	87.8
Feb.	I	25	38	23	56	58	111	96	102	42	47.6	64.2	9.07	22.97	87.6
	II	45	52	46	86	102	137	121	162	67	76.2	94.6	9.60	24.17	86.3
	III	90	63	83	102	172	120	153	202	102	120.0	105.8	10.37	25.40	84.0
	IV	98	40	102	53	188	128	220	166	173	156.2	88.6	11.20	25.87	84.3

A - *M. Persicae*B - *A. gossypii*

Build-up of aphid vectors in eastern U.P.

as efficient vectors of potato viruses viz. PVY and PLRV. However *M. persicae* has been established as more efficient vector than *A. gossypii* (Singh et al. 1982).²

Since *M. persicae* appears late and reaches critical level usually after 20th January in eastern U.P., hence haulms cutting in seed crop can be delayed by 10-15 days by adopting recommended package of practices for seed crop, which will facilitate proper bulking of tubers resulting in higher yields and better remuneration to the farmers. The information thus obtained has great significance in initiating potato seed production programme in this tract to meet the requirement of seed by the farmers for getting richer harvest.

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YIELD POTENTIAL AND STABILITY OF POTATO HYBRIDS IN NW PLAINS OF INDIA

G.S. Kang¹ and R.K. Bihman²

Abstract : *Thirteen advance generation promising potato hybrids along with Kufri Chandramukhi as control were evaluated for tuber yield at 60 and 90 days harvest for 3 consecutive seasons during 1982-83 to 1984-85 in N.W. plains. Wide genetic variability was observed among the genotypes for tuber yield at 90 days and for increase in tuber yield during 60 to 90 days period but the same was not true for tuber yield at 60 days. Genotype x environment interaction was significant for tuber yield at 60 and 90 days and increase in tuber yield during 60 to 90 days which altered the ranking of the genotypes in different years. The hybrids JI-5857, JI-1808 and JH-222 showed promise and hence can be utilized in potato improvement programme for the region.*

INTRODUCTION

In India, although, percent increase in potato production and productivity during 1950 to 1986 was 544% and 82% respectively, but the average yield (12.6 t/ha) is much lower than the developed countries (1). One of the main reasons for low productivity is the poor potential of the available cultivars (4). Therefore, enhancement of tuber yield by improving yield potential of hybrids/cultivars through breeding is vital for increasing production and productivity. Western Indo-Gangetic plains comprising of the state of Punjab and Haryana is an important potato growing area of the country both for production of ware and seed potatoes. Therefore, evolving improved potato cultivars suitable for cultivation in this region assumes significance. Development of high yielding cultivar is a continuous process, however, some promising hybrids have been identified for use in future breeding programme of the region.

MATERIALS AND METHODS

Two sets of advance generation promising hybrids (Table 1) developed at Central Potato Research Station, Jalandhar (Punjab) were assessed for tuber yield for 3 consecutive seasons (1982-83 to 1984-85) using Kufri Chandramukhi as control. Hybrids/cultivars were planted in two randomized block design with four replications in each of the seasons. Tubers were planted at a distance of 20 cm in rows 60 cm apart. Net plot size was 4.3 m² in 1982-83 and 2.88 m² in 1983-84 and 1984-85. Tuber yield was recorded after 60 and 90 days of planting over the replications.

Analysis of variance was done separately for different crop seasons. Pooled and stability analyses were done as suggested by Eberhart and Russell (2), Perkins and Jinks (6) and Gomej and Gomej (3). In pooled analysis environment (year) mean squares were tested against replication mean squares within environment; genotype mean squares were tested against genotype x environment mean squares; and genotype x environment mean squares were tested against error mean squares. The genotype x environment mean square was partitioned into linear (heterogeneity between regression-predictable) and non-linear (remainder-non predictable) components. The mean squares for both these components

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were tested against respective error mean squares. The regression and remainder mean squares of each genotype were tested against error mean squares and regression mean squares of each genotype was also tested against their respective remainder mean squares. Deviation of regression coefficient (bi) from unity was tested against its standard error.

RESULTS

1. Yield

1.1. 60 days harvest : The genotypes differed significantly in different years of assessment (Table 1) but no significant differences were observed amongst genotypes when the data over the years were pooled (Table 2). On pooled data basis, the genotype x environment interaction was significant (Table 2). The genotypes JF-547 and JI 5857 were the highest yielders in set I & II respectively on the basis of mean over the years.

1.2. 90 days harvest : Except for set I during 1982-83, genotypes differed significantly in all the three years but the pooled data (Table 1, 2) revealed significant genotype x environment interactions (Table 2). In set II also, mean yield of genotypes in different years differed significantly (Table 2). Genotypes JI 1808 and JI 5857 had the highest mean yield over the years in set I and II respectively.

1.3. Increase in yield : The genotypes differed significantly in all the three years and also on pooled basis. In set I, mean yield in 3 years differed significantly. The genotype x environment interaction was significant for genotypes in set I only (Table 1, 2). Genotypes JI 1804 and JI 5857 registered highest yield increase during 60-90 days period in set I and II respectively.

2. Stability analysis

The genotypes exhibited significant interaction with years for all the traits studied except yield increase in set II (Table 2). Both linear and non linear components were significant for yield at 90 days in set I and for yield at 60 days in set II. This indicated that both predictable and non predictable components constituted the presently observed genotype x environment (year) interaction. While, for yield at 90 days in set II, only linear component was significant, only non linear components were significant for yield at 60 days and for yield increase in set I. The significance of mean squares for linear component against error MSS for yield at 90 days in set I and II and yield at 60 days in set II showed that regression co-efficients for different genotypes differed amongst themselves for these traits. Since each genotype is unique in exhibiting a specific set of traits, therefore, these were tested, analysed and presented for genotypes and traits (Table 3).

2.1. 60 days harvest : Regression coefficients were significant for three genotypes viz. FR/B 10, JG 657, JF 547 (Table 3). For five genotypes namely JG 657, JG 1334, JI 1804, JF 547 and JI 1808, the deviation from regression was significant and G x E interaction was non significant for JG 224.

Table-I : Yield Performance of Potato Hybrids (set I), Yield (q/ha)

Hybrid/cultivar	60 days				90 days				Increase from 60 to 90 days			
	1982-83	1983-84	1984-85	Mean	1982-83	1983-84	1984-85	Mean	1982-83	1983-84	1984-85	Mean*
FR/B 10	228	201	174	201	300	307	314	307	72	107	141	107 (53)
JG 657	232	184	168	195	319	286	332	312	87	102	164	118 (61)
JP 547	221	260	206	229	368	332	289	330	152	72	83	102 (45)
JG 224	193	175	185	184	326	294	331	317	133	120	146	133 (72)
JG 1334	221	175	202	200	332	287	390	336	101	112	187	134 (69)
J1 1804	121	188	162	157	358	365	315	346	236	177	154	189 (120)
J1 1808	183	236	198	206	369	367	409	382	186	131	211	176 (85)
K.CM	205	191	160	185	265	260	262	262	60	69	101	77 (41)
Mean	200	201	182	195	329	313	330	324	128	111	148	
LSD (0.05)	41	36	25		NS	40	38		68	40	NS	

Table-I : Yield Performance of Potato Hybrids (set II), Yield (q/ha)

Hybrid/cultivar	60 days				90 days				Increase from 60 to 90 days			
	1982-83	1983-84	1984-85	Mean	1982-83	1983-84	1984-85	Mean	1982-83	1983-84	1984-85	Mean*
JP 5106	184	188	208	194	369	344	384	366	185	155	175	172 (89)
J1 5857	231	215	209	219	428	401	416	415	198	186	207	196 (93)
EM/H 1601	204	232	219	218	346	341	332	340	142	109	113	122 (56)
JH 222	211	106	175	164	425	282	329	345	214	176	154	181 (110)
JP 4864	180	185	157	174	358	334	331	341	178	149	174	167 (95)
E 4486	215	205	194	204	410	361	348	373	195	156	155	169 (82)
K.CM	203	176	150	177	282	260	217	253	79	84	65	77 (43)
Mean	204	187	188	193	374	331	337	337	170	145	149	
LSD (0.05)	31	47	32		70	44	43		61	51	51	

* Value in Parenthesis is percent yield increase over yield at 60 days.

Table 2 : Pooled analysis of variance for tuber yield at 60 and 90 days and yield increase during 60-90 days period.

Source of variation	Mean sum of squares (MSS)							
	SET-I				SET-II			
	DF	60 days	90 days	Yield increase	DF	60 days	90 days	Yield increase
Environments (Years)	2	3896	3178	11039++	2	2671	6096++	4936
Replications with environments	9	1416	874	453	9	785	831	1230
Genotypes	7	5125	14272 ^{aa}	17022 ^a	6	5762	29119 ^{aa}	20555 ^{aa}
Genotype x environment	14	2700**	3270**	4717**	12	2486	5569**	791
Heterogeneity between regression	7	1160	2970*	2682	6	2770**	9335** ^b	752
Remainder	7	4241**	3564**	6753**	6	1887*	1803	830
Pooled error	63	553	1280	1306	54	632	1319	

++ Significant against replications within environment MS at P=0.01

* and ** Significant against pooled error MS at P=0.05 and P=0.01 respectively

a and aa Significant against genotype x environment MS at P=0.05 and P=0.01 respectively.

b Significant against remainder MS at P=0.05

In set II, only one genotype JH 222 exhibited significant linear and non-linear components. For K. Chandramukhi, only linear component was significant and rest of the genotypes had non-significant G x E interaction.

2.2. 90 days harvest : Only one genotype JG 1334 had both linear and non linear components significant, while 3 genotypes namely JH 222, JF 4864 and E 4486 had only linear component significant while for JF 547 only non linear component was significant.

2.3. Yield increase : Only linear components was significant for genotypes JG 657, JG 1334, JI 1808 and JH 222, whereas only non linear component was significant for genotypes FR/B 10, JF 547 and JI 1804. For rest of the genotypes, G x E interaction was non significant indicating that for this trait, the genotypes fall into three distinct categories.

DISCUSSION

For north-western indo-gangetic plains, two types of varieties are needed : (i) those with reasonable yield potential at 60 days and (ii) main season varieties giving high yield at 90 days. It will be ideal to have a genotype with good yielding capacity at both the 60 and 90 days after planting. If such a genotype is not available, then, one having high yield increase during 60-90 days period can be used in combination with a genotype having high yield at 60 day to evolve a desirable one with high production and productivity.

Although JF 547 and JI 5857 gave highest yields in set I and II respectively at 60 days, significant differences were not detected among genotypes for this trait (Table 1, 2). Hence there is a need to diversify the genetic base for improvement in this trait.

The genotypes JI 1808 and JI 5857 gave highest yields at 90 days in set I and II respectively. JF 547 also yielded reasonably good (Table 1). Hence in order of preference, hybrids JI 5857, JI 1808 and JF 547 are promising for tuber yield both at 60 and 90 days.

For yield increase during 60-90 days period, the hybrids JI 1804 and JI 5857 were the best followed by JH 222 and JI 1808. But yield increase *per se* is not a useful trait for breeding purpose and percent increase over yield at 60 days is a more dependable criterion for selecting genotypes. For this character, JI 1804 and JH 222 are most promising followed by JF 4864 and JI 5857.

The stability, defined as the ability of a genotype to avoid substantial fluctuations over a range of environments, is a breeding objective that has been difficult to achieve so far. It is due to the genotype x environment (G x E) interaction. Hence, its determination is essential for evaluation of stable genotypes that could be used reliably for commercial cultivation or in breeding programmes.

Of the genotypes found to be promising for yield potential at 60 days, JF 547 exhibited significant S^2_{di} and hence is unstable. While JI 5857, in addition to being above average responsive had non significant S^2_{di} . Another promising genotype EM/H 1601 had negative response but stable in performance thereby indicating its suitability for low productive environments.

Table-3 : Stability parameters of genotypes

Genotypes	60 days				90 days				Yield increase			
	M	bi	S ² di	M	M	bi	S ² di	M	M	bi	S ² di	
Set I												
FR/B 10	201	2.07**	1150	307	307	0.01	-837	106	106	0.99	5651*	
JG 657	195	1.95*	4141**	312	312	2.26	-933	117	117	1.76*	3758	
JF 547	229	1.89*	2248*	330	330	-0.27	11224**	101	101	0.20	13339*	
JG 224	184	-0.08	-18	317	317	1.97	-1192	133	133	0.70	-1189	
JG 1334	200	-0.30	3524**	336	336	4.27**	5134*	134	134	2.11**	4232	
JL 1804	157	-0.23	8666**	346	346	-1.66	2363	189	189	-0.74	11883**	
JL 1808	206	0.76	4808**	382	382	1.29	1894	176	176	2.11**	-390	
KCM	185	1.94	-151	262	262	0.13	-1178	77	77	0.87	378	
Set II												
JF 5106	194	-0.77	210	366	366	0.43	1725	172	172	0.98	-767	
JL 5857	219	1.10	-553	415	415	0.84	-1029-	196	196	0.13	-464	
EM/H 1601	218	-1.30	-380	340	340	0.34	-981	122	122	1.39	-1314	
JH 222	164	4.37**	7983**	345	345	4.83**	56	181	181	1.99**	526	
JF 4864	174	0.43	854	341	341	-2.92**	-1100	167	167	0.82	-419	
E 4486	204	0.89	-371	373	373	2.05*	-281	169	169	1.64	-1196	
KCM	177	2.29*	950	253	253	1.43	3684	76	76	0.03	-653	

* $P < 0.05$

** $P < 0.01$

Of the three genotypes JI 1808, JI 5857 and JF 547 promising for yield at 90 days, JF 547 has significant S^2_{di} and hence is unstable. The remaining two genotypes have non-significant S^2_{di} and are responsive to good environments.

Out of 4 promising genotypes for yield increase during 60-90 days period, two genotypes namely JI 1808 and JH 222 have non significant S^2_{di} and above average response. Although JI 5857 exhibited non significant S^2_{di} but had negative response. Genotype JI 1804 has significant S^2_{di} and hence unstable. In addition to the genotypes identified above, it is possible to isolate more in a breeding programme with better stability traits since mean performance, responsiveness and deviation from regression are under the control of separate genetic systems (5, 6). Such promising genotypes are FR/B 10, E 4486 and Kufri Chandramukhi for yield at 60 days; JH 222 and E 4486 for yield at 90 days and JG 657, JG 1334 and JH 222 for yield increase during 60-90 days period.

From the above discussion, that considered yield potential, responsiveness and phenotypic stability, it is inferred that genotypes having promise are JI 5857 for commercial cultivation as 60 and 90 days variety and for yield increase, JI 1808 for yield at 90 days and for yield increase and JH 222 for yield increase. Besides these, others which can be profitably used as parents in breeding programme for the region are FR/B 10, E 4486, Kufri Chandramukhi, JG 657 and JG 1334.

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EFFICACY OF HERBICIDES FOR WEED CONTROL IN POTATO IN MEGHALAYA HILLS *

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Abstract : *In field trials at Central Potato Research Station, Shillong (Meghalaya) in summer seasons of 1978-80, all the herbicides and manual weed control measures reduced the weed population and drymatter accumulation of monocot and dicot weeds and gave higher yields than unweeded control. Among the herbicides metribuzin at 0.7 kg/ha as pre-emergence was most effective against weeds and gave maximum weed control efficiency followed by paraquat at 0.5 kg as post-emergence and alachlor at 1.5 kg and nitrofen at 1.0 kg/ha as pre-emergence. Uncontrolled weeds reduced the tuber yield by 12.7 to 26.6 per cent in different years.*

INTRODUCTION

Potato (*Solanum tuberosum* L.) a major crop of Meghalaya is infested with many grassy and broad leaf weeds which cause considerable reduction in its yield. Wider spacing, frequent rains and liberal use of manures and fertilizers in potato cultivation provide favourable conditions for the luxuriant weed growth particularly during early stages of crop growth. The age old practice of controlling weeds by physical methods although effective, are time consuming and cause damage to root system. Some times non-availability of labourers and continuous rains may not permit the mechanical operations. Under these situations herbicides offer a bright scope for weed control in potato under different agro-climatic conditions but the information is lacking under the high rainfall areas of Meghalaya. Keeping in view the present investigation was undertaken to evaluate the efficacy of different herbicides for weed control in potato in the hills of Meghalaya.

MATERIALS AND METHODS

Field experiments were conducted at Central Potato Research Station, Shillong, Meghalaya (1800m above MSL) in three summer seasons of 1978-80. The climate of the region is humid temperate. The average rainfall was 2250 mm and mean monthly temperature varied between 10°C to 20°C.

The experiment was laid out in randomised block design replicated four times. A basal dose consisting of 100kg N, 66kg P and 42kg K/ha was applied in furrows in the form of ammonium sulphate, single superphosphate and muriate of potash, respectively at the time of planting. Medium sized tubers (35-45g) of cv. Kufri Jyoti were planted at 50cm inter and 20cm intra-row spacing on 28th March, 2nd April and 26th March during 1978, 1979 and 1980, respectively. The lifting of the crop was done on 30th June, 1978, 12th July, 1979 and 11th July, 1980. The details of treatments are given in Table 1.

Fluchloralin was applied as pre-planting and incorporated into the upper 3-4cm soil layer before making the ridges. Paraquat was sprayed at about 5 per cent emergence of potato plants and propanil at 3-4 leaf stage of weeds as post-emergence. All other herbicides were applied as pre-emergence within 3-4 days after planting.

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Table-1 : Weed biomass production and weed control efficiency in different treatments.

Treatments/herbicides	Dose Kg/ha	Dry weight of weeds (g/ha)						Weed control efficiency (%)		
		1978		1979		1980				
		Monocot	Dicot	Monocot	Dicot	Monocot	Dicot			
Weedy check (control)	—	21.4	3.5	16.8	4.0	13.8	2.8	17.3	3.4	—
One hand weeding	—	6.1	0.9	2.9	0.4	—	—	4.5	0.6	77.7
One hand weeding + earthing up	—	3.5	0.8	2.7	0.3	2.5	0.4	2.9	0.5	83.6
Alachlor	1.5	9.5	1.2	4.0	0.4	4.6	0.6	6.0	0.7	67.6
Ametryn	1.5	14.4	1.8	6.8	0.7	7.0	1.0	9.4	1.2	48.8
Fluchloralin	0.7	14.0	2.2	5.5	0.7	6.2	0.9	8.6	1.3	52.2
Linuron	0.5	13.2	1.4	10.4	1.0	8.2	1.2	10.6	1.2	43.0
Methabenzthiazuron	1.5	—	—	6.8	0.8	6.9	1.0	6.8	0.9	58.8
Metribuzin	0.7	4.9	0.7	2.3	0.6	4.2	0.6	4.0	0.6	77.8
Nitrofen	1.0	8.2	1.4	4.8	0.6	5.4	1.2	6.1	1.1	65.2
Paraquat	0.5	5.3	1.3	3.2	0.5	5.3	1.0	4.6	0.9	73.4
Propanil	0.9	11.6	1.4	4.4	0.7	6.6	1.0	7.5	1.0	58.9
Prometryn	1.5	11.2	2.0	6.2	1.0	8.4	1.2	8.6	1.4	51.7
CD at 5%		5.4	0.8	1.9	0.5	2.0	0.5	—	—	—

Number and dry weight of monocot and dicot weeds were recorded from two locations in each plot using a quadrat of 50 x 50cm at 40 days after planting and at harvest. Weed control efficiency (WCE) of each treatment was calculated by using the formula :

$$WCE = \frac{WDWC - WDWT}{WDWC} \times 100 \quad \text{where } WDWC = \text{Weed dry weight in weedy check, and}$$

$WDWT = \text{Weed dry weight in treatment}$

RESULTS AND DISCUSSION

Weed intensity : Important weed species recorded in the experimental plots were *Digitaria adscedens*, *Setaria glauca* and *Echinochloa species* among the monocots and *Spergula arvensis*, *Oxalis corniculata*, *Polygonum alatum*, *P. cordata*, and *Galinsnga purviflora* among the dicots. The intensity of weeds recorded at 40 days after planting and at maturity was maximum in weedy check plots and all the herbicides and manual weed control measures reduced the weed population significantly over control in all the years. (Table-1). Metribuzin at 0.7kg/ha, alachlor at 1.5kg/ha, nitrofen at 1.0 kg/ha as pre emergence and paraquat at 0.5 kg/ha as post-emergence were found most effective in minimising weed population than other herbicides. Among the cultural treatments weed population was lower where one hand weeding + earthing up were given as compared with one hand weeding alone. In general weed population was more in 1978 than other years.

Weed biomass production and weed control efficiency : All the herbicides and manual weed control measures significantly reduced the dry matter production of monocot and dicot weeds during all the years (Table 1). Metribuzin resulted in maximum weed control and thus showed the lowest dry weight of weeds which was closely followed by paraquat, alachlor and nitrofen. Lowest weed control efficiency was observed with linuron followed by ametryn, prometryn and fluchloralin. The favourable effect of pre-emergence application of metribuzin was due to its prolonged presistence in the soil which resulted weed free situation throughout the crop growth period. Similar results were also reported by Randhawa and Sandhu (2), Hooda *et al.* (1) and Singh *et al.* (3). One hand weeding + earthing up treatment recorded 83.6% weed control efficiency, while one hand weeding registered 77.7% weed control efficiency.

Tuber yield : The herbicides did not show any visual phytotoxic effect on the crop except a low degree of phytotoxicity (chlorosis in the leaves) was observed with paraquat but the plants recovered within 4-5 days after its application.

Uncontrolled weeds reduced the tuber yield by 12.7 to 26.6% in different years. Metribuzin recorded the highest yield (except in 1978) followed by alachlor, paraquat and nitrofen. The increased yield following these herbicides were obtained on account of poor weed population and growth in these treatments, which were not sufficient to compete with the crop plants for different growth factors. The results of Randhawa and Sandhu (2), Hooda *et al.* (1) and Singh *et al.* (3) also indicated the suitability of metribuzin, alachlor, nitrofen and paraquat for weed control in potato under different agro-climatic conditions. Linuron gave the lowest yield followed by prometryn and ametryn, confirming the results

of Verma and Grewal (4). Among the cultural treatments one hand weeding + earthing up gave more yield than one weeding alone in the year of heavy weed infestation (1978), and were at par during 1979. The tuber yield of potato were poor during 1978 due to severe damage of crop by late blight disease.

These results indicated that metribuzin at 0.7kg/ha, alachlor at 1.5kg/ha, nitrofen at 1.0kg/ha as pre-emergence and paraquat at 0.5kg/ha as post-emergence showed good promise for weed control in potato under agro-climatic conditions of Meghalaya.

Table-2 Effect of different herbicides on tuber yield of potato.

Treatments/herbicides	Dose kg/ha	Tuber yield (q/ha)		
		1978	1979	1980
Weedy check (control)	—	121	224	192
One hand weeding	—	143	271	—
One hand weeding + earthing up	—	164	272	214
Alachlor	1.5	147	275	217
Ametryn	1.5	132	267	195
Fluchloralin	0.7	139	261	200
Linuron	0.5	128	248	193
Methabenzthiazuron	1.5	—	257	198
Metribuzin	0.7	132	281	220
Nitrofen	1.0	148	268	204
Paraquat	0.5	160	274	216
Propanil	0.9	146	270	202
Prometryn	1.5	132	261	194
CD at 5%		20	29	15

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CONTROL OF BACTERIAL WILT OF POTATOES BY AGRONOMIC PRACTICES *

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Abstract : Agronomic practices like use of seed potato from disease free area, blind earthing, stable bleaching powder application @ 12 kg/ha in soil at planting, early planting and early harvesting and control of weeds by paraquat and summer/winter ploughing were tested for their efficacy in controlling bacterial wilt and brown rot of potato caused by *Pseudomonas solanacearum* at seven locations representing six agroclimatic zones of India. At Deesa and Chhindwara seed contributed 100% primary inoculum and the disease was controlled completely by use of disease free seed.

At Shillong, Bhowali, Ranchi, Kalyani and Bhubaneswar 50-75% of primary inoculum came through seed tubers produced in wilt infested areas and 25-50% from other sources like native vegetation. Wilt and brown rot incidence was reduced by 50-100% (70-100% at most places) and 50-85% by disease free seed + bleaching powder application mixed with fertilizer at planting + blind earthing. Ploughing the land after harvest of potato crop and exposing the soil to winter temperatures in hills and summer temperatures in plains reduced wilt and brown rot by 50-83% and 50-70% at Ranchi, Shillong and Bhowali, by 78-100% and by 50-82% at Kalyani. Early planting by third week of June in hills reduced bacterial wilt by 71-83% and brown rot by 71-86%. The above treatments increased emergence as well as yield and have been recommended for control of the disease.

INTRODUCTION

Bacterial wilt and brown rot of potatoes caused by *Pseudomonas solanacearum* is the second important disease of potato in India after late blight. The disease is prevalent in North western mid hills, eastern hills, plateau and plains and parts of Deccan and Central Plateau. It causes losses in the range of 4-55% (7,9). The disease has also rendered these areas unfit for seed potato production. Since no source of host resistance was found stable under Indian conditions a programme was undertaken to identify agronomic practices to control the disease. The results obtained earlier (8, 9) were further tested in multilocal trials under All India Coordinated Potato Improvement Project. This paper reports the results and conclusions of these trials.

MATERIALS AND METHODS

The trials were conducted at seven locations in six agroclimatic zones (Table 1). Fields showing maximum wilt incidence in the locality were selected. The trials were laid out in RBD with four replications. The plot size was 6.0 x 2.0m² (10 rows of 10 plants) gross and 4.8 x 1.6m² (8 rows of 8 plants) net. A wilt susceptible cultivar Kufri Jyoti was used and planted at 60x20 cm spacing. The fertilizer doses and irrigation schedules were as recommended for the locality. The following seven treatments were tested.

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Table-1 : Details of Locations where Agronomic Practices were Tested for Control of Bacterial Wilt and Brown Rot of Potato

Location	Latitude & Longitude	Zone	Soil		Mean daily temperatures (°C)						Rainfall (mm)	
			Type	PH	April to May Max. Min.	Highest Max.	Dec. to Feb. Max Min.	Lowest Min.	April to May	Dec. to Feb.		
Shillong (Meghalaya)	25°34'N 91°53'E	North eastern hills	Red and Yellow	5.5 to 6.5	23-24 14-17	26-28	19-22	4.5-6.4	0.3-1.4	1006.4	50	
Bhowali (Kumon Hills, UP)	29°28'N 79°39'E	North western hills	Brown hill	5.5 to 6.5	26-30 16-19	28-30	15-17	3-4	-1 to -2	84.4	136.8	
Ranchi (Bihar)	23°23 'N 85°20' E	Eastern Plateau	Red and Yellow	4.0 to 5.8	34-38 21-24	40-41.5 (10%)	23-26	10-12	5-7.6	72.5	66.7	
Kalyani (West Bengal)	22°32 'N 88°20 'E	North Eastern Plains	Sand Loam	5.5 to 6.5	36-36.3 25-27	39.7-40.1 (10%)	27-29.5	14-16.5	10-11.5	184.4	41.2	
Bhubaneshwar	20°48 'N 85°56 'E	North Eastern Plains	Red Loam	3.8 to 6.0	38.3-38.8 25-27	42-43.5 (10%)	28.5-31.5	15.5-18.2	12-14	98.8	43.6	
Deesa (Gujarat)	24°12 'N 79° 'E	Western Plains	Sand Loam	7.8 to 8.0	39.2-41.3 21.6-27.2	43.1-44.6 (30%)	28-32	10-12	6-6.8	0.2	2.0	
Chhindwara (Madhya Pradesh)	22°6 'N 79° E	Central Plateau	Black Sandy Loam		36.4-39.5 22-25	40-42.1 (30%)	25.5-29.0	10-13	5.6-7.2	25.8	27.5	

* Figures in parenthesis give frequency of occurrence of highest maximum temperatures.

T₁ = Planting seed from bacterial wilt free areas. T₂ = T₁ + full earthing at planting (blind earthing). T₃ = T₁ + Bleaching powder application @ 12 kg/ha. The bleaching powder (SHRIRAM KLORICIN) was obtained from M/s DCM Chemical Works, 18 Barakhamba Road, New Delhi. It was mixed with fertilizer and applied in furrows just before planting. T₄ = T₃ + blind earthing. T₅ = T₁ + Winter/summer ploughing. The soil was ploughed twice with a mould board plough in March end in plains and left exposed to summer heat upto June and in September-October in hills and left exposed to winter cold upto February. T₆ = Paraquat as weedicide at Kalyani, Deesa, Chhindwara, Bhubaneshwar, and early planting (third week of February) and early harvesting (third week of June) at Bhowali, Shillong and Ranchi. T₇ = Apparently healthy seed tubers from diseased crop (local seed). The observations recorded were : Plant emergence at weekly intervals after planting; wilt incidence at 30 days intervals, brown rot incidence in tubers at harvest and total yield in quintals per hectare.

RESULTS

The results of the trials locationwise are given in Table 2 and 3 and are discussed below:

Bhowali (North Western Hills) : During three years of trials, the agronomic practices were found to reduce the wilt by 50-83% and brown rot by 40-91% and increased the yield significantly over control (table 2). Use of disease free seed + early planting and early harvesting gave the maximum reduction in both wilt and brown rot i.e. 80-81% and 76-91% during different years. The next best treatment was use of disease free seed + winter ploughing which reduced wilt by 68-83% and brown rot by 47-74%. Use of disease free seed + bleaching powder application + blind earthing was the third best treatment. The use of disease free seed alone reduced wilt by 51-63% and brown rot by 40-71%.

Shillong (North Eastern Hills) : The results of three years showed that all the agronomic practices were effective in controlling wilt by 50-81% and brown rot by 40-84% (Table 2). The best treatments were use of disease free seed with early planting and early harvesting or application of bleaching powder + blind earthing. These treatments reduced wilt by 75-81% and brown rot by 42-84%. Winter ploughing reduced wilt by 53-58% and brown rot by 42-84%.

Ranchi (Eastern Plateau) : The two years data (Table 3) showed that the agronomic practices reduced wilt incidence by 70-100% and brown rot by 35-82%. The best treatments were of disease free seed + bleaching powder application with or without blind earthing which controlled wilt by 92-100% and brown rot by 82%. Summer ploughing and weed control by paraquat reduced wilt by 81-100% and brown rot by 71%.

Kalyani (West Bengal) : Only wilt incidence and yield in various treatments were reported. All the agronomic practices significantly reduced wilt incidence and increased the yield. The best treatments were use of disease free seed + blind earthing + application of bleaching powder and use of disease free seed + summer ploughing. Both the treatments reduced wilt incidence by 80-100%. The yields were higher by 62-79 q/ha in these treatments over control showing that losses due to tuber rot were significantly reduced (Table 3).

Table-2 : Effect of Agronomic practices on Potato Bacterial wilt and brown rot and tuber yield in hills of India.

Location	Treatment	1986-87				1987-88				1988-89		
		Wilt (%)	BR (%)	Yield (q/ha)	E	Wilt (%)	BR (%)	Yield (q/ha)	E	Wilt (%)	BR (%)	Yield (q/ha)
Bhowali (Uttar Pradesh) Western Hills	T1	14	20	138	—	17	10	278	—	20	17	239
	T2	13	18	151	—	17	8	327	—	23	12	323
	T3	13	16	169	—	18	10	290	—	23	14	281
	T4	13	14	177	—	17	6	298	—	20	10	258
	T5	6	9	194	—	9	3	338	—	8	4	329
	T6	10	20	139	—	8	9	338	—	12	12	301
	T7	32	38	128	—	46	35	222	—	41	28	230
	SE	3	2	18	—	4	3	10	—	5	3	19
	CD (0.05%)	5	4	37	—	8	5	43	—	2	5	42
Shillong, Meghalaya Eastern Hills	T1	0	—	—	94	4	16	109	94	14	19	142
	T2	0	—	—	95	9	12	120	94	14	32	120
	T3	10	—	—	93	33	22	85	95	18	38	102
	T4	12	—	—	91	4	10	135	97	12	12	157
	T5	11	—	—	90	6	10	178	94	10	11	187
	T6	—	—	—	87	10	7	137	93	20	12	48
	T7	24	—	—	87	21	61	162	94	47	19	54
	SE	2	—	—	55	4	3	20	2	4	5	29
	CD (0.05%)	3	—	—	88	2	7	21	4	9	7	61

E = Percent emergence, BR = Percent tuber infection, T1 = Seed from bacterial wilt free area, T2 = T1 + blind earthing, T3 = T1 + Bleaching powder 12 kg/ha, T4 = T3 + full earthing at planting, T5 = T1 + early planting and early harvesting, T6 = T1 + winter ploughing, T7 = Apparently healthy seed from bacterial wilt infested crop, — = Not reported

Table-3 : Effect of Agronomic Practices on potato Bacterial Wilt and Brown Rot and Tuber Yield in Plains and Central and Eastern Plateau of India

Location	Treatment	1986-87				1987-88				1988-89		
		Wilt (%)	BR (%)	Yield (q/ha)	E	Wilt (%)	BR (%)	Yield (q/ha)	E	Wilt (%)	BR (%)	Yield (q/ha)
Ranchi (Bihar) Eastern Plateau	T1	—	—	—	—	1	—	68	95	8	21	132
	T2	—	—	—	—	0	—	20	94	3	8	129
	T3	—	—	—	—	0	—	68	93	2	5	132
	T4	—	—	—	—	0	—	71	94	2	5	127
	T5	—	—	—	—	1	—	65	93	5	8	134

Control of bacterial wilt of potatoes

Contd. Table 3

	T6	—	—	—	—	0	—	19	95	4	8	128
	T7	—	—	—	—	8	—	61	93	26	28	130
	SE	—	—	—	—	2	—	7	1	1	2	5
	CD (0.05%)	—	—	—	—	3	—	13	2	2	2	10
Kalyani (West Bengal) Eastern Plains	T1	0	—	283	82	1	—	296	96	8	—	296
	T2	0	—	278	82	1	—	295	97	7	—	307
	T3	0	—	297	82	2	—	291	96	7	—	313
	T4	0	—	291	82	1	—	294	98	4	—	318
	T5	0	—	278	83	1	—	279	96	4	—	305
	T6	0	—	273	83	3	—	282	96	8	—	300
	T7	3	—	216	83	12	—	232	94	18	—	240
	SE	1	—	25	1	1	—	20	0	1	—	10
	CD (0.05%)	2	—	49	2	2	—	42	1	2	—	20
Bubanes- war (Orissa) Eastern Plains	T1	—	12	127	76	25	—	98	—	—	—	—
	T2	—	12	112	80	16	—	108	—	—	—	—
	T3	—	9	96	79	8	—	118	—	—	—	—
	T4	—	11	102	82	5	—	134	—	—	—	—
	T5	—	15	104	79	28	—	95	—	—	—	—
	T6	—	—	—	80	19	—	103	—	—	—	—
	T7	—	22	104	82	45	—	76	—	—	—	—
	SE	—	1	30	2	3	—	21	—	—	—	—
	CD (0.05%)	—	1	36	3	4	—	43	—	—	—	—
Chhindwara (Madhya Pradesh) Central Plateau	T1	—	—	—	100	0	0	309	95	0	0	295
	T2	—	—	—	95	0.4	0	304	93	0	0	295
	T3	—	—	—	100	0	0	329	96	0	0	343
	T4	—	—	—	95	0	0	316	96	0	0	306
	T5	—	—	—	100	0.6	0	278	95	0	0	260
	T6	—	—	—	100	1.1	0	309	96	0	0	288
	T7	—	—	—	95	6.2	0	267	93	6	0	241
	SE	—	—	—	3	1	0	22	3	1	0	20
	CD (0.05%)	—	—	—	5	2	0	44	6	2	0	43
Deesa (Gujarat) Western Plains	T1	0	0	375	98	0	0	334	97	0	0	206
	T2	0	0	424	98	0	0	334	98	0	0	211
	T3	0	0	396	98	0	0	337	98	0	0	212
	T4	0	0	375	98	0	0	345	96	0	0	208
	T5	0	0	409	98	0	0	351	99	0	0	228
	T6	0	0	401	98	0	0	346	95	0	0	229
	T7	10	12	314	95	9	10	293	91	8	12	170

Contd. Table 3

SE	2	1	22	1	2	1	20	1	1	1	21
CD (0.05%)	4	3	45	3	3	3	43	22	3	2	44

E = Percent emergence, BR = Brown rot. T1 = Seed from wilt free area, T2 = T1 + blind earthing, T3 = T1 + Bleaching powder 12kg/ha, T4 = T3 + blind earthing, T5 = T1 + summer ploughing, T6 = T1 + paraquat as weedicide, T7 = Apparently healthy seed from wilt infested crop, — = Not reported.

Bhubaneshwar (Orissa) : The two years data show that the best disease control was achieved by use of healthy seed + application of bleaching powder and/or by use of healthy seed + blind earthing up + application of bleaching powder. The wilt incidence and brown rot were reduced by 60-90% and 31-59% respectively (Table 3).

Chhindwara (Madhya Pradesh) : The trial was conducted for two years. During both the years all the cultural practices reduced wilt incidence by 83-100% and tuber rot by 100% and increased the yield significantly over the control (Table 3). Use of disease free seed alone or combined with soil application of bleaching powder were the best treatments as they controlled the disease completely and increased the yield by 42-102 q/ha.

Deesa (Gujarat) : All the cultural practices were effective in controlling the disease and increasing the yield by 41-110 q/ha (Table 3). Even use of disease free seed alone gave 100% control of the disease. The data conclusively prove that the disease can be controlled completely by use of healthy seed alone. The disease occurs only when local seed is used. The results thus also show that the pathogen does not survive in soil and the only source of inoculum is the seed tubers.

Temperature, rainfall and vegetation in relation to disease control : The disease could be controlled completely by agronomic practices at Deesa and Chhindwara where during April and May the highest maximum temperatures were above 40°C with 30% frequency of occurrence and the rainfall was below 26 mm (Table 1). The disease could be controlled by use of disease free seed alone, shows that the pathogen does not survive in field soils or native vegetation at these two locations. At Kalyani, Bhubaneshwar and Ranchi where the highest maximum temperatures of above 40°C occurred with only 10% frequency and also the rainfall was in the range of 72-184 mm during April-May, the use of disease free seed had to be combined with bleaching powder application, summer ploughing and blind earthing to get good disease control. The healthy seed alone could reduce the disease at these locations by about 50-75% only. It is, therefore, apparent that 50-75% primary inoculum comes through seed and the remaining 25-50% from other sources. The weedicide paraquat was superior to use of disease free seed alone at Ranchi and Bhubaneshwar thereby showing that weeds do contribute the primary inoculum. The rainfall at these places ranged 72-184 mm during April-May which is adequate to support weeds which might harbour the pathogen.

In hills, both at Bhowali and Shillong early planting and early harvesting consistently gave the best disease control probably due to low temperatures (10.6-21°C) prevailing upto May (Fig. 1). The winter

ploughing was the second best treatment at Bhowali where the lowest minimum temperatures during December-February were below 0°C. It was much inferior at Shillong where the lowest minimum temperatures were above 0°C (0.3-1.4°C).

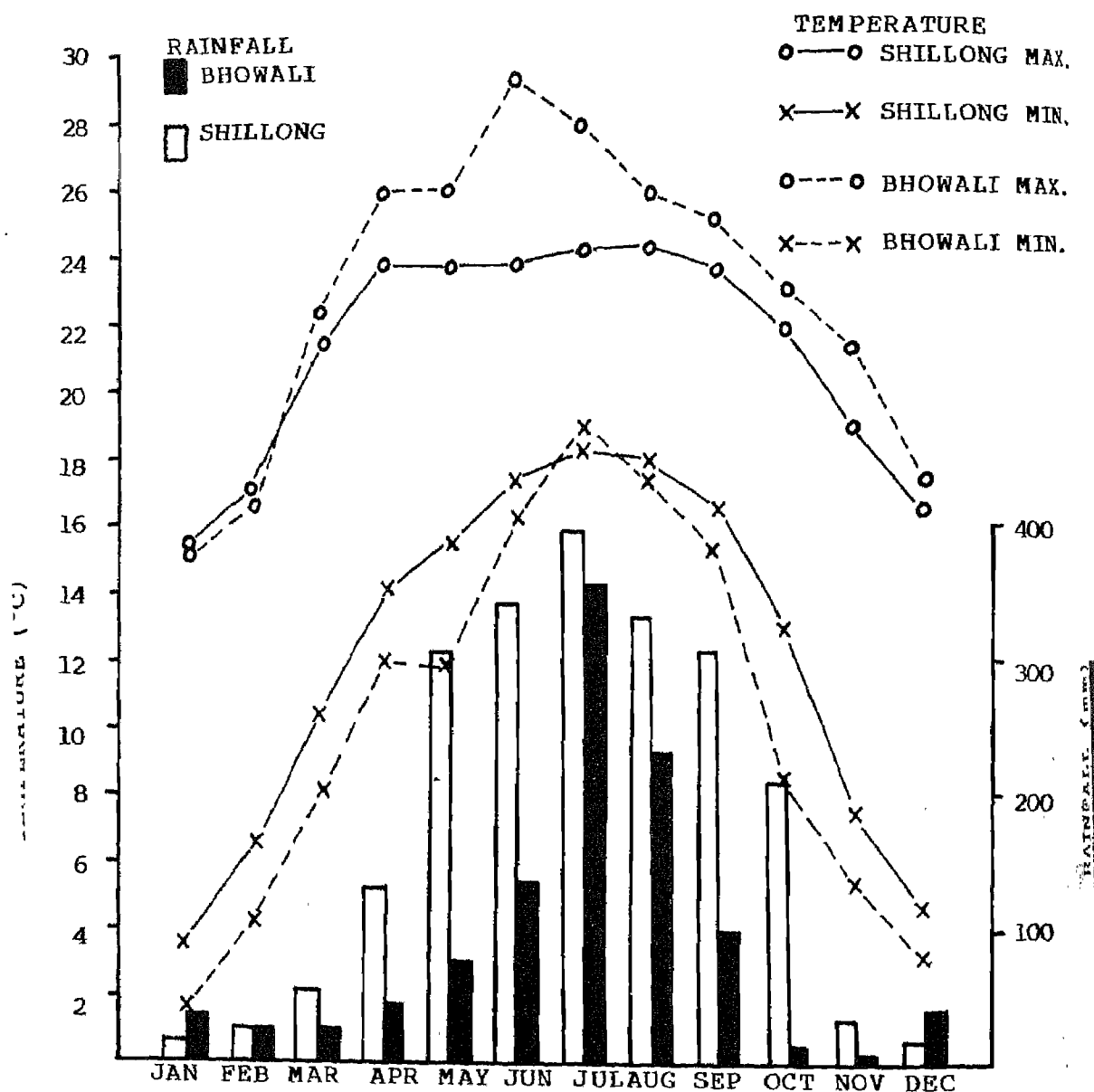


Fig.1. Mean monthly minimum and maximum temperatures and monthly rainfall at Bhowali and Shillong.

CONCLUSIONS AND DISCUSSION

The results of trials at seven centres representing six agroclimatic zones conclusively prove that, in both hills and plains bacterial wilt and tuber rot incidence were reduced by 50-100% (70-100% at most places), when disease free seed was used for planting + stable bleaching powder was applied @ 12 kg/ha mixed with fertilizer at planting + blind earthing up is done. Ploughing the land after harvest of potato crop and exposing the soil to winter temperatures in hills and summer temperatures in plains reduced bacterial wilt and tuber rot by 50-83% and 50-70% at Ranchi, Shillong and Bhowali by 50-100% and 50-82 at Kalyani and by 82-100% at Deesa and Chhindwara. Early planting by third week of February and harvesting by third week of June reduces bacterial wilt by 71-83% and brown rot by 71-86%.

The treatments increased the yield and did not affect emergence adversely. These results of multilocal trials confirm the earlier findings (8, 9). Based on the above results it was recommended (2), "for control of bacterial wilt and brown rot the seed tubers should be obtained from a bacterial wilt and brown rot free crop preferably from areas free from the disease. Stable bleaching powder @ 12 kg/ha should be mixed with fertilizer and applied at planting in furrows. Earthing up should be done immediately after planting. After harvesting potato crop the field should be ploughed in plains in March and left exposed to summer temperatures during April and May and in hills in September-October and left exposed to winter temperatures during December and January. In hills and Ranchi plateau, early planting (latest by third week of February) and early harvesting (latest by third week of June) should be adopted".

The results further show that the only source of primary inoculum at Deesa and Chhindwara is the seed tubers. Thus the disease can be eradicated from these areas by following the agronomic practices recommended above and subsequently ensuring supply of seed from disease free areas. In fact these areas can produce their own seed once the disease has been eradicated and a phid free periods are identified.

At locations other than Deesa and Chhindwara included in this study, 50-75% primary inoculum comes through seed alone. The other possible sources of primary inoculum are soil, plant debris, other hosts and symptomless carrier plants. The survival of the pathogen in pure soil phase is rather poor (1, 5, 10). There is mounting evidence that long term survival is dependent on native vegetation (4, 12). Therefore, the remaining 25 to 50% inoculum most likely comes through host/symptomless carrier plants and their root remnants in deeper soil layers (3). In hills the left over infected tubers in field do not rot during winter and might harbour the pathogen. Thus, in these areas better control of the disease can be achieved by combining the agronomic practices, field sanitation and rotations with crop like maize, wheat, finger millet, sorghum, pearl millet, cabbage, cauliflower, knol-khol, carrot, beetroot, onion and garlic (6,10,11). Work should be taken up to identify weeds or crop plants which harbour the pathogen in these areas so that proper measures can be taken to control such weeds and to avoid such crops in rotation with potatoes.

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MORTALITY OF POTATO SEEDLINGS AND ITS CONTROL*

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Abstract : Extensive mortality of potato seedlings raised from true potato seeds was observed at the Central Potato Research Station, Moudpuram, Meerut. Main cause of the seedling mortality was found to be *Fusarium, oxysporum* f. sp. *tuberosi*, Schlecht. although high soil temperature were also associated to some extent. Amongst three set of fungicide treatments, combination of seed + soil treatment gave the maximum control of seedling mortality followed by soil treatment alone (respectively 26.5 and 30.7% mortality). Seed treatment with fungicides was least effective (59.4% mortality as against 70% in untreated control). As for individual fungicide treatment, combination of seed + soil treatment with Benlate gave the maximum control (16.9% mortality) indicating that Benlate is the most suitable fungicide for controlling seedling mortality.

INTRODUCTION

Selection of potato cultivars for central plains of India is done at the Central Potato Research Station, Modipuram, Meerut (U.P.). Several thousands of seedlings are raised from true seeds every year out of which, a sizeable number dies, the cause of which was not known. The process of raising seedlings starts in the end of September when the soil temperatures are very high (mean temperature 25.6°C) and it was believed that high soil temperature are solely responsible for seedling mortality. However, mortality was also observed in seedlings raised as late as 4th week of October when the soil temperature were not so high. It indicated that beside soil temperature other factor(s) are also associated with seedling mortality. Present paper reports on the possible causes of seedling mortality and its control.

MATERIALS AND METHODS

Fungus isolation and Pathogenicity : Small bits were cut from the infected stem portion of the potato seedlings, processed as per standard practice, plated on P.D.A. and incubated at $25 \pm 1^\circ\text{C}$ for five days.

Earthen pans (45 cm diameter) were sterilized by methylated spirit and filled with sterilized mixture containing soil, sand and farm yard manure in 50:25:25 ratio. Soil mixture was infested with one week old fungus culture grown on P.D.A. (10 PDA plates/pan) and 2-3 leaf stage seedlings were transplanted in it. After 15 days of transplanting soil was again drenched with fungal spore suspension (1.5 lac/ml). Control earthen pans were maintained simultaneously.

Transplanting time in relation to seedling mortality : Wooden boxes (40x25cm) filled with infested and uninfested (sterilized) soil separately were used for raising the seedlings. Infested soil was prepared by mixing soil with *F. oxysporum* culture grown on sand-maize medium in 10:1 ration. Fifty potato seedlings were transplanted in each box on four different dates viz. 13, 28 September, 13 and 28 October. Two boxes each of infested and sterilized soil were used at each transplanting.

Chemical control : Benlate, Bavistin, Aretan-6 and Vitavax were evaluated as seed and soil treatments as follows :

* Part of the Ph.D. thesis submitted by the senior author.

1. Central Potato Research Institute, Shimla 2. A.M.U. Aligarh 3. Vegepro, Food and Feed Ltd., Orai (U.P.)

Mortality of potato seedlings and control

1. Soil treatment with Bavistin and Benlate separately @ 20cc of 250 ppm solution/bag.
2. Seed treatment with i) Bavistin (100 ppm), ii) Benlate (100 ppm), iii) Vitavax (100 ppm) and iv) Aretan-6 (1000 ppm) individually for 30 minutes.
3. Soil treatment with Bavistin + seed treatment with i) Bavistin, ii) Benlate, iii) Vitavax and iv) Aretan-6 as in treatments 1 and 2.
4. Soil treatment with Benlate + seed treatment with i) Bavistin ii) Benlate, iii) Vitavax and iv) Aretan-6 as in treatments 1 and 2.

Untreated seeds and soil served as control. In all 100 seeds were used in each treatment. Soil drenching was undertaken just before the transplanting of seedlings. After fungicide treatment, the seeds were washed in sterilized water and allowed them to germinate. One seedling was transplanted to each polythene bag containing *F. oxysporum* infested soil.

RESULTS AND DISCUSSION

Identification of the pathogen : Within 3-5 days of planting, the fungus started growing out of the infected stem bits. Fungus colonies were initially white which turned radish brown generally with a purple tinge in later stages. Micro- and macro-conidia were abundantly present. The macroconidia measured $9 \times 3 \mu$ to $45 \times 5 \mu$. Chlamydospores were both intercalary as well as terminal, with smooth walls. The isolate was identified as *Fusarium oxysporum* Schlecht. (IMI No. 246008) at C.M.I., Kew, England.

In Pans inoculated with *F. oxysporum*, typical damping off symptoms (Fig. 1) appeared in the seedlings after 20-25 days of transplanting and the fungus reisolated whereas in sterilized soil no seedling mortality was observed (Fig. 2). It indicates that *F. oxysporum* is responsible for seedling mortality. *Fusarium* spp. have been reported to cause dry rot of potatoes in storage (3, 4), Wilt of potato (6) and damping off in various crops (2). However, damping off of potato seedlings raised from botanical seeds has so far not been reported.

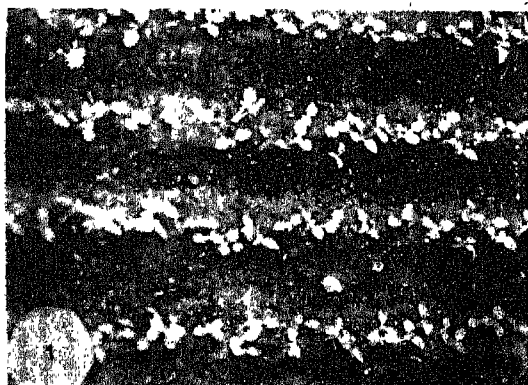


Fig. 1 : Uninoculated soil (Control) showing healthy seedlings.

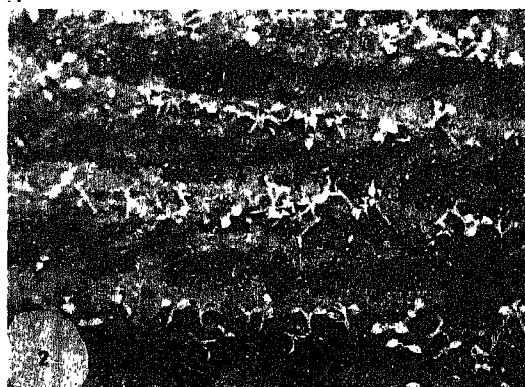


Fig. 2 : Soil artificially inoculated with *Fusarium oxysporum* showing damping off of seedlings.

Table-1 : Relationship of sowing time with seedling mortality

Sowing time	Soil temperatures ($^{\circ}\text{C}$)			Seedling mortality	
	Maximum	Minimum	Mean	Sterilized soil	Unsterilized soil
13 September	32.1	22.6	27.3	20.6	43.4
28 September	35.1	18.0	26.5	19.2	38.8
13 October	33.4	18.5	25.4	18.0	35.6
28 October	32.0	14.0	23.0	4.5	21.9
Mean -				15.57	34.92
SE $\pm$ for sowing time				2.46	
CD (0.05) „ „				5.76	
SE $\pm$ for soil				5.2	
CD (0.05) „ „				12.19	

Table-2 : Effectiveness of different systemic and organomercurial fungicides for the control of damping off in potato seedlings

Chemicals	Seedling mortality (degrees)
Soil Treatment -	
Bavistin	31.1
Benlate	30.4
Seed treatment -	
Bavistin	49.2
Benlate	53.6
Vitavax	70.2
Emisan-6	68.1
Soil treatment with Bavistin +	
Seed treatment with -	
Bavistin	30.3
Benlate	26.6
Vitavax	37.1
Emisan-6	31.3
Soil treatment with Benlate +	
Seed treatment with -	
Bavistin	19.5
Benlate	19.6
Vitavax	19.9
Emisan-6	30.8
Control	70.3
SE $\pm$	8.18
C.D. (0.05)	16.68

Relationship between transplanting time and seedling mortality : The mortality was more (43.5%) in seedlings transplanted on 13th September when the soil temperatures were high (27.3°C) but it gradually decreased with the delay in transplanting (Table 1). It indicates that seedling mortality gets aggravated at high soil temperature which is in confirmity with, i) behaviour of *F. oxysporum* which grows better at high temperature (1) and ii) Fusarium wilt of potato which also gets aggravated at high soil temperature (5). Seedling mortality was also observed in sterilized soil. Mortality was high in early transplanted seedlings which decreased with each subsequent transplanting. Seedlings transplanted on 28th October showed very low mortality rate (4.5%; Table-1). From these results it is concluded that high soil temperatures alone may also cause seedling mortality but in nature combination of both *F. oxysporum* and high soil temperature are responsible for large scale mortality of potato seedlings.

Effect of fungicides on seedling mortality : Although, all the three treatments with fungicides viz. soil, seed and soil + seed treatment reduced the seedling mortality over untreated control but combination of soil + seed treatment was better over other treatments (DI being 30.7, 59.4 and 26.5% in soil, seed and soil+seed treatments as against 70% in untreated control). Amongst soil treatments, both Bavistin and Benlate were equally effective. As for seed treatment, Bavistin and Benlate were effective to some extent (DI being 49.2 and 53.6%) but Vitavax and Aretan-6 were totally ineffective (Table 2). Amongst combination of soil + seed treatments, soil application with Benlate and seed dressing with Benlate was the best (DI, 16.9%). It may therefore be concluded from these results that Benlate is the best fungicide for controlling potato seedling mortality and that preferably both seed and soil should be treated with this fungicide to get maximum control.

ACKNOWLEDGEMENT

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SHORT NOTE

**POPULATION TREND OF *MYZUS PERSICAE* SULZER ON
DIFFERENT STAGES OF POTATO CROP IN KARNATAKA***

T.P. Trivedi¹ and K.D. Verma²

Green peach aphid *Myzus persicae* Sulzer is the major vector of potato viruses. It is prevalent throughout the crop season in Bangalore, Kolar and Belgaum. Potato crop is grown from July to Sept. and October to April. The effect of plant growth and leaf stage on build up of aphid was described by Taylor (3). He found that older leaves were much preferred by aphids. The similar results were found by Kennedy *et al* (1, 2) in case of *Aphis gossypii* on sugarbeet. The influence of potato plant phenology on population of *M. persicae* on long and short duration varieties was studied by Jansson *et al.* (4). He found that peak population reached 8 days earlier in short duration than long duration cultivars.

The present study is aimed to know the preference of various stages of potato crop by *M. persicae* in the field conditions and its trend of population build up in such areas where aphids were found throughout the period.

Five potato fields of different dates of plantings were selected for aphid monitoring at G.K.V.K. in the campus of University of Agricultural Science, Bangalore. Cultural operations were similar in all the fields. Crop was planted from middle of November to end of December. Aphid count was recorded from germination to harvest on eleven randomly selected plants from three patches of each field. Population count was taken on upper, middle and lower leaf of each plant. Aphid data recorded on third week of January on all the five stages of crop simultaneously was subjected to analysis of variance. The initial data was transformed (x+1) and its log value before doing the analysis of variance.

The result showed that aphid population was significantly different on 27, 38, 50 and 63 days crop but there was no significant difference in 63 and 69 day old crop (Table 1). It was found nil on 27 days crop and highest on 69 days old crop. The occurrence of alatae aphid was first recorded, 12/100 leaves in first week of December in oldest set of crop which climbed highest, 323/100 leaves in 4th week of January where as aphid population was nil on 27 days old crop at the same time. This clearly showed that stage of crop and leaf has definite role on landing, settling and population build up of aphids on potato in this region. The similar trend was observed in Belgaum and Kolar. This was concluded that stage of crop plays important role in such areas where number of potato crops were grown in the same season.

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2. Central Potato Research Station, Modipuram, Meerut, U.P.

Table-1. Pupulation of *M. persicae* in different stages of potato crop

Stage of crop as on 24.1.1985 (days)	Average aphid population*
69	2.48 ^a (323.3)
63	2.10 ^a (125.6)
50	1.25 ^b (17.0)
38	0.66 ^c (6.0)
27	0.00 ^d (00)
C.D. at 5%	0.50
S.E.m ($\pm$)	0.15

* Log (X + 1) values

Figures in brackets are detransformed values.

Treatment means followed by the same alphabet are not statistically different.

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SHORT NOTE

USE OF MERISTEM-TIP CULTURE FOR PRODUCING VIRUS-FREE POTATOES

M.J. Hossain, A.L. Khan and M.M. Rashid¹

Meristem-tip culture (8, 11, 14, 17) and heat treatment (7, 10) have been used for producing virus-free potatoes. The techniques are not always successful although it can be improved by combining these two factors together (5, 12, 16).

Yield of potato in Bangladesh is very low, ranging from 9-15 tons/ha, due to heavy virus infections (1). This low yield may be increased by producing virus-free plants via meristem-tip culture. The study, therefore, undertaken for producing virus-free potato plants via meristem-tip culture and heat treatment and to observe their field performance.

Ten local, viz. Bograi, Lalshil, Deshisada, Assamisada, Lalita, Dohazarilal, Dohazarisada, Jhaubilati, Shilbilati and Lalpakri and one exotic (Patrones) cultivars of potato were used in this study. Plants of the cultivars were grown in 230 x 200 mm plastic pots in the insect proof net house. Virus infection was insured by different testing methods described by Rashid *et al.* (18). 50% of the infected plants were subjected to heat treatment for 30 days at 36°C for 16 hrs and at 30°C for 8 hrs daily. Sterilisation of plant materials, excision of axillary bud-tips and their culture on MS(1962) media and their *in vitro* multiplication were done following the method described by Espinoza *et al.* (3). Developed *in vitro* plantlets were tested as stated previously. Only the disease-free plantlets were transferred from test tube to soil in the insect proof net house for studying their field performance. The soil type, plantlets transplantation and their after care were done as already reported by Hossain (6).

The percentage of culture viability decreased as a function of heat treatment although the differences between treated and untreated samples were not appreciable. However, of 566 excised meristems from heat treated plants, 424 (74.9%) grew and developed into rooted plantlets whereas it was 412 (76.5%) out of 538 for the untreated samples (Table 1). Our results of culture survival are in agreement with the findings reported by Dhingra and Sangar (2) and Pennazio and Redolfi (15).

About 49% plantlets originating from heat treated meristems of the local cultivars were found free of viruses while it was only about 7% for untreated samples (Table 1). Even a 100% progeny of the cvs. Deshisada, Lalita and Dohazarilal remained infected when meristems sampled from untreated plants. About 92% and 20% virus-free plantlets were obtained from the treated and untreated samples respectively in the exotic cv. Patrones. Our results are found in close relation with the findings reported by Stace-Smith and Mellor (19); MacDonald (9); Dhingra and Sangar (2).

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Table-1 : Performance of plantlets of some potato cultivars derived through meristem culture *in vitro* and *in vivo* conditions.

Cultivars	No. of excised	In vitro		In vivo						
		% of viable culture	% of virus-free plantlets	Av. height of plants (cm)	No. of branches/plant	No. of leaves/plant	Length of each compound leaf (cm)	Fresh wt./plant (g)	Yield per plant (g)	Yield increase over control (%)
Bogra	44/52*	68.2/88.5	53.3/6.5	178	69	350	12	4748	0	
Lalshil	49/34	77.6/67.6	44.7/8.7	202	81	402	15	4589	0	
Deshisada	53/65	73.6/72.3	51.3/0	173	81	463	14	4500	0	
Assamisada	62/51	62.9/76.5	53.8/7.7	193	75	385	11	5032	0	
Lalita	59/49	71.2/77.6	45.2/0	179	78	385	11	4690	0	
Dohazarilal	58/65	79.3/70.8	58.7/0	210	95	495	13	4998	0	
Dohazarisada	69/47	76.8/83.0	49.1/2.6	181	89	500	10	5250	0	
Jhaubilati	55/61	83.6/73.8	41.3/11.1	207	65	473	9	5213	0	
Shilbilati	52/59	80.7/76.3	30.9/4/4	193	75	462	14	4892	0	
Lalpakri	65/55	75.4/78.2	59.2/9.3	197	80	397	15	5122	0	
Mean	56.6/53.8	74.9/76.5	48.8/7.19	191.3	78.8	437.5	12.4	4903.4	0	
Plant derived from infected tuber				57	14	53	7	328	321	
Patrones	61/50	78.7/77.5	91.7/19.5	86	6	22	19	503	917	41.08
Plant derived from infected tuber				66	5	17	15	401	650	

* Numerators designate meristems subjected to heat treatment before sampling; denominators, the untreated meristems

The virus-free *in vitro* plantlets of the local cultivars did not produce any tuber when transferred in the soil whereas plants of the same cultivars grown from the infected tubers produced many small tubers. The virus-free plants produced numerous stolons and fibrous roots. The stolons were very long, 30 to 50 cm, and most of them came out of the soil and converted into effective stems without bearing any tubers.

In the field the *in vitro* plantlets themselves showed some abrupt morphological changes. The plants became upto 210 cm tall and very bushy while the average height of plant grown from infected tuber was about 57 cm (Table 1). The number of leaves and branches per healthy plant varied from 350 to 500 and from 65 to 95 respectively. While that for infected plant were from 40 to 65 and from 10 to 17 respectively. Fresh weight of a plant was recorded as much as 5250 g as compared to tuber grown infected plants, 250 to 400 g. Length of each compound leaf was also increased from 6-9 cm in infected plants to 9-15 cm in healthy plants.

Productivity of the cv. Patrones was increased by 41.08% over the infected plants as a result of freeing from viruses (Table 1). This result is supported by findings of Gregorini and Lorenzi (4), who developed virus-free plants of one Italian local cv. San Michele to obtain 67% higher yield than that of infected stocks. Morphological characters like, height, number and length of leaves, etc. have also been improved.

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SHORT NOTE

EFFECT OF ASCORBIC ACID ON POTATO YIELD

V.N. Banerjee and Rakesh Bhargava¹

Ascorbic acid (AA) is an important constituent of plant redox-system. It has been reported by many workers that ascorbic acid plays a significant role in the ontogenic development of plants viz. growth, development and yield (1-3, 6, 7). In potato also, it has been reported that spraying the crop with AA enhances the quality, as well as the yield of tubers (5, 8).

The present experiment was conducted to evaluate the efficacy of AA on seed tuber treatment under long day conditions in the hills.

The experiment was conducted during 1978 crop season at Shimla (Kufri). Seed sized tubers of variety Kufri Jyoti (40-60 g) were given dip treatment in ascorbic acid (G.R. Sarabhai, M. Chemicals) solution (100 ppm) for 6 hrs. The tubers, after treatment were taken out of the solution and air dried under shade for two days and subsequently, planted in the field at a spacing of 60 x 25 cm along with water dipped tubers as control with the gross plot size of 3.75m x 3.0m having 19 replications each. Recommended agronomic and cultural practices were adopted. The crop was harvested at maturity and the tuber yield of each plot was recorded. The differences in yield between treated and untreated (control) treatments were statistically analysed.

The results obtained are presented in Table 1. It can be seen that the average yield in the control and treated plots was 2.86 kg/m² and 2.97 kg/m² respectively. Thus, the experimental results revealed that the potato yield increase significantly over control as a result of ascorbic acid dip treatment. The present experimental findings are in agreement with those obtained by Choudhari *et al* (5) and Mehta *et al* (8). The reason for the increased yield with ascorbic acid treatment could be explained in two ways, i) the ascorbic acid brings about rapid conversion of the auxin precursors into active auxins, which results in cell wall extension and ii) this extension process initiates more water uptake by the plant cells and ultimately adds to the tuber yield (10, 13). This auxin balancing property of ascorbic acid has also been shown by Tonzig (14). Another plausible explanation which has been advanced is that the exogenous application of ascorbic acid brings about stimulation of plant metabolism which results in increased plant growth (1). This stimulation may be on account of induction of enzymatic activity as shown by Saxena *et al* (11). Moreover, since it is also known that ascorbic acid can form free radical (FR) (9, 15) and these free radicals are involved in the process of energy transfer in biological systems (4, 12).

It has also been suggested that the exogenous application of ascorbic acid enhances the level of energy through the formation of free radicals (FR) and charge-transfer-complex (CTC) with

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macromolecules (11) which accelerates the rate of mobilization of photosynthates produced into the tubers thereby increasing the potato yield.

Table-1 : Effect of ascorbic acid treatment on tuber yield.

Treatments	Mean yield (kg/m ²)
1. Water dip (control)	2.86
2. Ascorbic acid (Vit C) dip (100 ppm)	2.97
3. SEm $\pm$	0.03
4. CD (0.05)	0.09
CV (%)	4.52

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PREVALENCE AND DISTRIBUTION OF TUBER DISEASES OF SEED POTATOES IN WESTERN UTTAR PRADESH*

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The 'Seed Plot Technique (1, 2) and facilities of cold storage have motivated potato growers in Meerut region to produce seed potato on a large area. At present, nearly 25% of the total quantity of potatoes in 80 cold stores in this region accounts for seed (Personal communication from R.K. Sharma). This material, in fact, is supposed to be free from the tuber diseases i.e. foundation seed I, II and certified seed should not exceed 5% infected tubers in case of common scab and black scurf and 1% in late blight as per standard and limits approved in 1982-83. However, despite all precautions and selection, some tubers carry fungal and/or bacterial infections responsible for rotting during storage and poor and gappy emergence of the crop. Besides, under favourable conditions, the diseased tubers act as primary source of inoculum (3, 4). Since Meerut region is fast emerging as a seed belt in western Uttar Pradesh, it was deemed necessary to conduct a survey and check the health standards of the seed stocks. This note reports the incidence of common scab (*Streptomyces greuseus*), black scurf (*Rhizoctonia solani*) and late blight (*Phytophthora infestans*) recorded in samples from 617 seed stocks of commercial common varieties viz. Kufri Chandramukhi, Kufri Bahar, Kufri Badshah and some others produced in different areas and stored in 42 cold stores in Meerut region during 1985-87.

In Meerut district, a total of 302 seed samples of 100 tubers each, representing 56 localities stored in 25 cold stores were examined during 1985 and 1986 (September and October) before planting. In 1987, 119 samples produced in 17 localities and stored in 9 cold stores in district Bulandshahar and 196 samples brought from 26 areas kept in 18 cold stores in district Ghaziabad were also examined for the incidence of these diseases.

Observations in respect of common scab and black scurf were taken on i) % samples infected; ii) % disease incidence and iii) % disease index and in case of late blight only the first two factors were recorded. The disease index was calculated using 0-5 scale :

Grade	Rating	% affected tuber surface
0	0	Nil
1	5	up to 10%
2	15	10-20%
3	25	20-30%
4	40	30-50%
5	75	Above 50%

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Table-1: Incidence of tuber diseases of seed potatoes in Meerut region

District	Variety	Common scab			Black scurf			Late blight		
		% samples infected	% disease range	Incidence	% samples infected	% disease range	Incidence	% samples infected	% disease range	Incidence
Meerut *	Kufri Chandramukhi	43.6	2.0-42.8	0.1- 6.9	100.0	1.2-98.0	0.1-11.7	51.3	0.2-3.0	0.2-3.0
	Kufri Bahar	48.8	1.0-87.6	0.1- 27.1	98.1	1.0-93.0	0.1-10.2	39.5	1.0-3.0	1.0-3.0
	Kufri Badshah	62.2	1.0-54.0	0.1- 1.0	91.9	2.0-77.0	0.1- 5.7	41.0	1.0-2.0	1.0-2.0
	Others	36.4	2.0-3.0	0.1- 0.3	100.0	12.0-72.0	0.9- 8.2	72.7	1.0-3.0	1.0-3.0
Bulandshahr	Kufri Chandramukhi	66.7	2.0-22.0	0.1- 1.4	100.0	6.0-85.0	0.4-11.7	0.0	0.0	0.0
	Kufri Bahar	81.1	1.0-96.0	0.1- 9.8	84.2	2.0-98.0	0.1- 8.8	0.0	0.0	0.0
	Kufri Badshah	77.8	8.0-18.0	0.4- 1.1	10.0	12.0-18.0	1.0- 1.3	0.0	0.0	0.0
	Others	55.6	1.0-8.0	0.1- 9.8	100.0	2.0-82.0	0.1- 8.1	0.0	0.0	0.0
Ghaziabad	Kufri Chandramukhi	100.0	2.0-32.0	0.1- 3.3	100.0	11.0-30.0	0.9- 2.9	15.4	0.3-1.7	0.3-1.7
	Kufri Bahar	78.5	2.0-71.0	0.1- 7.2	88.6	2.0-73.0	0.1-12.9	41.7	0.1-1.0	0.1-1.0
	Kufri Badshah	58.6	2.0-23.0	0.1- 2.1	82.8	4.0-66.0	0.1-12.0	0.0	0.0	0.0
	Others	83.3	2.0-13.0	0.1- 1.1	100.0	14.0-41.0	1.0- 4.3	0.0	0.0	0.0

* Mean of two years data

$$\text{Disease index} = \frac{\text{Sum of No. of tubers} \times \text{disease grade}}{\text{Total No. of tubers examined}}$$

The incidence of common scab (Table 1) was observed in all the varieties, and 36.4 to 100.0% samples revealed symptoms. The disease incidence varied from 1.0 to 96.0% and the disease index ranged between 0 to 27%.

In case of black scurf, none of the variety was free, and 84.2 to 100% samples had the disease symptoms. The disease incidence was 1.0 to 98.0% and the disease index varied from 0 to 12.9%.

As regards the late blight, in district Meerut 39.5 to 72.7% seed stocks were found infected. The disease incidence range, however, was low (0.2 to 3.0%). In district Bulandshar, during 1987, late blight infected tubers were not observed and were only apparently free from symptoms in the samples. In Ghaziabad district, 15.4 to 41.7% samples were observed carrying disease with 0.1 to 1.7% disease incidence. In variety Kufri Badshah and others the tubers did not show disease symptoms.

The survey results indicate that the infections of these tuber diseases in seed stocks was alarming and the incidence was more or less similar as it has been in Punjab (5). Seed potato is a costly input and for profitable cultivation of this crop unless the diseased seed is given necessary treatment, the situation may cause serious threat to this development endeavour.

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SHORT NOTE MANAGING *FUSARIUM* WILT OF POTATO BY ADJUSTING DATE OF PLANTING*

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Surveys carried out in Meerut region of Uttar Pradesh revealed that *Fusarium* wilt caused by *Fusarium oxysporum* f. sp. *tuberosi* Schlecht. is one of the main soil borne disease of potato crop in that region. It's incidence was more (10 to 20%) in early planted crop as compared to crop planted late where it's incidence did not exceed 5 per cent (10). Management of this disease through chemicals has been possible (1, 3) but seems impracticable because of its tuber and soil borne nature. Crop rotation although, help reduce its incidence (2, 4, 6, 9) but it may not find favour with all the growers. Since the potato wilt fungus requires higher temperature (5, 8) for infection, it is likely to manage this disease by delaying the plantings and there by taking the advantage of low soil temperature at plant emergence. This paper reports on the possibility of controlling this disease through adjustment in planting dates.

An experiment was laid out in a naturally wilt infested field in randomized block design with four replication using variety Kufri Chandramukhi. Crop was planted on five dates viz. 1, 10, 20, 30 October and 10 November. Each plot measuring 3 x 2.4 sq. m. contained five rows with 12 tuber in each row. NPK doses were applied @ 150:100:100 kg/ha. Other cultural practices were attended to as per the recommendations for the region. Minimum and maximum soil temperature were recorded at the time of each planting as well as at wilt initiation. Pre-and post-emergence wilting were recorded in each plot uptill crop maturity along with the final tuber yield.

To estimate the yield losses caused by *Fusarium* wilt, a trial on the above lines was conducted in an adjacent field which was devoid of wilt infestation. Tuber yields of the two experiments were compared for estimating the yield loss.

Crops planted in October required 20-21.8 days for plant emergence but November planted crop germinated a little late (25.6 days). Wilting appeared early in October planted crop as compared to crop planted in November. The maximum, minimum and mean temperature were highest (24, 17 and 20.5°C) at the time of wilt initiation in crop planted on October 10 and gradually decreased with the delay in each subsequent planting. It indicates that at high temperatures wilt fungus becomes more active leading to early wilting.

A positive correlation was observed between planting time and wilting (Table 1). Pre-emergence wilting was highest in crop planted on October 1 followed by October 10 and 20 (DI being 2, 1 and 0.05%, respectively). Crops planted later than October 20 did not show any pre-emergence wilting. Post-emergence wilting also showed similar trend except that it occurred in all the crops irrespective

*Part of the Ph.D thesis submitted by the senior author. 1. Central Potato Research Institute, Shimla (HP). 2. A.M.U., Aligarh. 3. Vegepro, Food and Feed Ltd., Orai (UP).

Table-1 : Correlation of planting time with wilt development

Planting time	Soil temperatures at sowing			Soil temperatures at wilt initiation			Wiltling	
	8 hr °C	14 hr °C	Mean °C	8 hr °C	14 hr °C	Mean °C	% pre-emergence wilting	% post-emergence wilting Total wilting
1 October	15.5	32	24.1	17	24	20.5	2.0	17.4 19.4
10 October	24	27	25.5	16	23	19.5	1.0	14.6 15.6
20 October	22	28	25	15	16	16.5	0.05	10.3 10.4
30 October	20	24	22	14.2	16.1	15.2	0.0	7.1 7.1
10 November	15	24	19.5	13.9	15.2	14.6	0.0	3.9 3.9
SE ±								3.2
C.D. (0.05)								8.4

Table-2 : Yield loss due to wilt infection in crops planted on different dates

Planting Time	Infested field		Uninfested field		% loss in yield
	% wilt	Yield Q/ha	% wilt	Yield Q/ha	
1 October	19.4	182	0.0	225	19.1
10 October	15.6	224	0.0	266.3	15.7
20 October	10.4	290	0.0	325	10.8
30 October	7.1	266	0.0	284	6.3
10 November	3.9	223	0.0	231	3.5
SE ± (M)	—	14.0	—	10.7	0.0
CD (0.05)	—	30.0**	—	33.0**	—

of their planting time. It's incidence was highest (17.4%) in October 1 planted crop and lowest (3.9%) in crop planted on November 10. Reduction in wilt incidence was significant in crops planted on October 30 and November 10 as compared to October 1 planted crop (Table 1). These results show that *Fusarium* wilt of potato can be effectively managed by shifting the planting date from October 20 to October 30 or if possible, November 10. These observations corroborate the earlier reports (2,5, 7) that *F. Oxyosporum* causing potato wilt is a high temperature disease. In no circumstances crop should be planted before October 20 in wilt infested fields.

A negative correlation was observed between wilt incidence and yield. Highest reduction in yield (19.1%) was observed in plots having highest wilt incidence (19.4%). Whereas least reduction was observed in plots having lowest number of wilt infected plants (Table 2). Crop planted on October 20 gave moderate reduction in wilt incidence and highest tuber yield (Table 2) indicating that October 20 is the best planting time as far as tuber yield is concerned. However, reduction in wilt incidence can further be brought about by delaying the plantings upto October 30 without any significant reduction in yield (Table 2). Therefore October 20 to 30 is the most suitable date of planting for managing the *Fusarium* wilt as well as for getting optimum tuber yield.

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STUDIES ON THE EFFECT OF CYTOZYME ON POTATO YIELD*

V.N. Banerjee¹

Cytozyme is a bacterially derived high molecular weight protein extract and yield improvement in potato with this chemical has been reported (1-3). The aim of the present study was to find out the effect of Cytozyme applied at different stages of the crop on growth and subsequent yield of potato.

The preparation "Cytozyme crop" (Cytozyme, Andhra Pradesh Ltd.) was used in the present study and is referred to as "Cytozyme". Cytozyme (400, 600 and 800 ml/ha) was sprayed at 40 and/or 60 days after planting on cultivar Kufri Jyoti during 1981, in a field experiment replicated six times at Central Potato Research Station, Kufri (HP).

The plot size was 12.2 m² with 50 cm inter-row and 25 cm intra-row spacing. Control (no spray) and water sprayed plots were maintained to evaluate precisely treatment differences. The recommended cultural and manurial practices were followed. Observations on plant height, number of stems and leaves were made one week after treatment. Final tuber number and grade wise tuber yield were recorded. The data was statistically analysed.

It was observed that application of cytozyme had no effect on plant morphology and yield of the crop at any of the treatment/treatment combination. Our results are not in agreement with those reported by Pandita and Hooda (2) where they had pointed out that a combined application of 10% seed treatment and 0.75% crop spray improves the growth and yield of the crop. This differential response may be because of the conditions under which the crops were grown. Pandita and Hooda tested the effect under short day condition whereas the present study was conducted under long days condition.

Thus, it can be concluded that under long day condition, the application of Cytozyme does not effect the crop yield significantly.

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MAJOR PEST PROBLEMS OF POTATO IN U.P. HILLS AND THEIR MANAGEMENT

Gajendra Singh¹

Potato is a major cash crop grown in U.P. Hills. This gives to the farmers better returns compared to those of the plains. Although the yield are comparatively low (Av. 130 q/ha), they are compensated by higher prices of the hill produce. Therefore, over all profits per hectare are somewhat better in hills. Area and yield of potato from various hill districts of U.P. for 1984-85 and 1985-86 are shown in Table 1.

Pests and disease problems rob the costly potato produce of hills more as compared to that of plains, although major insects are the same in hills as in the plains. Their severity vary considerably.

MAJOR INSECT-PROBLEMS OF POTATO IN U.P. HILLS

Potatoes are attacked by several insects in field as well as in storage. Major damage is caused by the aphids, jassids, cutworms, termites, whitegrubs leaf eating caterpillars, epilachna and other beetles. Tuber moth larvae damage this crop mainly in stores inflicting sometimes considerable losses.

SOIL PESTS

Following insects which pass major part of their life cycle in soil or on ground come under this category :

- 1) Termites : *Odontotermes* spp. and *Eremotermes* spp.
- 2) Cut worms : (i) *Agrotis flammatra* (ii) *A. ipsilon* (iii) *A. segetum* (iv) *A. spinifera*
- 3) Whitegrubs : (i) *Holotrichia serrata* (ii) *Anaomala* spp.

Table 1 : Area and production of potato in different hill districts of U.P. during 1984-85 and 1985-86

S. No.	Districts	Area (hectares)		Production (tonnes)	
		1984-85	1985-86	1984-85	1985-86
1.	Nainital	2786	2830	45993	36068
2.	Almorah	1102	1102	18759	14434
3.	Pithoragarh	1977	1977	33645	25895
4.	Dehradun	1179	1147	20845	15592
5.	Tehri Garhwal	1251	1251	21296	16386
6.	Uttar Kashi	1431	1431	24360	18743
7.	Garhwal	258	258	4392	3379
8.	Chamoli	1562	1562	26590	20459

Source : Agricultural Situation in India August 1986, pp 415 and September 1987, page - 584.

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Among the above insects cutworms are the most serious pests of potatoes in U.P. hills. Others are occasionally serious in pockets only. Cutworms are polyphagous insects feeding on several crops such as chillies, brinjal, tomatoes, gram, pea etc. Due to less organic matter, shallow character, sandy and stony nature in the hilly soils, cutworm larvae cause serious losses to the potato crop in hills. Many times farmers apply undecomposed manure to the soil which further gives more suitable hiding places to these worms.

Life history of various species have been studied in details in plains only (1, 2, 3). Larval periods are longer at lower temperatures in hilly region and humidity is abundant in June-July. Therefore, cutworms sometimes cause substantial losses to tubers especially in mid hills at Bhimtal, Bhowali etc. Venkatraman had postulated migration of cutworms from plains to hills in summers (4). However, more work is needed on this aspect of cutworms biology.

MANAGEMENT : (i) Fully decomposed manure should be applied. It may be mixed with folidol 2% dust or aldrin 5% dust.

(ii) Earthing should be as thorough as possible. Tubers should not be left exposed.

(iii) Spraying with chlorpyrifos 20 EC @ 2.5 litres/ha in 1000 litres of water should be done on soil and on plants, atleast twice at 10-15 days interval. Other insecticides such as carbaryl 50 WP @ 2 kg/ha in 1000 litre water will also be effective in checking the damage.

(iv) Poison baiting of the larvae with Nuvan 0.05% treated wheat bran or crop refuges placed in heaps at several places in the field, may also kill some insects.

SAP SUCKERS : Sap sucking insects cause both direct as well as indirect injury to plants by sucking the sap as well as by transmitting viral diseases. Major pests, are listed below :

(1) Aphids : (i) *Myzus persicae* (ii) *Aphis gossypii* (iii) *Microsiphum euphorbae* (iv) *Aphis fabae* (v) Other Spp.

(2) Jassids : (i) *Amrasca bigutulla bigutulla*

(3) Whitefly : (i) *Bemisia tabaci*

Myzus persicae has been reported as the main vector for transmission of leaf roll and mosaic diseases of potatoes, although at normal populations it does not cause economic losses to the potato yields. In U.P. hills aphids generally cross critical level by June end.

Jassids also cause economic losses if weather remains dry and temperatures prevailing are high. They are more serious in lower hills.

Myzus persicae and *Aphis gossypii* breed on several hosts viviparously especially on peaches in the hills.

Aphids at normal densities do not cause economic damage to the table crop. However in seed crop their number should not exceed to the critical level (20 aphids/100 compound leaves).

Management of Aphids and viral diseases in seed potato crop : Seed plot technique is to be adopted which incorporate following steps :

i) Use of certified healthy virus free seed materials. ii) Isolation : Seed crop should be separated 20 metres at least from other fields, iii) Regular inspections and roguing off type plants. iv) Planting of the crop at proper time, v) Recommended variety of the area should be grown. vi) Regular aphid counts and use of insecticidal cover. vii) Haulm cutting at proper time. viii) Grading of material: Only medium sized potatoes for seed should be chosen. Small sized should be left out. ix) Application of thimet @ 10 kg/ha at planting is recommended for seed crop followed by two sprays starting 45 days thereafter at 15 days interval.

Leaf eating caterpillars : Various noctuid and arctuid caterpillars feed on the leaves of potato. Major species of caterpillars are *Spodoptera littoralis*, *Plusia orichalcea* and *Spilosoma (Diacrisia) obliqua*. The moths of these insects lay eggs in batches on the lower surface of the leaves. Some may migrate to potato fields from near by crops. Sometimes their infestation may be noticeable affecting crop growth and yield.

Management : i) Many parasitoids and pathogens mostly take care of these caterpillars in nature. If parasitoids are active spraying should be avoided. ii) Collection of egg and larval clusters may also be useful. iii) Spraying if required may be done with endosulfan 0.05% or with quinalphos 0.05%.

Leaf eating beetles : Major damage among the beetles is done by epilachna larvae and adults. On hills *Hinosepilachna ocellata* is the major species. Adult *Monolepta signata* may also be present and cause some damage. Blue beetle *Aulachophora atripennis* sometimes also seen feeding on potato leaves. Epilachna may cause severe damage in mid-hills in May-June. Larvae feed in cluster in beginning.

Management : (i) Hand collection and destruction of egg, larvae, pupae and adults at regular interval. (ii) Spraying with carbaryl 50 WP @ 2 g/litre (2 kg/ha in 1000 litres of water).

Potato tuber moth : Damage by *Phthorimaea operculella* has been reported from Kumaon hills from Bheemtal and Almora district areas. Damage was reported from field (15%) as well as from stores (30%). There is need to work out the ecological parameters which govern the damage of this insect in Kumaon hills. We have so far not found damage of this insect in 'Tarai' plains. Systematic survey work is needed to find out extent of losses caused by the tuber moth and its relationship to various altitudes.

Management : i) Thorough earthing is required, potatoes should not be left exposed in the field. ii) Damage if noticed in the field carbaryl 0.1% should be sprayed. iii) In stores potatoes should be stored under layers of sand (5 cm thick). In case of seed potatoes a layer of malathion 5% dust should be applied on the sand.

Strategies for future entomological research : Emphasis on the following aspects is needed in the near future for better pest management in potato crop :

1. Studies on economic threshold and economic injury levels of various potato pests. 2. Studies on the population and damage of potato tuber moth by systematic and regular surveys in various climatic zones of the country 3. Effect of altitudes and climatic factors on the population dynamics and damage of potato tuber moth. 4. Life table studies of *Myzus persicae* for several years on important hosts. 5. Detailed studies on relationship between the population build up/multiplication of *Myzus persicae* at various population densities and spread of PLRV, PVY and PVA. In various agro-climatic zones of India.

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THREATENING DISEASE AND PESTS OF POTATOES IN JAMMU AND KASHMIR

F.A. Zaki and M. Amin Masoodi¹

Potato is an important vegetable crop. The area under cultivation in India is 8,53,000 ha with total production of 12.64 million tonnes in 1984-85 (7). This is an all time record for potato cultivation in the country. There has been 374 and 633 per cent increase in area and production respectively, during the last 35 years (4). The estimated world production of potato is about 400 million tonnes and about 35 per cent of the crop is lost due to diseases, insect pests, nematodes, weeds and also by mammals (1). In J&K the area under potato cultivation is 2,000 ha and the yield has officially been figured to a low of 22.1 q/ha. However, the scientists of State Agriculture University and the officers of the State Department of Agriculture working on potato claim it to be as high as 100-150 q/ha (personal communication). The agro-climatic conditions of the state department are highly conducive for the potato cultivation with hill regions ideally suited for seed production. While, the areas of Machil, Gurez, Shopian, Herapora, Boriha, Sedow, Phalgam, Gulmarg etc. in Kashmir, the potato cultivation is extensive, it has also gained acceptance in other parts of the State.

Pest and disease problems take a heavy toll of potato in the State, but little attention has been paid to the research on these aspects. However, important and prospective pest and disease problems are discussed below :

Diseases of Potato : The important diseases of potato in Jammu and Kashmir are listed in Table 1. Late blight is the most serious disease of potato in the State. The incidence and severity of the disease is more in higher regions of the valley. During the last few decades the disease occurred in epidemic form in some years. In hill regions the weather conditions (low temperatures and high humidity) are favourable for the disease epidemics. Therefore, the crop is under constant threat to the disease in Machil, Gurez, Boriha, Herapora, Sedow and other such areas.

Early blight of potato is also an important disease of potato in the State. It appears slightly earlier in the season than the late blight, but causes maximum damage to leaves late in the season if the weather remains favourable.

Fusarium wilt is prevalent in Dal area of Srinagar or in area with excessive soil moisture or irrigation. The base of the stem is girdled by a rot similar to that caused by *Rhizoctonia*. The leaves roll upwards, turn purple and have a rosette appearance. In wet cold soil the underground part of the stem may rot early in the season, and the plant wilts and dies. During hot, dry weather or late in the season the wilt develop more slowly. Tubers are discoloured and develops a dry and powdery rot at the stem end.

Bacterial wilt of Potato has recently been recorded by Mir and Dar (un-published). The disease is highly infectious and readily spread by agricultural implements. The tubers may rot in the field or

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in storage. The disease develops rapidly in hot and dry weather. So, it is a prospective problem in the plains of the valley.

Several viral diseases attack potatoes and spread to healthy plants. Most of these diseases do not affect the market qualities of the tubers for table purpose, but all reduce the size and number of tubers produced, thereby, reducing marketable yield. The viral diseases are especially important for potato seed production where it becomes a factor for rejection. Among the viral diseases, mild mosaic and leaf roll has been recorded in the State. A-and X-viruses have been found associated where M-virus was absent.

Though the damage and yield losses caused by potato diseases appear to be substantial in the state, no data is available on the extent of crop losses. Late blight in epidemic years may cause a total failure of the potato crop.

Insect pests : All parts of Potato crop are affected by insect pest whether above or below ground (Table 2). About 15 insect pests are associated with the crop according to preliminary investigations (3,8). Besides aphids and white flies which act as vectors, the soil inhabiting insects are a major source of damage to potato crop in the Valley.

Agrotis ipsilon and *A. segetum* are two important cutworms associated with potato crop in Kashmir. In out-break years they are common in all districts of Kashmir. *A. ipsilon* is probably more common species cutting the plants off at ground level. Grubs of several species of scarabids including, *Brahmina* sp., *Adoretus* sp, *Melalontha* sp. damage potato crop in Kashmir. The injury is seldom seen until harvest time (5). Wire worms associated with *Agrotis* sp. damage the crop by feeding on seed pieces or retarding the plant growth. They often gather in groups. One Collombola sp. *Sinella curviseta* affects germination and reduces the yield of potatoes, in the floating lands in and around Dal Lake. The population reaches peak in May and germination of the crop is reduced by about 20.0% (6).

Among the aphid complex, *Aphis gossypii* and *Myzus persicae* are found. White fly *Bemesia* sp. is another species recorded as vector of viral diseases (9).

Nematode parasites : The dominant species associated with potato in J&K are listed in table 3. The population pattern of these species in a potato field revealed that *Pratylenchus* sp. was maximum during June, which, thereafter, started declining and was lowest in late August. The population of *Helicotylenchus* sp. remain static upto July and thereafter, started increasing to reach its maxima in August. However, the population of stunt nematodes reached its minimum on August 27.

These are preliminary reports and work is being continued to exactly ascertain the population pattern, pathogenicity and damage of these nematodes on potato.

Management strategies : The approach to crop protection has been developd on a pest by pest basis which led to several undersirable effect including pesticide resistance, secondary pests and environmental

contamination. However, in the recent past there has been tremendous progress in crop protection technology. The draw backs associated with dependance on insecticides for pest control has become increasingly apparant and alternate control strategies have gained greater attention. Considering the importance of the crop no systematic studies have been undertaken to develop management strategeis for the potato crop. However, various chemical control measures against underground insect and nematode pests (phorate or aldicarb granules @ 1.5 kg a.i./h) foliar insects (methyl demeton 0.025% or dimethoate 0.04%) and late blight disease (mancozeb 0.2% or copper oxychloride 0.3%) have been recommended (5).

In view of unique physiographic situation of Kashmir (a true temperate area) and the ideal environment it provides for the cultivation of seed and table potatoes, the future efforts to combat various pests and diseases should be initiated on a more comprehensive basis.

Futuristic Approach : 1) The systematic and organized survey and surveillance for the incidence and distribution of various insect, nematode pests and diseases.

- 2) The determination of crop losses and economic injury levels.
- 3) The study of biological characteristics of various pests including their seasonal development and population dynamics in different ecological zones.
- 4) The epidemiological studies on the late blight of potato and development of a prediction model thereof, for the forecasting and warning in different agro-ecological zones of the state.
- 5) The development of cropping system for the disease and pest management.
- 6) The use of selective pesticides safe to environment.
- 7) Identification of potential natural enemies of various pests and pathogens.
- 8) Screening of cultivars resistant to various pests and diseases.
- 9) Development of integrated pest management strategies.

Finally, the extension programmes should be strengthen for the transfer of technology. On farm advisory services made extensive, in view of potato being grown on large scale in far flung areas like Gurez, Machhil, Herapora, Borihal, Sedow etc.

Table-1 : Important Diseases of Potato in Jammu and Kashmir

Disease	Causal organism
Late blight	<i>Phytophthora infestans</i>
Early blight	<i>Alternaria solani</i>
Fusarium wilt	<i>Fusarium solani</i>
Black scurf	<i>Rhizoctonia solani</i>
Bacterial soft rot	<i>Erwinia carotovora</i>
Bacterial wilt	<i>Pseudomonas solanacearum</i>
Mild Mosaic	A and X-virus
Simple Mosaic	X-virus
Leaf roll	Viral strain not known.

Table-2 : Insect pests of Potato in Jammu and Kashmir

Common Name	Scientific Name
White grubs	<i>Brahmina</i> spp. <i>Adoratus</i> spp. <i>Melolontha</i> sp.
Collembola	<i>Sinella curviseta</i> Brook
Cut worms	<i>Agrotis ipsilon</i> , <i>A. segetum</i>
Wire worms	<i>Agrotis</i> sp.
White fly	<i>Bemisia</i> sp.
Aphids	<i>Myzus persicae</i> <i>Aphis gossypii</i>
Leaf hoppers	<i>Empoasca</i> sp.
Chrysomelid beetles	<i>Halitica</i> sp.
Plant bugs!	

Table-3 Nematode parasites of Potato in Jammu and kashmir

Root-Knot Nematodes	<i>Meloidogyne</i> hapla
Potato root nematode	<i>Ditylenchus</i> spp.
Root lesion nematodes	<i>Pratylenchus</i> spp.
Spiral nematodes	<i>Helicotylenchus</i> spp.
Stunt nematodes	<i>Tylenchorhynchus</i> spp. <i>Quinculcius</i> spp.
Aphelenchids	<i>Aphelenchoides</i> spp.

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POTATO PRODUCTION IN UP HILLS – CONSTRAINTS AND FUTURE STRATEGIES

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Potato is grown in 79% of the world's countries (FAO, 1986). It is second only to maize in terms of number of producer countries and fourth after wheat, maize and rice in global tonnage. FAO statistics show that the percentage increase in potato production from 1961-65 to 1979, for all developing countries, was greater than 99% while that of cereals and other roots and tubers was only 47% and 44% respectively (International Potato Centre, 1981). The average yield of potato in India is 15.2 t/ha as compared to 31 t/ha in U.S.A. and 42 t/ha in Netherlands.

Potato is one of the most efficient crops for converting natural resources, labour and capital into a high quality food. They can yield more nutritious food material more quickly on less land and in harsher climate than most other major crops, and the edible food material can be harvested only after 60 days. Potato produces more food per unit area than cereals and that too, in a much shorter time. In some respects it excels cereals in nutritive value and palatability. Even 100 g of potato can supply a significant percentage of daily protein requirements and on a cooked basis it is similar to that of cooked rice. It is the consideration of these qualities which justify potato for an honourable place in agriculture.

Area, production and productivity : Potato has attained the status of one of the most important cash and food crops in India. The state of Uttar Pradesh has the largest area (38.8%) and production (47%) of potato as compared to other states of India. During last 15 years, the area and production of potato have shown remarkable increase in U.P. (Table-1). The pattern of increase in area and production remained almost the same through the state. The average yield fluctuated between 4.58 to 9.40 t/ha between 1960-61 and 1973-74. However, subsequently the average yield increased progressively nearing 18.42 t/ha in 1983-84 which however lags behind that of states of Gujarat (28 t/ha), West Bengal (21 t/ha) and Punjab (20 t/ha).

Nearly 90% of the area under potato is in sub-tropical plains and humid plateau region of southern Peninsula. The North Indian hills, which are akin to temperate climate, account for only 10% area under this crop.

In U.P. hills, potato was first introduced in Kumaon by Major Welcham, an Englishman, in 1882. In the early decades of this century potato had become an important crop of the region. At present, potato is cultivated in U.P. hills over an area of about 11,500 ha (Table 2), which has increased substantially in both Kumaon and Garhwal divisions. Ever since 1959-60, the area under potato has increased more than 10 times both in Distt. Dehradun in Garhwal division and Distt. Nainital in Kumaon division, while the increase in production has been to the extent of 20 and 30 times in districts Dehradun

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and Nainital, respectively. Similarly the average yield of the region increased progressively (18.5 t/ha) which compares well (Table 3 & 4) with the state average (18.4 t/ha).

Table-1 : Area, production and average yield of potato in Uttar Pradesh.

Year	Area (lac ha)	Production (Lac tonnes)	Average yield (Qtls/ha)
1970-71	1.61	14.86	92.00
1971-72	1.78	16.80	94.01
1972-73	1.72	16.31	93.24
1973-74	1.87	17.21	92.00
1974-75	2.25	25.00	115.00
1975-76	2.35	26.36	110.00
1976-77	2.45	30.00	120.00
1977-78	2.50	35.00	140.00
1978-79	3.00	45.00	150.00
1979-80	2.42	31.68	130.00
1980-81	2.73	42.34	154.95
1981-82	3.03	45.89	152.25
1982-83	2.86	44.86	156.82
1983-84	3.12	57.57	184.25
1984-85	3.40	58.00	170.20
1985-86	3.10	40.72	131.00

Source : Agriculture Situation in India.

Table-2 : Area (ha) under potato in U.P. Hills

District	Year						
	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86
Nainital	2,132	2,177	2,194	2,102	2,203	2,786	2,830
Almora	915	915	915	915	915	1,102	1,102
Pithoragarh	930	930	930	930	930	1,977	1,977
Kumaon Division	3,977	4,022	4,039	3,947	3,048	5,865	5,909
Dehradun	959	969	987	971	960	1,179	1,147
Tehri	559	559	559	559	559	1,251	1,251
Uttarkashi	631	631	631	631	631	1,431	1,431
Pauri	563	129	129	129	129	258	258
Chamoli	645	645	645	645	645	1,562	1,562
Garhwal Division	3,357	2,933	2,951	2,935	2,924	5,681	5,649
U.P. hills	7,334	6,955	6,990	6,882	5,972	11,546	11,558

Source : Agriculture situation in India.

Table-3 : Potato production (Metric tonnes) in U.P. hills

District	Year						
	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86
Nainital	27,895	34,094	32,213	31,619	40,814	45,993	36,068
Almora	14,330	14,330	13,931	14,476	16,857	18,759	14,434
Pithoragarh	12,168	14,565	14,159	14,714	17,133	33,654	25,895
Kumaon Division	54,394	62,989	60,303	60,809	74,804	98,406	76,397
Dehradun	12,547	15,175	15,078	15,604	18,035	20,845	15,592
Tehri	7,314	8,754	9,607	8,844	10,372	21,267	16,386
Uttarkashi	8,256	9,882	9,820	9,983	11,625	24,360	18,743
Chamoli	8,439	10,101	9,820	10,205	11,883	26,590	20,459
Pauri	6,900	2,020	1,953	2,041	2,394	4,368	3,379
Garhwal Division	43,456	45,933	46,278	46,667	54,218	97,483	74,559
U.P. hills	97,849	1,80,922	1,06,581	1,07,486	1,29,022	1,95,899	1,50,956

Source: Agriculture Situation in India.

Cropping seasons and factors affecting production in U.P. hills : In U.P. hills, potato is grown upto 4000 m above MSL. Depending upon the elevation, potato is planted during spring and autumn seasons under irrigated conditions or during summer as rainfed crop. The main summer crop is planted in March-April and harvested in August-September. It is cultivated at altitudes above 1600 m MSL and such areas constitute more than four fifth of the potato crop of the UP hills. The growing seasons and various biotic/abiotic factors affecting potato production in different situation in UP hills are summarized in Table 5.

Potato based crop rotations : Various rotations, involving potato, that are adopted in the UP hills are as follows :-

	Conventional	Improved
Valley	Potato-Radish-Paddy Potato-Onion-Maize Potato-Tomato-Bhindi	Potato-Radish-Maize Potato-Frenchbean-Paddy Potato-Cauliflower-Bottle gourd
Mid-hills	Potato-Cabbage-Fallow Potato-Peas-Fallow Potato-Vegetable-Lahi	Potato-Cabbage-Coriander Potato-Peas-Radish Potato-Radish-Lahi
High Hills	Potato-Cabbage Potato-Radish	Potato-Cabbage Potato-Peas
Very High hills	Only Potato	Only Potato

Table-4 : Potato Productivity (Q/ha) in U.P. hills

District	Year						
	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86
Nainital	130.84	156.61	146.82	150.42	185.3	165.1	127.45
Almora	156.61	156.61	152.25	158.21	184.2	170.2	130.98
Pithoragarh	130.84	156.61	152.25	158.21	184.2	170.2	130.98
Kumaon Division	136.77	156.61	149.30	154.06	184.6	168.5	129.29
Dehradun	130.83	156.61	151.40	160.70	187.9	176.8	135.93
Tehri	130.84	156.60	171.86	158.21	184.2	170.2	130.98
Uttarkashi	130.84	156.60	155.62	158.21	184.2	170.2	130.98
Pauri	122.56	156.59	152.24	158.22	184.38	170.0	130.96
Chamoli	130.84	156.60	152.25	158.22	184.38	170.0	130.96
Garhwal Division	129.45	156.60	156.67	159.03	185.0	171.5	131.97
U.P. hills	133.11	156.6	152.98	156.54	184.8	170.0	130.68

Source : Agriculture Situation in India.

Varieties under cultivation : Various Varieties under cultivation in different situations in the region are listed below :-

Valley	Mid-hills	High-hills	Very high hills
Kufri Badshah	Kufri Jyoti	Kufri Jyoti	Upto-date
	Upto date	Upto date	Tumri
Kufri Chandramukhi		Magnum Bonum	Magnum Bonum
		Gola	Majestic
Kufri Jyoti		Tumri	Dunbar Cavalier

However, Kufri Jyoti is the only recommended variety for cultivation in UP hills. Many farmers still use degenerated seed stocks of old introduced cultivars such as Majestic, Magnum Bonum, Upto-date, Dunbar cavalier, Gola, Tumri etc. for want of seed of improved varieties. These are grown in mixture, and all these cultivars are susceptible to late blight which occurs regularly. Cut tubers, which are more prone to rot in the soil, are planted to save on seed costs. The availability of seed of improved varieties in sufficient quantity and at right time are the major production constraints.

Diseases and pests : Late blight caused by the fungus *Phytophthora infestans* is the most serious disease of potato in the hills. The disease can cause losses ranging from 10-80% depending upon weather conditions and variety used. Bacterial wilt or brown rot caused by *Pseudomonas solanacearum* is the second most important disease of potato particularly in the crop raised above 2000 m MSL. The maximum incidence of disease (up to 30%) has been found in Nainital district followed by Tehri Garhwal and

Almora (less than 1%). The yield losses may be upto 20-25% and may be as high as 30-70% in the worst affected areas. Other diseases of significance are Cercospora blotch, Phoma and early blight.

Amongst insects, cut worm, white grub and defoliators damage the crop markedly specially during years of dry weather.

Table-5 : Cropping seasons and various factors influencing potato production in UP hills

Region	Elevation in MSL	Crop season	Climate	Stress factors	
				Disease	Insect pests
Valleys	1000-1500	Autumn : Sept. to Nov. -Dec. (Irrigated) Spring : Jan. -Feb. to May (Irrigated)	Frost before harvesting	Late blight in early stages, high incidence of viral diseases.	Cut worms, rootknot, nematode leaf hopper, aphids.
Mid-hills	1500-2500	Summer : March- Aug. Sept. (Rainfed)	Frost, hail after planting, difficient moisture in growth stages & excess moisture during and after tuberization.	Late blight during tuber development, Brown rot.	Cut worms, white grub, Epilachna beetle, aphids in summer.
High-hills	2500-3000	Summer : April to Sept. (Rainfed)	Frost and hail in early stages, excess moisture during tuberization.	Late blight	White grub, Epilachna beetle, leaf hopper and cut worms.
Very high hills	3000-3500	Summer : June- Sept. (Rainfed)	Dry weather during vegetative growth, early snow fall at harvesting.	Late blight in later stages occasionally.	

Major constraints : The topographical, geographical and environmental conditions of UP hills are quite suitable for potato cultivation. But, inspite of all these favourable conditions, potato production in the region remains quite low due to following major constraints :

- Non-availability of inputs, such as quality seed of improved cultivars, fertilizers, chemical and plant protection measures at right time and required quantity.
- Non-adoption of improved cultural practices.
- Lack of information about improved agro-techniques.
- Scarcity of two cost improved agricultural implements to improve labour efficiency.

- v. Defective land use and cropping pattern.
- vi. Lack of proper extension based educational and training programme.
- vii. Scourage of diseases like late blight and brown rot.
- viii. Lack of transportation, storage and marketing facilities.

Suggested future strategy for increasing potato production in U.P. Hills : Hills usually have little additional land to cultivate. As population expands and man/land ration increases, the productivity per unit area must be increased to help/solve food problem. The crops like potato which produce much energy and protein per unit time should be more popularized. The goal, therefore, for future should be to facilitate greater frequency of consumption by working the following :

- i. To reduce the price of potato relative to other vegetables.
- ii. To encourage wider market distribution on a more regular basis.
- iii. To improve home potato storage.
- iv. To promote varieties suitable for local vegetable preparations.
- v. To provide information on new methods of incorporating potatoes into local diets.

If a crop is to expand, farmers must be willing to grow it and must consider risks, profitability, cash flow and the suitability of the crop for their farming pattern and home consumption. In general, potato meets their needs except for the high risks associated with production and marketing, and as such, future expansion very much depends upon reducing the price of potatoes relative to other crops.

The scope for reducing production costs per hectare are limited to breeding disease resistant varieties, improving seed production programme, but the cost of chemical fertilizers and pesticides nullify this reduction. The fertilizer is a costly input and its judicious use is imperative to increase the yield and reduce the cost of production. An integrated nutrient management approach including the use of bio-fertilizer, organic manures, and wastes as complimentary source of fertilizer is of paramount importance to achieve best results at low cost. The results of long-term field experiments show that in the acid brown hill soils, FYM @ 30t/ha meets full requirements of phosphorus and potassium and part of nitrogen needs. Application of local mulch material improved potato yield conserving soil moisture and also economises on fertilizer use and weed management to some extent. Therefore, the combined application of organic manures and fertilizers is of great significance under rainfed conditions of hills where crop experience moisture stress.

The strategy for reducing cost per kg and increasing productivity of potato could be considered as : i. In a given region, the attainable yield should be determined through field trials which would help to identify factors limiting yield and the potential yield increase that could be attained. There is only one coordinated centre located at Pantnagar. Hence, there is necessity to have more centres

for testing the improved varieties and technology in the region. ii. Because tuber seed cost are so high, priorities should be accorded to improving the health, production and distribution of cheap seeds in sufficient quantities at right time. There is very poor infrastructure for producing quality seed of potato in the region. Presently this work is being done in the following centres :—

Kumaon Division : Balati (Pithoragarh) Supi, Managhar, Kashipur, Paninagar, Mukteshwar(Nainital)
Garhwal Division : Joshimath (Chamoli), Bharsar (Pauri), Balcha (Uttarkashi), Dhanolti, Gaja (Tehri).

There is, thus, urgent need to strengthen the seed production programme in the region to ensure timely availability of quality seed to the grower in sufficient quantities. iii. Where growing conditions are difficult, cultivars tolerant to drought, frost, etc. are needed to help growers increase yield with only moderate increase in production costs. iv. More research is needed to provide reliable tools to growers to increase the labour efficiency. v. Simple effective systems are needed to store ware and seed potatoes over long periods. vi. More attention should be paid to breeding for keeping qualities. vii. The areas of low production are not necessarily the areas of low consumption. With improved transport system, high potential areas may supply potatoes cheaply to nearby markets. viii. The programme of work should also include studies of relative values of different food crops, taking into account not only local traditional food but including potato as a potential high value, high protein food capable of being grown in many varied environments.

POTATO DISEASES AND PESTS AND THEIR MANAGEMENT IN THE HILLS OF HIMACHAL PRADESH

G.S. Shekhawat

Himachal Pradesh is situated at a longitude 75°, 45' to 79°, 04' and latitude 32°, 22' to 30°, 12' N and altitude of 350-6975 meters above mean sea level (MSL). Potato is one of the main cash crops in the State. It occupies 2.29% of net cropped area and contributes 2.01% of gross agricultural value (16). Eighty nine per cent of the area under potato is in hilly districts viz. Kinnaur (3.25%) Kullu (6.90%), Lahaul and Spiti (8.33%), Mandi (14.08%), Shimla (47.71%), Sirmour (7.44%) and Solan (1.05%). Similarly eighty nine percent of the total potato production also comes from the above eight hilly districts (1). The plant pathologists and entomologists of the Central Potato Research Institute have been carrying out survey of diseases and pests of potato in the above districts since 1973. This paper covers information from these survey reports and also discusses the strategies for management of important diseases and pests.

Diseases : A total of 24 diseases have been recorded in the State. They are late blight (*Phytophthora infestans*), early blight (*Alternaria solani*), leaf spots (*Phoma* spp.), leaf blotch (*Mycovelocella concors*), Verticillium wilt (*Verticillium albo-atrum*), Fusarium wilt (*Fusarium* spp.), Sclerotinia wilt (*Sclerotinia sclerotiarum*), Oospora wilt (*Oospora pustulans*), bacterial wilt (*Pseudomonas solanacearum*), black scurf (*Rhizoctonia solani*), common scab (*Streptomyces* spp.), powdery scab (*Spongospora subterranea*), pink rot (*Phytophthora erythroseptica*), latent or faint mottle mosaic (PVX, PVS), mild mosaic (PVA), leaf rolling mosaic (PVM), aucuba mosaic (PAMV), severe mosaic (PVY), Crinkle mosaic (PVX + PVA), rugose mosaic (PVX + PVY), leaf roll (PLRV), purple top roll (MLO), blind tubers and thin/hairy sprouts (Physiological or MLO).

Late blight : This is the most important disease (Table-1) in Kinnaur, Kullu, Mandi, Shimla and Solan districts which receive heavy rainfall during June to September (Table-4). In cold desert of Lahaul and Spiti, it is of minor importance mainly because of dry weather during the potato crop season (23, 24). The disease generally appears between 1-15th July and kill the susceptible varieties by mid August. Resistant variety Kufri Jyoti gets infected late i.e. by 30th July and the maximum build up of the disease occurs by the end of August (7) and therefore it is the most popular variety. In Mandi district where both Kufri Jyoti and Magnum Bonum (a late blight susceptible variety) are grown, the disease incidence in the former cultivar is much less (range 0-4%, average 1.7%) as compared to the latter (100%). The losses due to the disease range 21-74% in susceptible varieties and 5-20% in resistant variety Kufri Jyoti. Nevertheless Kufri Jyoti has been gradually showing increased susceptibility due to appearance of new and complex races of the pathogen (4). To overcome this problem the Central Potato Research

Institute has developed some hybrids which possess field resistance to *P. infestans*. It is also proposed to develop parental lines using various *Solanum* spp.

Unfortunately, resistance in Kufri Jyoti and the new hybrids available at present has been derived from *Solanum demissum* — a species possessing major gene resistance. Such a resistance is not expected to be durable against a genetically flexible pathogen like *P. infestans*. Therefore the correct approach should be the use of minor gene resistance (field resistance) available in other *Solanum* spp. like *S. andigena*, *S. phureja*, *S. verrucosum*, *S. bulbocastanum* and *S. microdontum* for developing hybrids with durable resistance (4, 7, 19).

There are several alternative chemicals available for control of the disease. These include mancozeb, copper oxychloride, oxadixyl and metalaxyl formulations (5, 8, 9, 12). Among these mancozeb is the most commonly used fungicide for control of the disease. Use of a single fungicide continuously might result in selective depletion of beneficial soil microflora. It would, therefore, be desirable to give alternative/sequential sprays of one or more fungicides.

A system of forecasting has been developed for Shimla hills (3) and forecasts are announced through All India Radio, Shimla advising the farmers to spray their crop within a week. This facility is extended to enable the farmers to give need based sprays. However, a majority of the farmers do not spray their crop most probably because of non-availability of chemical, financial constraints and the misconception that a resistant variety like Kufri Jyoti does not need fungicidal protection. It must be remembered that no resistance is likely to be absolute solution for this disease unless it is supported by two to three fungicidal sprays.

The main source of inoculum for the disease development is the infected seed tubers (9,11,15). In Shimla hills, visible tuber infection at harvest range 5.2-39.0 per cent of which 1.2-3.1% still remains after grading, packing and putting of tubers in stores. Even if all the infected tubers are rigorously sorted out before storage, 0.75-0.32 percent tubers carry invisible (latent) infection and serve as source of inoculum when planted (9, 11). It is, therefore necessary to reduce/eliminate seed infection. This can be achieved by reducing tuber infection in the field by proper earthing up and covering of tubers, preventing build up of foliar inoculum by chemical sprays and by haulm cutting when 20% of the foliar infection is observed. The work done at CPRI has given encouraging results in eradicating tuber borne inoculum by dip treatment of cut tubers for 30 min. in 0.15 to 0.2% oxadixyl or metalaxyl (11). More work is required on this aspect and also on methods for detecting latent tuber infection.

Soil and tuber borne disease : The soil and tuber borne diseases namely common scab, black scurf and powdery scab are second in importance after late blight (Table 1 and 3). These diseases do not cause yield losses but disfigure the tubers and reduce their market value. Such tubers are also not fit to be used as seed. The incidence of these diseases is the highest in Lahaul and Spiti area and is on the increase as is evident from survey results of 1983 and 1987 (25). In 1983 the incidence of common scab and black scurf ranged 16 to 35 and 7 to 15 per cent respectively. In 1987 survey, the incidence

of common scab was 40-66 and that of black scurf was 27-32 per cent. In Shimla hills the incidence of common scab and black scurf range 0 to 11 and 19 to 46 per cent respectively (24). These diseases are on the increase in all the districts primarily because of monoculture of potato. Most of the produce from higher hills is sold as seed which fetches better price and therefore the farmers are tempted to grow potato after potato which has resulted in build up of soil inoculum of the organisms causing these diseases. Secondly, infected seed is used and no measures are taken to reduce seed or soil borne inoculum. Control measures for tuber and soil borne diseases are available and should be introduced immediately. These include: i) treatment of seed tubers for eradicating seed borne inoculum by dipping the tubers in 0.5% organomercurial compound or in 3% boric acid (Pharmaceutical grade) for 30 minute within 45 days of harvest, ii) Crop rotation with cereals, millets, maize, onion, garlic, pea, cabbage etc. and iii) ploughing the land immediately after harvest so that it is exposed to low winter temperatures. The ploughing reduces population of the pathogens and also conserve water from winter rains and snow.

Among other tuber borne diseases powdery scab is important in higher hills (above 2500 meters MSL) of Shimla district with incidence ranging from 2.1-14.1 per cent (2). Recently in 1987 pink rot incited by *Phytophthora erythroseptica* has been recorded in Shimla hills with incidence as high as seven per cent (11, 18). Diseases like dry rot, and soft rot are of minor importance with incidence of 1-5 per cent in Shimla and 0.58 to 1.84% in Lahaul and Spiti. In Kufri-Fagu area of Shimla district dry rot is the major problem in storage with incidence as high as 21 per cent (11).

Verticillium wilt is prevalent throughout the Lahaul valley and its incidence ranges 3.2-95%. The disease appears to be primarily carried through seed potatoes. If seed potatoes free from infection are used for planting the incidence is reduced to 0-8% (25).

Viral diseases : The viral diseases (also called degenerative diseases) are not important in the State excepting in Lahaul and Spiti (Table 2). The high wind velocity, relatively low temperatures and frequent rains (Table 4), which characterise the climate of high hills of the State are uncongenial for the build up of the aphids, which are vectors of potato viruses. This is true for the hills above 2100 meters except cold deserts of Lahaul and Spiti. Therefore the aphid population remains below critical level, though they appear in mid July. For controlling them spray the crop with oxydemeton-methyl @ 1-2 l/ha or dimethoate 1.0 l/ha in 1000 to 1200 litres of water once or twice during July-August at about 10 days intervals (12).

In Lahaul valley the average virus incidence ranged to 10-18% in 1983 and 11-38% in 1987 (Table 3) which is much above the limits prescribed for certified seed potatoes. Since the climate of the valley during potato crop season remains dry and warm, build up of aphid population is very high and the population reaches critical level by the first week of August at the most places (24). Since the haulm cutting is done in the end of August and beginning of September and no insecticide is sprayed on the crop, the aphids get about 30 day and more to freely transmit the viruses. The Lahaul valley remains snow bound from October-November to April. Therefore potato can be planted earliest by the end of April or first week of May and the haulms can not be cut before the end of August to obtain optimum

yields. For reducing virus incidence there are two possible alternatives namely i) spray of systemic insecticides at 10-15 days intervals starting from the first week of August or ii) complete the haulm cutting latest by mid August, after giving one spray of insecticide in the first week of August. The second alternative is more appropriate for reducing virus incidence but will reduce the yield because the tuber bulking period will be shortened. The first alternative is better for getting optimum yields and can also reduce virus spread provided it is ensured in the entire valley that initial virus incidence in the crop is very low and all the farmers follow the spray schedule religiously. In a valley like Lahaul it is possible because it is cordoned by high hills all around which prevents introduction of virus inoculum from outside the valley. The entire valley grows only seed potato and there is a well organised seed potato marketing society which in collaboration with State Seed Certification Agency can ensure that insecticides are made available to the farmers and spray schedule is followed.

Leaf spots : Leaf spots and early blight are important in Lahaul and Spiti districts (Table 2, 3). The incidence is alarmingly high (24). In Shimla and Mandi districts their incidence is light to moderate. These diseases are easy to control by spray of mancozeb @ 2 kg/ha and by application of nitrogen @ 200 kg /ha or more, or by spraying 0.2% urea when the crop is about 45-60 days old.

Bacterial wilt or brown rot : This is a major problem in Sirmour district (Table 1). The disease is prevalent throughout the district but its incidence varies depending on the locality and field (20, 24). In most of the fields the incidence remains below 10 per cent . However, in certain areas like Thanedhar, Deedag, Nohra, Khainda, Charna, Chunvidhar and Kheradhar the incidence ranged 10-80%. In tubers the disease incidence ranged 5-30%. The disease is also present at lower altitudes below 2100 meters (20) and in Lahaul and Spiti district at lower Keylong in Bhaga valley and Hinsal in Pattan Valley in traces. The disease is primarily seed borne and the pathogen may also remain viable in infested fields for 2-3 years (21). Lahaul and Spiti and Sirmour districts are seed producing areas and therefore, even low incidence of brown rot is not desirable. In Lahaul valley only a few pockets have shown the disease so far. These pockets should be quarantined and potato should not be grown there at least for another five years. In Sirmour district the disease can be controlled by i) use of disease free seed, ii) application of stable bleaching powder @ 12 kg/ha along with fertilizer in furrows at the time of planting and iii) by growing potato in three years rotation with maize, cereals and onion (9, 11, 22).

Potato pests : Thirteen pests have been recorded in the hills of the State (17). These include aphid (*Myzus persicae*), leaf hoppers (*Alebroides nigroscutellatus*, *Seriana equata*, *Orosius albicinctus*), epilachna beetle (*Epilachna ocellata*), flea beetle (*Psyllodes plana*), defoliating caterpillar (*Heliothis armigera*), cut worm (*Agrotis segetum*), white grub (*Lachnosterma coriacea*), slug (*Helix species*); tuber moth (*Phthorimaea operaculella*), root knot nematode (*Meloidogyne hapla*, *M. incognita*), Stunt nematode (*Quinisulcius capitatus*), lesion nematode (*Pratylenchus species*). Only the cut worms and white grubs are important. The former occur regularly in the early period of crop growth (May-June) when the weather remains dry. In Shimla, Kulu, Mandi, Sirmour and Kinnaur districts 16-93% fields

are attacked by the pest population ranging 1-10 worms per 50 plants. The damage ranges 0.5-10% on foliage and 8.5-30 on tubers (10). In Lahaul and Spiti, the incidence of foliar damage was high in Mayar valley (5-10%) and in warmer areas of Pattan valley (2-10%), where as in Bhaga valley and in cooler parts of Pattan valley it was only in traces (25). Control of cut worms is possible by drenching the ridges with clorpyrifos 20EC @ 2.5 L/ha in 1000-1250L of water when 75% plants have emerged (12).

White grubs are prevalent throughout the state, but they attack potato crop severely in Shimla and Sirmour districts where 60-76% fields get infested and have grub population ranging 1 to 11 per 50 plants with average of 4 grubs per 50 plants (17). In Shillaroo, a white grub hot spot in Shimla district, the grub population reaches as high as 18 grubs per m² and damages 74.7% tubers (10). Singh and Verma (36) reported 25-54% foliar and 3-11% tuber damage in Shimla hills. White grubs can be controlled by application of Phorate 10G or Carbofuran 3G @ 2.5 kg a.i/ha at earthing up (12).

The incidence of epilachna beetles normally remains low to moderate and severe attack is observed only in certain years. Leaf hoppers, flea beetles, defoliating caterpillars also occur in low to moderate intensities (17). In any case these pest do not warrant special control measures.

Conclusions and Suggestions : The state produces seed potatoes and supplies to different parts of the country and thus the diseases occurring in the state are liable to be dispersed long distances. It is therefore, necessary for the state Department of Agriculture to keep a watch on the disease and pest situation.

In olden days, North-western and North-eastern high hills had total monopoly on seed potato production. With the development of seed plot technique (13, 14) the States in the Indo-gangetic plains have also started producing seed potatoes of very high health standards. Himachal Pradesh has to compete with them and therefore it has to maintain matching, if not better, health standards of the seed. Fortunately for the state, the UP and Darjeeling hills can no more produce seed due to prevalence of brown rot (in UP hills) and wart (Darjeeling hills) diseases.

The farmers also do not take adequate plant protection measures and therefore, incidence of diseases is on the increase. Since potato is a cash crop in the state, this neglect should not be allowed. The State Government should launch an intensive programme to popularize plant protection measures.

The viruses, tuber borne diseases, leaf spots and wilts pose serious problems in Lahaul valley which is a major potato area in the State. It contributes 25% to the total seed potato produced in the State and 60% area of valley is under potato (25). Obviously the economy of the people in the valley is dependent on potato seed. Unless concrete steps suggested in the discussion on diseases in the preceding pages are taken, the seed industry is bound to be jeopardised.

Bacterial wilt and brown rot is a problem in Sirmour district. In addition to control measures, the State Govt. should restrict movement of seed potatoes from Sirmour to other districts to prevent the

spread of this dreaded disease. A few pockets having the disease in traces have been located in Lahaul valley also. The State Government should take measures to abandon potato cultivation at least for five years in these pockets.

Table-1 : Incidence of fungal and bacterial diseases in HP (1983-1984) hills

District	Disease incidence*							
	LB	EB	LS	CS	PS	BS	VW	BW
Shimla	5-50 (17.1)	T	5-30	M	2-14	M	T	0-0.1 (0.01)
Kulu	0.2-2.4 (1.9)	T	T	T	T	T	T	0.0
Mandi	0-100 (50.5)	T	5-10	T	T	M	T	0.0
Sirmour	0-80 (29.0)	T	T	M	0	M	T	0-60 (11.33)
Kinnaur	0-50 (15.4)	T	T	T	T	T	T	0.0
Lahaul-Spiti	0-20	0-75 (6.6)	1-45 (10.7)	0-100 (24.7)	0	0-68 (11.7)	0.95 (12.8)	0-5**

* LB = Late blight, EB = Early blight, LS = Leaf spots, CS = Common scab, PS = Powdery scab BS = Black scurf, VW = Verticillium wilt, BW = Bacterial wilt, T = Trace, M = Moderate

Figures in parenthesis are average disease incidence.

** = Detected only at lower Kelong (Bhaga valley) and Hinsal (Pattan Valley) with 0-5% incidence.

Source : Singh, B.P.; R.A. Singh, R.P. Singh. 1986. (24)

Table-2 : Incidence of viral/MLO diseases in HP (1983,1984) Hills

District	Disease incidence				
	Mosaic	Leaf roll	PTR*	Pseudo PTR	Thin sprout
Shimla	0-1 (0.14)	0	0	0-5 (1.0)	0
Kulu	0-0.5 (0.01)	0	0	0-2 (0.8)	T
Mandi	0-1 (0.23)	0	0	0-2 (0.1)	0.3-10 (4.0)
Sirmour	0-1 (0.18)	0-5 (0.6)	0	0	0
Kinnaur	1-10 (2.15)	0	0	0	1-5 (1.5)
Lahaul-Spiti	3-36 (14.1)	T	0	0	0

* PTR = Purple Top Roll, T = Trace Figures in parenthesis are average disease incidence.

Source : Singh, B.P., R.A. Singh, R.P. Singh. 1986, Diseases. (24)

Table-3 : Disease situation in Lahaul Valley of Himachal Pradesh during 1983 and 1987.

Disease	Incidence in different valleys						
	Bhaga		Chandra		Pattan		Mayar
	1983	1987	1983	1987	1983	1987	1983
Common scab	22.8	66.3	16.4	40.9	—	55.5	35.0
Black scurf	12.5	27.8	7.6	40.4	—	32.5	15.0
Leaf spots	11.7	51.9	6.8	66.3	11.8	70.5	—
Early blight	8.15	13.5	3.9	18.5	8.1	20.7	2.5
Verticillium wilt	18.6	13.4	7.5	25.1	18.6	15.8	1.0
Sclerotinia wilt	—	7.3	—	7.6		6.2	7.0
Late blight	—	0.3	1.20	0.2		0.7	
Mild mosaic	12.7	6.1	11.3	6.6	5.3	22.3	9.5
Severe mosaic	5.4	5.6	5.0	4.9	4.8	15.8	3.5
Leaf roll	0.05	0.35	0	0.3	—	0.7	0
Total virus incidence	18.1	12.0	16.3	11.7	10.1	38.8	13.0

Based on data from :

Singh, B.P., R.A. Singh and R.P. Singh. 1986. Diseases. (24)

R.P. Singh 1987 (Personal communication).

Singh, B.P. and Hira Nand. 1988. (25)

Table-4 : Total rainfall and number of rainy days in hill districts of Himachal Pradesh.

District	January-February		March-May		June-September		October-December	
	Normal rainfall	No. of rainy days	Normal rainfall	No. of rainy days	Normal rainfall	No. of rainy days	Normal rainfall	No. of rainy days
Kinnaur	225.0	8.7	240.0	11.7	239.0	8.9	851.2	32.8
Kulu	NA*	NA	NA	NA	NA	NA	NA	NA
Lahaul-Spiti	139.4	8.0	145.9	9.0	59.1	6.5	372.9	29.0
Mandi	136.8	6.9	177.8	10.6	1228.3	45.0	1679.7	65.9
Shimla	177.9	6.3	182.7	7.4	835.8	34.5	1326.8	51.9
Sinnour	122.1	3.6	75.6	1.0	1425.8	41.9	1768.9	47.5
Solan	147.9	4.4	135.5	4.0	1132.2	42.8	1474.6	53.2

*NA = Not available

Source : Annual Season and Crop Report for 1984-85. (1)

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FERTILIZER USE IN POTATO CROP IN NORTH-WESTERN HILLS OF INDIA – PRESENT STATUS AND FUTURE STRATEGIES

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In India, potato is grown on 825,5000 hectares. Its average yield is 154.2 q/ha and compares well with the world average yield. Tuber yield in India is much less than that in Netherlands (430 q/ha). Thus there is a great scope to improve the potato yield in India. The yield is quite high in the states of Gujarat, Uttar Pradesh, West Bengal, Punjab and Haryana but it is relatively lower in the north-western hills, of Himacahl Pradesh, J&K and UP. The main reasons of low yield in this region are moisture stress and malnutrition. The studies conducted in Shimla under lab to land programme indicate that potato yield can be raised from 80 q/ha to 300 q/ha with the use of good quality seed and application of recommended doses of fertilizers. In Himachal Pradesh itself the crop yield is quite high in Lahaul valley where an average yield is of around 300 q/ha. The main reasons for this is adequate supply of organic manures and fertilizers to potato in Lahaul valley. The role of fertilizers in production of potato crop in the north-western hills is discussed in this paper.

Manurial requirements of potato crop are quite high and the application of fertilizers and organic manures is considered essential to obtain economic and high yields. Nitrogen is the first limiting nutrient for potato crop even in acidic brown hill soils of this region, but the application of phosphorus and potassium is also equally important for successful cultivation of this crop. The use of micronutrients, particularly that of zinc is also becoming essential for the balanced nutrition and optimum yield. The fertilizers are one of the costly inputs and their judicious use is required to increase their efficiency and thus reduce the cost of potato production.

Nitrogen : It is the first limiting nutrient as the acidic brown hill soils are deficient in it. In the event of its deficiency, lower leaves of the plant becomes yellow and later the whole plant gives yellowish appearance and the growth of the plant is stunted. Nitrogen improves the vegetative growth and increases the tuber number as well as tuber size. Potato crop removed about 120 kg N/ha and peak period of nitrogen absorption is between 60 to 80 days, which coincides with tuberization and early bulking period of the crop (20).

Response to nitrogen : Highly significant response of potato to N have been reported from Shimla region (4, 12). The N needs varied from 120 to 150 kg N/ha and the responses ranged from 80 to 120 q/ha.

The efficiency of N fertilizers depend upon the time and method of application. Split application of N is generally recommended for its better utilization and higher yields (4, 12). In acidic hill soil of Shimla, split application of 120kg N/ha from calcium ammonium nitrate (CAN) i.e. 2/3rd at planting

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and 1/3rd at earthing up was beneficial but the split application of 40 and 80 kg N/ha was not beneficial (12). The efficiency of urea was also increased by its split application in acidic soil of Shimla hills (19).

N fertilizers are mostly applied by broadcast before planting and mixed up with the soil. However, the application of these fertilizers in furrows and band placement is recommended for their better utilization because of limited and sparse root system of the potato plant. In acidic soils of Shimla, placement of nitrogen fertilizer either in furrows or side bands was superior to broadcast with respect to potato yield and nitrogen uptake by the tubers (12). The optimum dose was 101, 104 and 120 kg N/ha for furrows, band and broadcast application, which increased the potato yield by 237, 223 and 200 q/ha respectively. However, the application of high doses of nitrogen fertilizers in furrows should be avoided, as it adversely affects the plant emergence due to high osmotic pressure of soil solution. The fertilizers should not be allowed to come in direct contact with the seed tubers.

The value of foliar application of urea was assessed at Shimla where 1/4 of N applied through foliar sprays was as effective as the application of full dose of N to soil (1). The beneficial effect of foliar application of urea on potato was also reported by Sharma and Grewal (19). The foliar nutrition of urea can increase the efficiency provided there is enough vegetative growth. Therefore, the soil application of nitrogen is necessary for initial vegetable growth. Thus foliar application of nitrogen acts as supplement to soil application.

Ammonium sulphate and CAN are suitable nitrogen fertilizer for potato but urea which, accounts for 80% of the total nitrogen fertilizer production is inferior (4, 21). The efficiency of urea was increased by applying half of its dose to soil at planting and the other half as foliar sprays. The mixing of urea with neemcake in the ratio of 3 : 1 on nitrogen basis also improved its efficiency. The low efficiency of urea as compared to ammonium sulphate and CAN was due to its adverse effect on plant emergence due to accumulation of free ammonia and nitrite in the soil.

Organic manure like farmyard manure (FYM) is applied to potato production to improve nutrient supply as well as the physical condition of the soil. In temperate climate of hills, there is accumulation of organic matter through the application of organic manure but the rate of mineralization is very low. The application of FYM increases the potato yield but hardly reduces the nitrogen dose. The combined application of FYM along with full dose of nitrogen is recommended for optimum potato production.

The application of nitrogen fertilizer on the basis of plant test was studied in acidic brown hill soils of Shimla and Fagu (Shimla). The optimum nitrogen doses for top dressing were 120, 111, 69 and 46 kg N/ha when the basal dose of nitrogen at the time of planting time was 0, 40, 80, 120 kg N/ha respectively at Fagu. (Table 1). At Shimla, the optimum doses of N were 97, 83, 63 and 45 kg/ha respectively. These results indicate that top dressing of N decrease with the increase of basal dose of N at planting. The best results were achieved by applying 80 kg N/ha at the time of planting and 69 kg N/ha at earthing up at Fagu whereas at Shimla with 80 kg N/ha at planting time and 63 kg N/ha at earthing up. The N concentration in the plant leaflet at 40-45 days plant growth was most

appropriate for working out the nitrogen doses for top dressing. The nitrate nitrogen content in the petioles was slightly better than N concentration (Table 2). These results clearly indicate that top dressing N needs could be precisely worked.

Table-1 : Nitrogen dose for potato in acidic hill soils

Location	Basal dose (kg N/ha)	Tuber yield (q/ha)	Optimum dose at top dressing (kg N/ha)	Tuber yield (q/ha)
Fagu (Shimla)	0	202	120	324
	40	276	111	362
	80	333	69	392
	120	362	46	386
C.D. (0.05)		14		14
Shimla (H.P.)	0	100	97	175
	40	152	83	209
	80	197	63	235
	120	217	45	231
C.D. (0.05)		17		17

Source : Grewal and Sud (1988)

Table-2 : Nitrogen dose as top dressing on the basis of nitrate nitrogen in petioles

Location	NO ₃ -N (40-45 days)	Nitrogen dose at top dressing (kg N/ha)	Tuber yield response (q/ha)
Fagu (Shimla)	< 1.5	118	122
	1.5-2.0	96	108
	2.0-2.5	29	39
	> 2.5	—	No response
Shimla (H.P.)	< 1.5	97	75
	1.5-2.0	87	73
	2.0-2.5	71	68
	2.5-3.0	48	52
	> 3.0	16	22

Source : Grewal and Sud (1988)

Phosphorus : It is the second limiting nutrient for potato production in acidic soils of North Western hills. The inadequate supply of this nutrient to the crop retards the growth of the plants, particularly the terminal growth during the early stages of the development. Plants are dull dark green in colour, stunted in growth, their foliage is crinkly and their leaflets fail to expand normally. The vegetative growth continues beyond the normal time of maturity and the tuberization is delayed. The application of phosphorus (P) improves the shoot as well as root growth and hastens the crop maturity. The number of tubers per plant is also increased. The potato crop (35 t/ha) removes about 35 kg P₂O₅/ha (20).

Potato response to phosphorus : Highly significant potato response to P has been recorded in acidic brown hill soil of H.P. (4, 6, 8, 21, 31). The optimum P dose was 112 kg P_2O_5 /ha in acidic soils of Jogindernagar and Nihri of Himachal Pradesh (15). The application of 112 kg P_2O_5 /ha increased the potato yield 72.5 q/ha in acidic soils of Kangra (13). In Shimla region 100 kg P_2O_5 /ha was the optimum dose which increase the potato yield by 112 q/ha (4). The high P response in these soils was due to their high P fixing capacity causing low availability of this nutrient.

In long term manurial trial at Fagu (Shimla) the direct application of P (100 kg P_2O_5 /ha) was needed for the optimum potato yield (5). The application of 30t FYM/ha was also able to meet P requirements of the potato crop. The residual effect of the fertilizer was nearly 50% and that of farmyard manure 55% on succeeding crop. The recovery of P from fertilizer was 21, 15 and 6 per cent in annual, biennial and residual effects respectively. The annual application of 20kg P or 46 kg P_2O_5 /ha was able to meet the P requirements of the potato crop when applied alongwith 15t FYM/ha. (Table 3).

Table-3 : Effect of manurial treatments on tuber yield and uptake of P and K by tubers (1979-84)

Treatments	Tuber yield	Uptake of nutrients (kg/ha)	
		P	K
Control	224	9.9	77
20 kg P/ha	257	13.1	88
20kg P + 40 kg K/ha	330	14.1	121
40 kg P/ha	279	14.0	97
40 kg P + 80 kg K/ha	361	16.2	135
20 kg P + 15t FYM/ha	322	15.5	115
20 kg P + 40 kg K + 15t FYM/ha	382	16.7	146
40 kg P + 15t FYM/ha	338	17.2	122
15t FYM/ha	311	15.0	112
30t FYM/ha	353	16.0	130
C.D. (0.05)	22	1.7	16

Source : Grewal and Trehan, 1984

The response to P depends upon P supplying capacity of soils. For efficient and economic use, P application should be based on the available P content of soils (3). In acidic soils of Shimla the soil containing less than 16ppm available soil phosphorus by Olsen's method and 35ppm by Bray's methods were deficient in this nutrient for potato and phosphorus fertilization on these soils was required, for optimum potato yields (3). Organic carbon content of acidic soils of Shimla region was also good index for predicting potato responses to P application (22). The soil containing less than 1.3% organic carbon were low in available P and its applicaton was needed for the potato crop.

The placement of P near the active roots of the plants is considered to be the best for its efficient use because it is not mobile in the soil and is converted into slowly available forms by its reaction with the soil constituents. The application of P in side bands was better than broadcast and furrows application in acidic soils of Shimla (16). The later studies by Verma and Grewal (31) revealed that

P application increased the potato yield and P uptake by the tubers in acidic soil of Fagu. The furrow placement of single super-phosphate was significantly superior to broadcast and band placement (31). The efficiency of broadcast and band placement was 59 and 57 percent respectively as compared to furrow placement. The optimum doses of P were 94 kg P_2O_5 /ha by furrow placement and 119 kg P_2O_5 /ha by broadcast and band placement. The recent studies by Grewal and Sud (10) revealed that application of P in the furrows along with seed tubers was the best with respect to tubers yield (Table 4). The furrow placement of water soluble P carriers reduced its contact with the soil and thus results in less fixation of applied P as compared to broadcast and double placement. Moreover it is present in the active roots of the plants. In case of less soluble P carriers such as rock phosphate, bone meal, dicalcium and tricalcium phosphate, the broadcasting is recommended because the mixing with the soil helps to increase their availability to growing plants.

Foliar application of phosphorus fertilizers to potato crop was also found beneficial in acidic soils of Shimla. However, foliar sprays have not been taken up by the potato growers on a large scale. The soaking of mother seed tubers in 0.4% P solution of mono-ammonium phosphate or single super phosphate was quite effective in acidic soil of Fagu (Shimla) (23). The soaking treatment was able to meet 25% P requirement of the crop on highly P deficient acidic hill soils of this region. Later studies on this aspect revealed that the soaking of mother tuber in 1.5% single super phosphate + 0.5% urea + 0.2% Dithane M-45 solution for 4 hour was quite effective in meeting partly the P needs of the crop, depending upon the available P status of soil. In this technique mother tubers must be well dried in a shade after the soaking treatment and planting should be done on a sunny day. The application of single super phosphate fertilizers along with the small dose of FYM i.e. 5 t/ha improved the efficiency of phosphorus fertilizers by 13 to 24% (Table 5).

Table-4: Evaluation of placement methods on phosphorus fertilizer use efficiency by potato at Kufri (Shimla)

Treatments	Tuber yield (q/ha)	P_2O_5 uptake (kg/ha)
Control	156	13.7
2-3cm below seed tubers		
50 kg P_2O_5 /ha	220	17.8
75 "	247	24.3
100 "	255	23.2
Along the seed tubers		
50 kg P_2O_5 /ha	238	21.9
75 "	264	25.8
100 "	258	24.3
2-3cm above seed tubers		
50 kg P_2O_5 /ha	214	19.6
75 "	242	22.0
100 "	249	23.3
C.D. (0.05)	16	—

Source : Grewal & Sud (1988)

Table-5 : Effect of farmyard manure on phosphorus fertilizer use efficiency by potato at kufri (Shimla)

Treatments	Tuber yield (q/ha)	P ₂ O ₅ uptake (kg/ha)
Control	172	15.7
FYM 5t/ha	197	20.4
50 kg P ₂ O ₅ /ha	232	24.3
75 kg P ₂ O ₅ /ha	249	25.5
100 kg P ₂ O ₅ /ha	259	25.8
50 kg P ₂ O ₅ + 5t FYM/ha	255	24.7
75 kg P ₂ O ₅ + 5t FYM/ha	270	26.2
100 kg P ₂ O ₅ + 5t FYM/ha	272	28.1
C.D. (0.05)	12	1.33

Source . Grewal & Sud (1988)

In acidic soils of Kangra district of Himachal Pradesh, the relative efficiencies of superphosphate, multiphosphate, deflourinated phosphate, fused magnesium phosphate and rockphosphate were 100, 83.3, 88.7, 74.6 and 61.9% respectively (17). The efficiency of mixture of rockphosphate and superphosphate applied in the ratio of 1:1 was 95% that of superphosphate alone. In acidic brown hill soil of Fagu, the water soluble P fertilizers like superphosphate, DAP and MAP was suitable for potato and rockphosphate was not (25). The later studies on acidic soil of Kufri (Shimla) revealed that water soluble forms of P such as superphosphate and sodium pyrophosphate were suitable for potato (14). The application of water soluble P fertilizers is required to meet high P needs of the potato crop in a short duration through sparse root system.

The utilization of applied P fertilizers and manure by potato crop seldom exceeds 15% and rest of it is converted into slowly available forms such as Al-P, Fe-P and Ca-P, depending upon soil chemical properties. These slowly available forms of P are utilized to some extent by the succeeding crops. In acidic brown hill soil of Fagu the application of 100 kg P₂O₅/ha from superphosphate or FYM to potato for four years increased the available P by 20.0 ppm (6). The increase in available soil phosphorus with FYM was comparatively more than that with P fertilizers. In long-term manurial trial on acidic soil of Fagu, the residual effect of P applied to potato through superphosphate and FYM was nearly half of their direct effects (5). These results indicate that residual effect of P fertilizers is quite marked on the succeeding crop but fresh application of P is needed for potato every year.

Potassium : K is third limiting nutrient. Its application alongwith N and P is needed in most of the soils for getting optimum yield. A potato crop removed, on an average, 230 kg K₂O/ha in this region (20). A continuous supply of K for normal growth of potato is needed although, the critical period is between 60 to 85 days after planting. The deficiency of K retards the plants growth and shortens the internode. In early stages its deficiency results in bluish green foliage and later leaves become necrotic, yellowish and brown. In case of acute K deficiency bronzing, drying up of the leaf margins and premature death of plant occurs. The plants with sufficient K are characterised by broad light green

shinning leaves. K improves the vigour and efficiency of the plant. It also increase the plant resistance to frost and diseases.

Response to K : The response to K have been recorded in many studies in this region (2,4). The recommended dose of K is 100 kg K_2O /ha which increased the crop yield by 50 to 60 q/ha. K generally increases the size of the tubers (26). However, the response to K differs with the K supplying capacity of the soil. The available K determined by neutral normal ammonium acetate and Morgan's reagent was good index for judging K supplying capacity of soils (4). The critical limits of available K in these soils for getting economic response are 120 ppm by normal neutral ammonium acetate and 65 ppm by Morgan's method. The soils containing less than 2 per cent ready oxidisable organic carbon can also be considered deficient in available K (22).

The potato plant needs K right from the early stages but its deficiency symptoms on leaves are generally noticed at tuber enlargement stage when tubers start competing with leaves. The foliar application of potassium and its top dressing to soil at later stage was not found better than soil application before planting. (2). The K application at the time of planting was found suitable by Pushkarnath and Patil (16) in Shimla hills. They recommended split application of K if weather is dry and not favourable for plant growth at the time of planting. The furrow application of K at planting was the best followed by band placement and broadcast at Fagu (11, 32). The K doses were 91, 83, and 120 kg K_2O /ha by furrow placement, band placement and broadcast respectively, which increased the potato yield by 83, 73 and 63 q/ha respectively at Fagu. The efficiency of broadcast and band placement of K was 58 and 96 per cent that of furrow placement. The recent studies by Grewal and Sud (10) show that furrow placement of K near the tuber increased its efficiency by 32% (Table 6). The application of K fertilizer alongwith the 5 t FYM/ha improved the efficiency of the fertilizer considerably (Table 7) (1).

Potassium chloride and potassium sulphate are the two main fertilizers used in potato production in deficient soil. The sulphur form of potassium is preferred over the chloride form because chloride ions have an adverse effect on tubers quality. The application of potassium sulphate gave more response than potassium chloride on soils deficient in sulphur (25). Potassium chloride is 50% less costly than the potassium sulphate. The apparent recovery of potassium is about 40 to 50% (11, 32). The rest of the potassium is converted in exchangeable and non-exchangeable forms in the soils which can be utilized to some extent by the succeeding crops (2,24).

Micronutrients : With the adoption of high yielding cultivars, high analysis NPK fertilizers, less use of organic manures, deficiency of micro nutrients is increasing. About 76% of the potato growing soils of Shimla region of Himachal Pradesh were deficient in Zn (29). The deficiency of Cu is also reported from farmer's fields. Micronutrients deficiency in potato plants can be diagnosed by visual symtoms and by soil and plant test.

Table 6 : Evaluation of placement methods on potassium fertilizer use efficiency by potato at Kufri (Shimla)

Treatments	Tuber yield (q/ha)	K ₂ O uptake (kg/ha)
Control	212	103
2-3cm below seed tubers		
50 kg K ₂ O/ha	284	133
75 "	295	145
100 "	282	124
Along the seed tubers		
50 kg K ₂ O/ha	289	142
75 "	318	160
100 "	282	138
2-3cm above seed tubers		
50 kg K ₂ O/ha	284	131
75 "	290	143
100 "	285	141

Source : Grewal & Sud (1988)

Table-7 : Effect of farmyard manure on potassium fertilizer use efficiency by potato at kufri (Shimla)

Treatments	Tuber yield (q/ha)	K ₂ O uptake (kg/ha)
Control	158	63
FYM 5t/ha	199	91
50 kg K ₂ O/ha	215	96
75 kg K ₂ O/ha	225	107
100 kg K ₂ O/ha	207	87
50 kg K ₂ O + 5t FYM/ha	228	102
75 kg K ₂ O + 5t FYM/ha	260	132
100 kg K ₂ O + 5t FYM/ha	242	113

Source : Grewal & Sud (1988)

Plant and soil test : The micronutrient deficiency symptoms appear in extreme cases of deficiency. Mostly, there are hidden hunger signs which can be detected only by chemical analysis of soils and plant tissues. The soil containing less than 0.55% ppm available zinc by DTPA method was deficient (29). In potato leaves the critical limit of Zn was nearly 30 ppm at Shimla (30). The soil and plant analysis can be of great help in diagnosing hidden micronutrient deficiencies in potato plants.

Response to micronutrients : Potato response to micronutrient application have been recorded by number of workers. Foliar application of 0.75% FeSO₄ increased the potato yield by 27 q/ha at Kufri (27). In acidic brown hill soil of Kangra district of Himachal Pradesh, application of 33.6 kg FeSO₄/ha increased the potato yield by 30.8 q/ha (13). The application of 5kg Zn/ha from ZnSO₄ increased the potato yield by 34 q/ha in acidic soil of Shimla (9). ZnSO₄ is better source of Zn than ZnO for soil application. The application of farmyard manure at 10 t/ha was able to meet the Zn requirement of

potato crop. The application of 50 kg MnSO_4 /ha increased the potato yield by 45 q/ha at Shimla (7). The Zn-P interaction in acidic brown hill soil of Shimla was also reported by Trehan & Grewal (29). Hence balanced application of both the nutrients was needed.

Amelioration of micronutrient deficiency : The micronutrient deficiency in potato can be met by their soil or foliar application or seed tuber treatment. The efficiency of soil applied micronutrient is comparatively low because the major portion of applied micronutrients is converted to unavailable forms. The application of high dose of micronutrient every year to the crop may create imbalance or its toxicity in soil which may be detrimental to plant growth. In foliar sprays, the plants are likely to suffer in case of their acute deficiency. The treatment of seed tuber with micronutrients could be effective method of their application because of the high seed rate in potato. The soaking of seed tubers in 0.05% micronutrient solution (Zn, Cu, Fe and Mn) increased the potato yield significantly in acidic brown hill soil of Shimla (18). The dipping of seed tuber in 2 percent ZnO suspension was the best with respect to tuber yield and zinc uptake in acidic soil of Shimla (28). These studies indicate that micronutrient can be applied effectively through seed tuber treatment. However, soil application of micronutrient is effective if their deficiency is well established in soil and foliar application if their deficiency is noticed in plants.

Fertilizers are one of the costly inputs in potato production. The total production of fertilizers in India are 5.46 million tonnes of N and 1.67 million tonnes of P (P_2O_5). The consumption of fertilizer is 5.78 million tonnes of N, 2.3 million tonnes of P (P_2O_5) and 90 million tonnes K (K_2O). The average consumption of fertilizers on all India basis is 32.9 kg N, 13.1 kg P_2O_5 /ha and 5.3 kg K_2O /ha. However, in north-western hill region the consumption of fertilizer is much lower than that of national average in India. In Himachal Pradesh it is 18.4 kg N, 4.2 kg P_2O_5 and 3.2 K_2O /ha. The total NPK consumption is 25.6 kg/ha (Table 8). Similarly in Jammu and Kashmir the total consumption of NPK is 37.0 but in UP the consumption is 69.1 kg NPK/ha. In the hill region of the State the consumption of fertilizer is comparable to Himachal Pradesh. The consumption in the plains particularly in Punjab is quite high i.e. 159.3 kg/ha. Keeping in view of the low fertilizer consumption in the north-western hills of India, it is but natural that production of potato and other crops is low. As discussed earlier for optimum potato production application 120 to 150 kg N, 100 kg P_2O_5 and 100 kg K_2O is needed in this region i.e. total consumption NPK fertilizers should be around 300-350 kg/ha. It is more than 10 times of present consumption. It is hoped that the potato growers of this region will improve potato fertilizer consumption in the coming years alongwith the other cultural practices and disease and pests control to improve potato production as the farmers are doing in Lahaul valley of Himachal Pradesh.

Table-8 : Consumption of plant nutrients from fertilizer (kg/ha) of gross cropped area (1987-88)

	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)	Total
1. Jammu & Kashmir	27.3	7.8	1.9	37.0
2. Himachal Pradesh	18.4	4.2	3.2	25.6
3. Punjab	112.8	42.3	4.2	159.3
4. Haryana	54.2	16.0	0.9	71.6
5. Uttar Pradesh	48.6	15.8	4.7	69.1
6. All India	32.9	13.1	5.3	51.3

Source : Fertilizer News, August 1988.

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Fertilizer use in potatoes crop in NW hills of India

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