INDIAN POTATO ASSOCIATION

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THE INDIAN POTATO ASSOCIATION

(Registerd under the Societies Registration Act. XXI. 1960)

The Society was founded in 1974 with the objectives :

(1) To advance the cause of potato research and development, culture and utilization.

(2) Provide opportunity for personal contact and fellowship among workers in different fields embracing the potato.

(3) Hold periodical conferences, symposia, workshops,

(4) Publishing books, reports, summaries of papers and other forms of scientific and technical literature, Potato Newsletter and the Journal of the Indian Potato Association.

(5) Co-operate with institutions in India and abroad and societies having similar objectives and field of activities.

(6) Promote exchange of scientific and other information and develop other means of communication between the potato agriculture and Industry.

(7) Foster Regional and International cooperation/collaboration in attainment of the objectives outlined.

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SUGGESTIONS TO THE CONTRIBUTORS

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2. All manuscripts submitted for publication will guide the Editors as to the acceptability and any necessary modicification required. A paper already published or under consideration for publication, wholly or substantially elsewhere, cannot be accepted.

3. Manuscripts must be in English, type-written, double spaced with at least 4 cm margins, on one side, on good quality paper and should be submitted in duplicate. A short running title be provided on a separate sheet in addition to the full title of the paper.

4. Full length paper should consist of Abstract, Introduction, Materials and Methods, Results & Discussions, Acknowledgement and Literature Cited.

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8. Diagrams should be drawn with black India ink on pale blue lined graph paper, transparent paper or white card sheets about twice the size of the finished block. Shading must be indicated by lines or dots. All lettering should be inserted in pencil outside the diagrams. Photographs must be black and white with adequate contrast and printed on white, glossy paper to allow for 1/4 to 1/2 reduction. Each table diagram and photograph must have a caption. Diagrams and photographs are taken together as figures and are numbered serially as Fig. 1 and Fig. 2 etc. Tables and figures with their captions should be submitted separately from the text in which only their eventual position should be indicated.

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1. Khurana, S.M. Paul, G.S. Shekhawat and B.B. Nagaich, 1983. Light microscopy of potato plants for detection of three mycoplasmal disease. J Indian Potato Assoc. 10 : 60-63.

2. Dixon, M. and E.C. Webb. 1964. Enzymes, 2nd Edn. pp. 562-64. Longmans Green, London.

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

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Contents

Padma Bhushan Prof VL Chopra, New Chief Patron of the Association

With a new leadership comes a new vision and direction. Hopes are high that Prof Chopra can move the ICAR and IPA to greater heights of achievement. Prof Chopra is one of the most innovative, successful, and personally self motivated agricultural scientist.

The honours and awards that Prof Chopra has received are a testimony to his years of professional success. He is the Fellow of the Third World Academy of Sciences, Trieste, Italy; Member Council, INSA, New Delhi; Vice-President, Society for Advancement of Breeding Researches in Asia and Oceania (SABRAO), and Vice-Chairman, International Board for Plant Genetic Resource (IBPGR), Rome, President of the International Genetics Federation during 1983-88; Honorary Vice-President and Secretary General of the 15th International Congress of Genetics in 1983; and Secretary, Indian Society of Genetics and Plant Breeding during 1977-1989. He has many national and international awards to his credit. These include the Borlaug Award (1983), NOPEX Award for Professional Excellence (1984), Padma Bhushan (1985), Outstanding Achievement Award of the FICCI (1986), Honor Summus Medal of the Watumul Foundation, USA (1987), Shri Om Prakash Bhasin Award for Science and Technology (1987) and INSA Silver Jubilee Commemoration Medal (1991).

Professor Chopra was born at Adhwal (now in Pakistan) on August 9, 1936; obtained BSc (Honours) Degree in Agriculture from the Delhi University in 1955, Associateship from IARI in 1957, and PhD from the University of Edinburgh, UK in 1967. He then joined IARI and had a distinguished career including Professor of Genetics during 1970-84 with additional charge of Head, Division of Genetics during 1974-75 and 1977-89. He was founder Director and Professor of Eminence in 1985-1990 of Biotechnology Center, IARI, New Delhi which has now acquired international status. During 1990-91 as an FAO Consultant/Chief Technical Advisor to the Government of Vietnam, he was responsible for establishing the Institute of Agricultural Genetics at Hanoi.

On the 14th of January, 1992 Professor Chopra took charge as the Secretary, DARE, Ministry of Agriculture, Government of India and Director General, ICAR.

Major Scientific Contributions

I. Mutagenesis :

On the basis of cytogenetic analysis in plant systems and genetic investigation in *Drosophila melanogaster* and *Escherichia coli*, the ionising radiation was established to cause major biological effects indirectly through media and food.

Protocols for realizing economically useful mutants that produce least physiological damage, were standardized and useful mutants selected for desirable grain quality and rust resistance in wheat; and with better partitioning of photosynthates through alterations of plant architecture in barley.

In *Azotobacter* - a free living nitrogen fixing bacterium, stable biochemical markers for amino acid and adenine requirements, drug resistance and nitrogen fixation were induced and characterised.

II. Studies on disease resistance in wheat

New source and genes were identified for resistance to rusts and hill bunt.

Mutants were induced in wheat variety "Karchia Local" which confer resistance against all brown and black rust races available in India and against experimentally constructed virulences in Austriala, Canada and USA.

Concepts and operational procedures for incorporating durable resistance have been devised.

III. Biotechnology of *Brassica* species

Genetic transformation in *B. carinata* through *Agrobacterium* mediated gene transfer and molecular characterization of alien integrate.

Molecular mapping, including that of somaclones through RFLP analysis in *B. Juncea.*

Generation of somaclonal and protoclonal variation in *B. juncea* and *B. carinata* as an aid to create novel variability.

Resynthesis of *B. carinata* by protoplast fusion and recovery of noval cytoplasmic hybrids.

Somatic hybridization between *Brassica* spp and other allien plant species have been achieved for conferring resistance to biotic/abiotic stresses.

Chlorophyll dificiency defect of *B. juncea* male sterile line was rectified with *B. oxyrrhina* cytoplasm through chloroplast substitution.

Development of alloplasmic male sterile lines of *B. compestris*, *B. juncea* and *B. napus* with cytoplasm of wild allied species *B. oxyrrhina* and also by substituting *B. juncea* cytoplasm by *Diplolaxis siettiana*, *Moricandia arvensis* and *Trachystoma balli.*

IV. Varietal development

In Wheat, varieties DL-20-9 for Northern zone and HW 657 for Peninsular zone have been developed and released.

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Effect of Irrigation on Yield and Water Relations of Some Exotic and Indigenous Potato Varieties

M.S. Khan[1], M.S. Islam[2], U.K. Saha[3] and H. Kabir[4]

ABSTRACT : Field experiments were conducted in Grey Terrace soil of Joydebpur and Grey Flood plain soil of Munshiganj, Bangladesh to study the yield and water relations of three exotic (Cardinal, Patrones and Kufri Sindhuri) and three indigenous (Zaubilati, Lalpakri and Dohazari) potato varieties as influenced by three different irrigation levels (0, 1 and 2 irrigations). The exotic varieties yielded higher than the indigenous ones. Tuber yield increased significantly with increasing irrigation number. The yield response to irrigation was more pronounced in exotic varieties as compared to indigenous varieties. Soil water depletions (SWD) was increased with decreased irrigation level and was higher in indigenous varieties under any given irrigation. Total water expense by potato was higher in indigenous varieties and showed an increasing trend with increased supply of irrigation water. The exotic varieties were found to be more efficient in water utilization.

INTRODUCTION

The potato *(Solanum tuberosum* L.) is grown in Bangladesh during the winter months. Rainfall during this period is scanty and often uncertain. Practically, successful production of the crop depends largely on suplemental irrigation. Various earlier investigations summerized the necessity of frequent irrigation for good growth and yield of potato (1,2,4,7). Varietal differences with regard to irrigation water is also well known (5). Thus, precise information on the effect of irrigation water on the performance of exotic and indigenous potato varieties might be useful. The study was therefore undertaken to elicit this information.

MATERIALS AND METHODS

Field experiments were conducted at two locations namely, Joydebpur and Munshiganj representing Grey Terrace and Grey Flood plain soils of Bangladesh. Some important properties of the experimental soils relevant to the present study are given in Table 1.

Three exotic (Cardinal, Patrones and Kufri Sindhuri) and three indigenous (Zaubilati, Lalpakri and Dohazari) potato varieties were tested at three levels of irrigation (0,1 and 2 irrigations). The experimental design was split-plot with three replications having irrigation treatments in the main-plots and varieties in the sub-plots. In single irrigation

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Table 1. Properties of the experimental soils

Soil properties	Experimental Locations	
	Joydebpur	Munshiganj
Sand (%)	18.4	61.3
Silt (%)	45.6	22.0
Clay (%)	36.0	16.7
Soil texture	Silty Clay Loam	Sandy Loam
Soil type	Grey Terrace soil	Grey Flood plain soil
Soil pH	6.2	5.8
Bulk density (g/cc)	1.4	1.3
Field capacity (Vol. %)	38.9	33.6
Wilting point (Vol. %).	17.9	15.2

treatment, 4.0 cm water was applied at stolon initiation and in case of two irrigation treatment, 4.0 cm of water was applied at stolon initiation and another 4.0 cm at bulking stage. Well sprouted 30-40 g tubers were planted at 60 cm X 20 cm spacing in 5.4m X 3.6m plot. The crop received fertilizers @ 150 kg N from urea, 60 kg P_2O_5 from triple super phosphate, 150 kg K_2O from muriate of potash, 20 kg S from gypsum and 5 kg Zn from zinc oxide per hectare. Except N, all the fertilizers were applied at planting. Soil water depletion (SWD) was computed from the periodic (at 15 days interval) moisture monitoring data of the crop root zone. Total water expense was expressed as the sum of irrigation water, rainfall (6.5 mm and 8.2 mm at Joydebpur and Munshiganj respectively) and SWD. Water expenses efficiency (WEE) was calculated as described by Cassel et al. (3).

RESULTS AND DISCUSSION

The data presented in table 2 revealed that at both the locations, the highest tuber yield was obtained from Cardinal (22.24 and 22.16 t/ha at Joydebpur and Munshiganj, respectively) which was significantly higher than other two exotic and three indigenous varieties. The yields of different varieties were in the order of Cardinal > K. Sindhuri > Patrones > Lalpakri > Zaubilati > Dohazari. Significant increase in yield in response to irrigation was found upto two irrigations at both locations (Table 2).

The interaction effect of irrigation and variety on tuber yield was also significant (Table 2). Different varieties responded differently. The yield increase over control due to one irrigation in exotic varieties ranged from 17 to 25% at Joydebpur and 18 to 32% at Munshiganj while, the same did not exceed 14% in indigenous varieties. The yield of exotic varieties increased by 31 to 41% over control due to two irrigations at Joydebpur and 31 to 46% at Munshiganj. Thus, yield response to irrigation was more pronounced in exotic varieties than indigenous ones.

Table 2. Main effects and interaction effect of irrigation and variety on tuber yield (t/ha)

Varieties	Joydebpur				Munshiganj			
	No irri-gation	One irri-gation	Two irri-gation	Mean	No irri-gation	One irri-gation	Two irri-gation	Mean
Cardinal	15.81	19.81	22.24	19.28	18.51	22.89	25.07	22.16
Patrones	14.25	16.70	18.62	16.52	15.62	18.49	20.46	18.19
Kufri Sindhuri	15.60	18.85	21.81	18.75	15.93	21.15	23.29	20.12
Zaubilati	9.75	10.38	11.75	10.63	9.07	9.96	10.94	9.99
Lalpakri	9.84	11.13	11.96	10.98	9.32	10.40	11.15	10.29
Dohazari	8.56	9.78	9.98	9.24	7.87	8.37	9.52	8.59
Mean	12.30	14.44	16.06	—	12.72	15.21	16.74	—
LSD (0.01)								
Irrigation				0.99				1.06
Variety				0.79				1.37
Irrigation × Variety interaction				1.44				2.23

The water expense and water expense efficiency (WEE) of different potato varieties under various irrigation levels are presented in Table 3. As expected, the soil water depletion (SWD) increased with decreased supply of irrigation water irrespective of varieties. The SWD was lower in exotic varieties as compared to indigenous ones at any irrigation level. The exotic varieties had greater canopy coverage which supposedly increased the rate of transpiration. But this effect might have nullified by the increased shading and subsequent reduction in soil water evaporation to a greater extent (6). The total water expense by potato was linearly related to increasing supply of irrigation water. The varieties also showed differences in their total water expense to some extent. The exotic varieties expensed comparatively lower amount of water than indigenous ones. Such results were due to differential SWD from their plots. The total water expense ranged from 16 to 24 cm at Joydebpur and 18 to 26 cm at Manshiganj in different varieties and irrigation levels. The WEE was higher in exotic varieties than indigenous ones. At Joydebpur, the highest WEE was observed for Cardinal under one irrigation (1.13 t/ha/cm). At Munshiganj, the variety Cardinal recorded the highest WEE (1.14 t/ha/cm) which was the same for all the irrigation levels.

From the results, it can be concluded that the exotic and indigenous varieties differed in their yield potential, response to irrigation and water relations. Thus, there is a need to consider the variety grown while supplying irrigation water.

Table 3. Water expense and water expense efficiency of different potato varieties

Irrigation frequency	Varieties	Soil water depletion (cm)		Total water expense (cm)		Water expense efficiency (t/ha/cm)	
		Joydebpur	*Munshiganj*	*Joydebpur*	*Munshiganj*	*Joydebpur*	*Munshiganj*
0	Cardinal	9.2	9.8	15.7	18.0	1.01	1.14
	Patrones	9.8	10.0	16.3	18.2	1.14	0.96
	Kufri Sindhuri	9.4	10.4	15.9	18.6	0.98	0.86
	Zaubilati	10.8	12.0	17.3	20.2	0.56	0.45
	Lalpakri	10.2	12.2	16.7	20.4	0.60	0.46
	Dohazari	11.5	12.6	17.9	20.8	0.44	0.36
1	Cardinal	7.1	7.9	17.6	20.1	1.13	1.14
	Patrone's	7.5	8.2	18.0	20.4	0.93	0.86
	Kufri Sindhuri	7.7	7.8	18.2	20.0	1.04	1.06
	Zaubilati	9.4	10.8	19.9	23.0	0.52	0.43
	Lalpakri	9.1	10.6	19.6	22.8	0.57	0.46
	Dohazari	10.0	11.0	20.5	23.2	0.48	0.36
2	Cardinal	6.0	5.8	20.5	22.0	1.08	1.14
	Patrones	6.4	6.0	20.9	22.2	0.89	0.92
	Kufri Sindhuri	5.9	6.1	20.4	22.3	1.07	1.04
	Zaubilati	8.2	9.2	22.7	25.4	0.52	0.43
	Lalpakri	7.9	9.3	22.4	25.5	0.57	0.44
	Dohazari	9.0	9.8	23.5	26.0	0..42	0.37

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Influence of Organic Manures and Nitrogen Levels on Nutrient Status, Translocation, Yield and Tuber Quality in Four Potato Based Cropping Systems*

K.C.Sud[1], R.C. Sharma[1] and P.M. Govindakrishnan[2]

ABSTRACT : The effect of organic manures and nitrogen was studied on potato in rotational cum manurial experiment being conducted since 1977 at Jalandhar during 1980-81. Application of organic manures in maize-potato (FYM)-wheat and GM-potato-wheat rotations had a significant effect on nutrient concentration, uptake, tuber and haulms yields upto 180 kg N/ha. Significant response to N was obtained upto 180 kg N/ha and yield increase was upto 129 q/ha. It had a positive effect on nutrients removal by haulms and tubers. The percentage of photosynthates translocated from haulms to tubers were less affected by organic manures and cropping systems whereas N rates decreased them. Nitrogen recovery by tubers was highest in maize-potato-wheat rotation and lowest in GM-potato-wheat. N rates increased true proteins (30.0%), crude proteins (49.2%), sugars (9.4%), and ascorbic acid content (7.9%). There was positive association between tuber yield and true proteins (0.718**) but negative with tuber K content (-0.643**)

INTRODUCTION

Potato (*Solanum tuberosum* L.) is an important crop in North western plains of India where it is grown under short day conditions during winter months. Potato yields as well as tuber quality depends upon the application of organic manures, fertilizer rate and also cropping systems. Most of the studies have been related to the harnessing the yield potential through fertilizer application (1, 6, 10, 12). Little information is available on the quality characters, like proteins, sugars, starch and ascorbic acid content. Study was therefore carried out on alluvial soils of Jalandhar (Ustochrept) to investigate the role of organic manures and nitrogen levels on the tuber yield and quality parameters in four cropping systems.

MATERIALS AND METHODS

A long term rotational cum manurial trial was started on sandy loam soil (pH 7.92) of Jalandhar in 1977. Split plot design taking twenty treatments consisting of combination of 4 cropping systems i.e. maize-potato (FYM)-wheat, GM (*Sesbania aculeata*) -potato-wheat, maize-potato-wheat and fallow-potato-wheat in main plots and 5 nitrogen levels i.e. 0, 60, 120, 180 and 240 kg N/ha in sub plots was followed with four replicates. Soil contained organic carbon (0.35%), $K_2Cr_2O_7$-Oxidisable N (270 ppm), Olsen P(15 ppm) and ammonium acetate-K (155 ppm).

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Leaf samples (4th leaf from top of main shoot) were collected at 50 days after planting during 1980-81. At harvest, haulms were collected from each plot, and fresh weight was recorded. Fresh chopped material (500g) was dried at 80°C in an oven to get per cent dry matter in haulms and dry matter yield of haulms was calculated. Composite tuber samples representing large, medium and small size were taken at harvest and washed. For determination of dry matter content, 50g of well chopped material was dried at 80°C for 48 hours. Fresh tuber material was analysed for starch, reducing and total sugars (15). Crude protein was determined by multiplying the total N determined by rapid chromic acid method of Sharma and Sud (7) by factor 6.25. True protein in fresh material was determined by dye binding procedure of Swaminathan *et al.* (13). Ascorbic acid in fresh tubers was determined colorimetrically using 2-4 dinitrophenylhydrazine (5). P and K in dry tubers, haulms and leaves material were determined in triacid digest (2). Nutrients uptake was calculated by multiplying nutrient concentration in haulms or tubers with respective dry matter yield. Simple correlation between yield and quality parameters were worked out (4).

RESULTS AND DISCUSSION

Tuber Yield : Application of 30t FYM/ha in maize-potato (FYM)-wheat system resulted in highest potato yield and lowest yield was in fallow-potato-wheat system (Table 1). Nitrogen application upto 180 kg N/ha had a significant effect on potato yield as well as haulms yield. The results are in accordance with the findings of Singh and Sharma (10). Interaction effects were non significant.

Nutrient composition : Green manuring with Dhaincha *(Sesbania aculeata)* before potato had a positive effect on N concentration in leaves, haulms and tubers (Table 2). Application of FYM was better than GM in increasing the P and K content in haulms and tubers. Similar increase was observed in maize-potato-wheat system. Beneficial effects of farmyard manure and green manure on nutrient concentration in potato have also been reported by Singh and Sharma (10) and Sud *et al* (12). N application resulted in linear increase in N and P content in potato leaves at 50 days of plant growth but leaf K was less affected by N rate (Table 2). The increase in P can be attributed to the better plant canopy and increased root growth with increasing N rate during early stage of growth (14). In haulms and tubers, applied N increased the N content by 25.8 and 42.7 per cent respectively over control (Table 2). Similarly N application increased P content in haulms. Higher levels of N decreased K content in haulms and tubers. Similar results have been reported by Sud *et al.* (11).

Nutrient uptake : Cropping systems as well as N fertilization had a significant effect on total nutrient uptake by haulms and tubers (Table 1). The N and P uptake was lowest in a fallow-potato-wheat whereas K uptake by tubers and total nutrient uptake was maximum in maize-potato (FYM)-wheat system (Table 1). The highest K-uptake in maize-potato (FYM)-wheat system was due to additional K supplied by 30t

Table 1. Effect of cropping systems and nitrogen levels on yield, nutrient uptake and photosynthates translocation by potato

	Tuber Yield (q/ha)	Haulms dry matter yield (q/ha)	Nutrient uptake by tubers (kg/ha)			Total Nutrient uptake (kg/ha)			Translocations (%)			
			N	P	K	N	P	K	Dry matter	N	P	K
Cropping System												
Maize-Potato (FYM) - Wheat	280	10.1	84	13.4	107	108	15.7	145	82.9	77.8	85.4	72.8
GM-Potato-Wheat	262	9.4	86	13.1	98	111	15.4	122	84.2	77.5	85.1	80.3
Maize-Potato-Wheat	238	8.1	85	13.4	87	103	15.3	109	85.0	82.5	87.6	79.8
Fallow-Potato-Wheat	244	8.7	79	11.9	89	98	13.7	114	84.3	80.6	86.9	78.1
N levels (kg N/ha)												
0	157	4.0	36	8.2	70	44	9.1	83	88.0	81.8	90.1	84.3
60	246	7.9	65	12.1	97	79	13.7	123	85.3	82.2	88.3	90.2
120	282	10.4	92	14.7	111	116	17.0	141	83.9	79.3	86.5	78.7
180	296	11.2	115	14.7	103	146	17.5	135	83.3	78.8	84.0	76.3
240	300	11.9	109	15.0	96	140	18.0	128	81.8	77.9	83.3	75.0
C.D. (0.05)												
Cropping system	11.8	1.5	4.4	0.6	4.5	7.6	0.9	7.1	—	—	—	—
N levels	9.7	0.9	3.2	0.5	3.8	4.6	0.6	5.7	—	—	—	—
Cropping system X N levels	NS	NS	6.4	1.0	7.7	9.1	1.2	11.4	—	—	—	—

farmyard manure. Nitrogen application upto 180 kg N/ha significantly increased the total nutrients uptake. The significant increase in N-uptake was observed upto 180 Kg N while that for P and K significant effects were only upto 120 kg N/ha (Table 1). Average uptake for N, P and K was 76.3, 7.12 and 49.5 kg/ha. N application above 120 kg N significantly decreased total K uptake and K uptake by tubers. The percentage of photosynthates translocated from haulms to tubers decreased with increasing N rates. However, organic manures application had less effect on photosynthates translocation in tubers. Nearly 85% of nutrient translocation was obtained in tubers.

Nitrogen recovery (determined by differential method) by tubers was highest in maize-potato-wheat rotation (53.8 per cent) followed by maize-potato (FYM)-wheat (42.4%) and 43.0% obtained in fallow-potato-wheat system. It was lowest in GM-potato-wheat (30.5%). Low recovery in GM-potato-wheat system could be attributed to the contribution of N from GM crop to the soil. Total N recovery (tubers and haulms) followed similar trend. N recovery by tubers at 60, 120, 180 and 240 kg N/ha was 48.9, 46.8, 43.8 and 30.6% respectively, however, total N recovery was (58.3%) at 180 kg N/ha and decreased to 40.1% at 240 kg N/ha.

Tuber quality : Among crop sequences, tubers obtained from maize-potato (FYM)-wheat system recorded lowest dry matter content i.e. 17.54% (Table 3). Application of farmyard manure to potato adversely affected starch and reducing sugar content. Compared to maize-potato (FYM)-wheat and fallow-potato-wheat systems, tubers from GM-potato-wheat and maize-potato-wheat showed higher concentration of proteins. Total and reducing sugar content in tubers was less affected by cropping systems exception being maize-potato (FYM)-wheat.

Nitrogen application upto 120 kg N/ha increased tuber dry matter, ascorbic acid and starch content, however N application at 180 and 240 kg N/ha decreased them. The adverse effect of high N rate on dry matter, starch and ascorbic acid content have also been reported by Shukla and Singh (9). Its application significantly increased both crude and true protein content in tubers by 49.2 and 30.0% respectively (Table 3). The results confirmed the findings of Gupta and Saxena (1), Sud *et al.* (11) and Sharma & Arora (8). Like proteins, N application increased total and reducing sugars by 9.4 and 46.3%. Kamal *et al.* (3) have also reported positive effect of N on sugar content in tubers.

Relationship between tuber yield and quality parameters : There was negative correlation between tuber yield and dry matter, starch, tuber P and K content, the correlations being significant with tuber K content only (-0.643**). A highly significant association existed between tuber yield and crude protein (0.750**), true proteins (0.718**) as well as with reducing sugar (0.658**). Total sugar content as well as ascorbic acid though were positively correlated with yield but correlation values were

Table 2. Effect of cropping systems and nitrogen levels on potato composition (per cent)

	Tubers			Haulms			Leaf		
	N	P	K	N	P	K	N	P	K
Cropping system									
Maize-Potato (FYM) - Wheat	1.68	0.274	2.21	2.42	0.232	3.78	5.07	0.501	4.64
GM-Potato-Wheat	1.88	0.259	1.97	2.56	0.218	2.64	5.14	0.478	4.30
Maize-Potato-Wheat	1.76	0.293	1.97	2.24	0.226	2.68	4.67	0.528	4.64
Fallow-Potato-Wheat	1.63	0.263	1.99	2.11	0.207	3.04	4.24	0.475	4.48
N Levels (kg N/ha)									
0	1.21	0.284	2.41	2.86	0.196	3.30	4.00	0.392	3.54
60	1.43	0.263	2.09	2.00	0.204	3.10	4.36	0.422	3.72
120	1.69	0.270	2.05	2.28	0.228	3.05	4.94	0.471	3.56
180	2.06	0.263	1.84	2.74	0.252	2.82	5.12	0.566	3.72
240	2.05	0.281	1.79	2.78	0.260	2.90	5.62	0.626	3.52

Table 3. Effect of cropping systems and nitrogen levels on tuber quality parameters (percent)

	Dry matter	True Protein	Crude Protein	Total Sugar	Red. Sugar	Ascorbic acid (mg/100g)	Starch
Cropping Systems							
Maize Potato (FYM)-Wheat	17.54	0.973	1.834	0.567	0.417	15.60	11.78
GM-Potato-Wheat	19.21	1.096	2.004	0.575	0.438	20.20	12.24
Maize-Potato-Wheat	18.71	1.054	2.058	0.570	0.442	16.80	11.90
Fallow-Potato-Wheat	19.31	0.984	1.954	0.567	0.446	18.24	12.24
Nitrogen levels (kg/ha)							
0	18.57	0.828	1.408	0.532	0.318	16.65	12.55
60	18.74	0.893	1.664	0.563	0.433	17.63	12.28
120	19.30	1.057	2.030	0.563	0.422	18.75	12.60
180	19.00	1.163	2.424	0.588	0.459	18.60	11.60
240	17.80	1.194	2.286	0.615	0.547	16.88	11.33

non significant. Dry matter content had a positive and significant correlation with ascorbic acid (0.649**) but negative with P content in tubers (-0.542**). Starch content was adversely related to crude and true proteins, total and reducing sugars and also tuber P content, relation being significant with proteins (-0.486* and -0.442*) only. However, with tuber K content, starch showed a significant association (0.429*) which was expected as K being a highly mobile nutrient helps in translocation of starch from leaves to tuber. There was close relationship between reducing sugars and crude proteins (0.555**) and true proteins (0.610**). A negative correlation existed between tuber K content and crude proteins (-0.744**), true proteins (-0.723**) and reducing sugars (0.797**). Ascorbic acid showed a negative association with P content in tubers (-0.407).

Above results clearly indicate the importance of organic manures and nitrogen in influencing potato yields, nutrients uptake, and also tuber quality characters. Tuber K content influences most tuber quality parameters and thus necessitate the need for applying higher doses of K along with increasing N rate.

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Potato Production from True Potato Seed : Assessment of TPS Progenies for Tuberlet Production

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ABSTRACT : Highest tuberlet yields were recorded in HPS-7/13 (6.66 kg/m^2) followed by HPS-I/13 (6.02 kg/m^2). Per cent survival and average tuber yield from tuberlets of all TPS progenies were similar to standard local cultivar Kufri Bahar. Marketable size tubers from F_1C_1 tuberlets TPS progenies were found to be the lowest, while the seed size tuber (below 50g) was higher in TPS progenies. Tubers of HPS-7/13 and Kufri Bahar were most uniform in shape, size and colour.

INTRODUCTION

The major constraints for potato production in the developing countries are the high cost and poor quality of seed. Seed is the one of the major inputs in potato production accounting for almost 50% of the cost of cultivation. To some extent these problems can be taken care of by using an alternate cheap method of potato production from the true potato seed (4). The use of true potato seed is emerging as low cost supplemental technology to the present method of growing potato from seed method (6). Use of TPS tuberlets can be very successful in areas where farmers are unable to get a good quality seed at low cost. The purpose of undertaking this study was to see the performance of true potato seed in tuberlet production and utilization of first generation (F_1C_1) for the potato production.

MATERIALS AND METHODS

The experiment was conducted at Zonal Agricultural Research Station, Chhindwara under All India Co-ordinated Potato Improvement Project during rabi, 1989-90 and 1990-91. For Tuberlet production the nursery beds were dig 9" deep trench. The soil was removed from the trench and filled with sub soil + FYM (1:1) mixture up to 6 inch, fertilizer were applied @ 75, 100 and 100 kg N, P and K per ha. Seed of TPS progenies were sown about 1/2 cm deep in the trench at 10 x 10 cm inter and intra row spacing. After seed sowing,the beds were covered with a layer of FYM. The beds were irrigated with water-can and finally covered with locally available 'Palas' or 'Bahunia' leaves, which were removed after 4-5 days. After 30 days of germination 3 inch layer of soil + FYM (1:1) with 25 kg N/ha was spread in the trench. Irrigations were done according to requirement. Additional 20 kg N/ha through urea was sprayed @ 0.1% solution every alternate day. The experiment was laid out in randomized block design with four replications having a trench size 3 x 1 m^2 area. The crop was

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dehaulmed 90 days after sowing. TPS tuberlets from Feb 1990 harvest of HPS-I/13, HPS-I/67,HPS-7/13, HPS-25/13, C-3 and C-17 progenies grown for tuberlet production in nursery beds, were kept in the cold store till the end of Oct 1990. Twenty days before planting the tuberlets of 5 to 40 g size were taken out from the cold store and kept in diffuse light for sprouting. The crop was planted on 23rd Nov 1990. 40 to 50 g size (Breeder's Seed) tubers of cv. Kufri Bahar were planted (60 x 20 cm) as check *for comparison*. Planting distance for the tuberlets was kept 60 x 7.5, 60 x 15 and 60 x 20 cm for 5 to 10, 10 to 20 and 20 to 40 gram seed size respectively. Preplanting application of NPK were applied in lines at the rate of 60:100:100 kg/ha. Additional 60 kg of nitrogen was applied at first earthing up. One prophylactic spray of fungicide was given at 45 days after planting and two insecticide sprays at 15 days interval (starting from 60 days after planting). Crop was dehaulmed after 90 days and harvested on 10th March 1991. Germination percentage after 30 days after planting, total yield in three grades, percentage marketable size (>75 g), seed sixe (<50 g) and tuber uniformity were recorded (1-5 scale) at harvest.

RESULTS AND DISCUSSION

The yield differences among the TPS progenies were found statistically significant (Table 1). The highest tuber yield was recorded in HPS-7/13 (6.66 kg/m^2) followed by HPS-1/13 (6.02 kg/m^2). The number of tubers/m^2 ranged from 467 to 635, the differences among the progenies were found to be nonsignificant. The average tuber weight among the progenies were statistically significant and maximum average tuber weights were recorded in HPS-1/13 (12.06 g) followed by HPS-7/13 (11.52 g), HPS-25/13 (11.00 g) and HPS-1/67 (10.85 g) while minimum in C-3 (9.35 g). Percentage survival of plants ranged from 72-100. Seedling tubers produced from potato seed have been successfully evaluated and used as planting material in some countries (5). In small nursery beds the adverse conditions can be controlled better than in the field (3).

Table 1. Performance of TPS progenies for tuberlet production in nursery bed

Progenies	Germination (%)	Yield kg/m^2	No. of tubers per m^2	Average tuber wt. (g)	Tuber uniformity
HPS-I/13	90	6.02	499	12.06	4
HPS-I/67	72	5.07	467	10.85	4
HPS-7/13	100	6.66	578	11.52	4
HPS-25/13	100	5.99	531	11.00	4
C-3	100	5.94	635	9.35	4
C-17	99	5.63	580	9.72	4
SEm ±		0.234	54	0.572	
C.D. at 5%		0.715	NS	1.723	

Tuber Uniformity score rate 5 = Most uniform, 1 = Least uniform.

The per cent survival of plants ranged from 76.26 to 95.31 (Table 2). Kadian *et al.* (3) reported that tuberlet produce below 10 g size can be successfully used for potato production. The yield differences among the progenies were non-significant when the crop was grown from tuberlets (F_1C_1) of TPS populations and seed tubers of cv. Kufri Bahar (Table 2). Kadian *et al.* (3) and Kadian & Upadhya (2) have also reported equal or higher yield from seedling tubers and seedling tuberlets of selected TPS progenies than seedling tubers of local variety. Tuber yield percentage of three grades of tubers (i.e. <25 g, 25-50 g and>50 g) were found to be non-significant, because the maximum contribution of the marketable size (>50 g) tubers of Kufri Bahar (23.07 t/ha) and seed size (<50 g) in TPS progenies. Thakur *et al.* (6) have also reported that no significant differences among the TPS with Kufri Jyoti in terms of total tuber yield in large and medium size tubers occurs. The tuber size of below 20 grams can successfully be used as seed tuber for next season, which gave the same potential yield as from seed tubers (30-50 g) of standard cultivar (3). It was observed that the tubers of HPS-7/13 and cv Kufri Bahar were most uniform in colour, shape and size, whereas the tubers of HPS-I/67 were least uniform (Table 2).

Table 2. Performance of tuberlets (F_1C_1) TPS progenies

Progenies	Survival (%)	Yield t/ha	Percentage of different grade tubers			Yield t/ha		Tuber
			<25 g	25-50 g	>50 g	Marketable	Seed Size	Unformity
HPS-I/13	84.24	35.84	6.80	36.52	56.68	20.31	15.53	4
HPS-I/67	76.26	34.34	11.41	40.59	48.00	16.48	17.86	3
HPS-7/13	95.31	35.77	8.21	40.92	50.87	18.20	17.57	5
HPS-25/13	87.42	35.69	6.05	45.11	48.84	17.43	18.26	4
C-3	88.35	34.91	7.99	40.56	51.45	17.96	16.95	4
C-17	94.86	36.00	10.11	48.88	41.01	14.76	21.24	4
K. Bahar	93.00	36.65	5.12	31.92	62.96	23.07	13.58	5
SEm ±	—	3.12	—	—	—	2.043	2.30	
C.D. at 5%	—	NS	—	—	—	NS	NS	

Tuber unformity score rate : 5 = Most uniform, 1 = Least uniform.

Based on the results, it can be concluded that the TPS progenies have good yield potential under the agroecological conditions of Satpura plateau of Madhya Pradesh.

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Effect of Growth Regulators on Establishment of Potato Seedlings in Nursery Beds in Relation to Seedling Tuber Production

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ABSTRACT : The investigations were carried out at Research Farm and Laboratories of Department of Vegetable Crops, Haryana Agricultural University, Hisar during 1988-89 and 1989-90. The roots of potato seedlings of HPS 1/67 were dipped in growth regulator solutions for one hour before transplanting. The seedlings were transplanted in nursery beds at a spacing of 10 x 10 cm accommodating 100 plants m^2 (s). The results indicated that in general all the growth regulator treatments improved the plant growth and seedling tuber yield of transplants. Root dip treatment with 5 ppm IBA helped best in early establishment of seedling, improved plant survival and growth characters. The seedling tuber yield under this treatment was significantly superior over control (water soaked) and statistically at par with control *(in situ)*. This suggested that root dip treatment with 5 ppm IBA helped best in overcoming the transplanting shock which is one of the major problems in potato production by seedling transplanting method under warm climate.

INTRODUCTION

Use of TPS for potato production is gaining popularity. The merits of using TPS include the small mass of seed required, low cost, easy transportability, long term seed storage even under room temerature in warm climates and most of the viruses are not transmitted via true seed. The demerits are lack of crop uniformity, longer growing season required and low yield (3). In regions, with long growing season, the true seed is either sown directly or seedlings are transplanted for producing potatoes for immediate consumption. However, in regions, with short growing season like Haryana, the true seed is either sown directly or seedlings are transplanted for seedling tuber production which are used as planting material in the following season. Transplanting seedlings for seedling tuber production appears to be most feasible method but limited capacity of seedlings to tolerate transplanting shock and environmental stress is a limiting factor to adopt this technology. Present investigations were aimed at studying the effect of growth regulators on overcoming the transplanting shock and help the seedling in early establishment in nursery beds for better growth and seedling tuber yield.

MATERIALS AND METHODS

The experiment was carried out at the farm and laboratories of Deptt. of Vegetable Crops, Haryana Agricultural University, Hisar, during 1988-89 and 1989-90 with HPS 1/67. Nursery beds (1 x 1m x 0.20 cm) were prepared by mixing the river sand, sieved

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surface soil of fine tilth and well rotten farm yard manure in the ratio of 1 : 1 : 1. Nitrogen, phosphorus and potash fertilizers were applied @ 15, 5 and 10 g/sq.m respectively. The seeds were sown on 30th September during 1988 and Ist October during 1989 @ one g per square meter. The seeds were placed in furrows 10 cm apart and covered with one cm layer of the same substrate. The beds were irrigated with water-can just after sowing. To protect the seedlings from high temperature the nursery was covered with *Sirki* during hotter part of the day. The nursery beds were kept free from weeds and were irrigated every day with water cane in the morning and everning. Five days after germination 0.1% urea was sprayed on the seedlings at alternate days till the seedlings were ready for transplanting. Seedlings were once sprayed with 0.25% mancozeb (Dithane M-45). The seedlings were transplanted on 2nd November, 1988 and 3rd November, 1989 in the nursery beds at a spacing of 10 x 10 cm apart. Before transplanting the roots of 4-5 leaf stage seedlings were dipped in the growth regulator solutions for one hour. The treaments were control *(in situ)*, control (water soaked), starter solution (5.32 g ammonium phosphate and 2.66 g potassium nitrate dissolved in one litre of water), 2, 5, 10 ppm of IBA, 5 ppm ABA and 50 ppm ethephon. Starting from one week after transplanting. Hoagland nutrient solution @ 5 litres per bed (1 m^2) was applied thrice at 10 days interval. Other cultural and plant protection measures were carried out as and when required. The data on plant survival, growth and yield characters were recorded during both the years of investigation.

RESULTS AND DISCUSSION

The results presented in Table 2 suggested that yield of seedling tubers in direct seeded *(in situ)* crop was significantly superior over transplants (water soaked). The main reason for higher yield in direct seeded beds could be that the plants did not receive any transplanting shock, had higher plant survival percentage and better haulm growth in terms of plant height, number of leaves per plant and foliage weight (Table 1). On the other hand in transplanted crop survival percentage of plants, plant height, number of leaves per plant, weight of foliage were significantly lower than direct seeded *(in situ)* crop. This indicated that transplants were not recovered fully from transplanting shock which could be the main reason for lower yield. Weaver (5) reported that tranplanted plants usually grow slowly during initial stage after transplanting because they have difficulty in establishing root system. Besides, the poor performance of transplants may be due to high temperature (30-32°C) during both the years for a couple of weeks after transplanting. The root damage during transplanting might have resulted in poor regeneration of roots, poor survival of plants and less haulm growth and ultimately lower yield of seedling tubers. Sattelmacher and Minzenmay (4) also reported about 80% redution in total root area in potato seedlings that were carefully transplanted at tropical site. They suggested this reduction as a major reason for slow field establishment of potato seedling in warm environment. Wiersema (6) also reported that potato transplants took more time under warm climate (spring) as compared to cooler climate (winter) to recover to the preplanting growth rate.

The use of growth regulators particularly IBA as, root dip treatment before transplanting in nursery beds, improved the survival percentage (Table 1) of plants as compared to control (water soaked). This indicated that application of IBA as root dip treatment hasten the recovery of root system after transplanting. The better plant survival with IBA-5 ppm indicated that the concentration of growth regulator also plays an important role in accelerating root system. McGuire et al. (1) reported that concentration of growth regulators just below the toxic point was optimal for root promotion, however, he preferred prolonged soaking for species that root with more difficulty.

Table 1. Effect of growth regulators on per cent survival and height of transplants in nursery beds

Treatments	% Survival (DAT)			Plant height in cm (DAT)		
	15	30	45	30	60	90
Control *(in situ)*	91.5	87.7	83.2	12.0	47.9	75.2
Control (water soaked)	72.6	68.3	61.6	7.6	31.5	56.1
Starter solution	77.1	68.9	64.9	8.1	32.8	66.0
IBA 2 ppm	81.1	71.7	69.3	9.3	37.3	66.9
IBA 5 ppm	86.3	84.2	80.1	11.3	44.7	70.0
IBA 10 ppm	85.0	79.0	74.4	9.8	38.2	66.6
ABA 5 ppm	81.7	73.3	68.0	9.8	36.9	65.9
Ethephon 50 ppm	77.6	74.3	66.0	8.4	35.9	62.6
C.D. at 5%	8.8	10.8	13.2	NS	6.8	7.5

DAT (Days after transplanting)

All the treatments of IBA and ABA proved effective in improving the seedling tuber yield (Table 2) over control (water soaked). The beneficial effect of overcoming the transplanting shock quickly under these treatments resulted in quick and better haulm growth. The data presented in table 1 and 2 indicated that application of IBA and ABA improved the plant height, number of leaves per plant and foliage weight which helped in the production of more assimilates and better translocation to the developing tuber and ultimately resulted in higher seedling tuber yield. Moorby (2) also reported that about 90% of dry matter which moves into the tubers is dependent on current assimilation. None of the treatments had significant effect on number of tubers per plant and proportion of different grade tuber except medium size tuber (30-50 mm) during both the years of investigation.

The seedling tuber yeild (Table 2) recorded under IBA-5 ppm was statistically at par with direct seeded *(in situ)* crop.

Table 2. Effect of growth regulators on number of leaves per plant, weight of foliage, number of tubers total yield and different grade tuber per plant, (by weight) of transplanting in nursery beds

Treatments	Number of leaves per plant	Weight of foliage (kg/m^2) Fresh weight	Dry weight	Number of tubers per plant	Total yeild (kg/m^2)	Tuber yield in different grade (per-centage) >50 mm	30-50 mm	<30 mm
Control *(in situ)*	163.8	3.08	0.68	12.4	6.06	1.7	32.0	66.2
Control (water soaked)	103.9	1.89	0.33	10.0	4.18	0.0	18.8	81.2
Starter solution	107.5	2.27	0.39	10.6	4.50	0.3	18.1	81.6
IBA 2 ppm	129.9	2.27	0.42	11.9	5.01	0.5	20.2	79.3
IBA 5 ppm	156.5	2.98	0.66	14.7	5.77	1.4	25.6	72.9
IBA 10 ppm	148.8	2.56	0.62	14.1	5.48	0.8	24.1	75.1
ABA 5 ppm	146.6	2.47	0.52	12.2	5.27	0.8	22.2	76.9
Ethephon 50 ppm	106.4	2.12	0.42	11.6	4.57	0.6	18.7	80.7
C.D. at 5%	7.9	0.24	0.05	NS	0.46	NS	7.3	NS

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Plant Growth Substances and Sprouting Conditions. I- Effect on Haulm Growth of Plants Raised from Nursery Rooted Sprouts

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ABSTRACT : In the present investigation, effect of some plant growth substances (PGS) given to the tubers before sprouting, and environment during sprouting, on the establishment and growth of sprout transplants in the field was studied. Although, all the PGS tried, improved establishment of transplants in the field and their growth, measured in term of plant height, number of branches, number of leaves and haulm weight. 5 ppm IBA proved to be most effective followed by 10 ppm ethephon other PGS tested were 2 ppm GA, 2 ppm kinetin, 1% thirourea and 1% potassium nitrate. Transplants developed from sprouts produced under moist sand showed superiority to other two sprouting conditions (under natural light and dark). Transplants developed from sprouts could not compete with the plants developed from whole tubers for the above mentioned growth parameters.

INTRODUCTION

The potato *(Solanum tuberosum)* is one of the most important and nutritious farm crops. Multiplication rate through conventional method varies from 1:3 to 1:15. Van Ho *et al.* (8) and Anamica and Singh (2) suggested the use of sprouts for increasing multiplication rate. Treating tubers with PGS before planting has been found to influence plant growth in several studies (1, 3, 4, 6). The present investigations were undertaken to find the effect of tuber treatment with different PGS and sprouting conditions on establishment of rooted sprouts and growth in the field.

MATERIALS AND METHODS

Potato cv Kufri Badshah was used in the study. Treatments consisted of combinations of seven plant growth substances, including control, and three sprouting conditions, in addition to a treatment of normal planting where seed tubers weighing about 60 g were planted at 60 X 20 cm (Table 1). Tubers were dipped in the solution of plant growth substances for half an hour as per treatment (Table 1) and then placed under three sprouting conditions (dark, natural light and sand). In dark condition tubers were placed in complete dark in a room where as in natural light conditions tubers were placed in well ventilated room under natural diffused light and no additional light was provided. For sprouting under sand, a layer of sand was spread on soil and the seed tubers were kept from end to end and covered with 2 inches of sand. This sand was kept moist by sprinkling water as and when needed. Minimum and maximum air

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Table 1. Effct of plant growth substances and sprouting conditions on haulm growth

Treatments	Final plant stand one week before harvesting (%)	Plant height (cm)	Number of branches per plant	Number of leaves per plant	Dry weight of foliage (g/m^2)
Plant growth substances					
Control	90.7	41.6	12.0	80.3	497
GA - 2 ppm	93.7	44.5	12.6	81.7	613
IBA - 5 ppm	94.1	53.4	15.9	121.4	813
Ethephon-10 ppm	93.7	51.8	15.2	114.2	753
Kinetin-2 ppm	93.6	50.2	13.3	87.6	603
Thiourea 1%	93.2	50.6	13.8	91.1	606
Potassium nitrate 1%	93.2	51.0	14.2	98.9	649
C.D. 5%	1.6	4.4	1.7	13.3	209
Sprouting conditions					
Under dark	92.7	45.9	14.7	86.2	494
Under natural light	92.4	50.5	13.1	101.4	643
Under sand	95.3	51.9	13.8	102.5	806
C.D. at 5%	1.0	2.9	NS	8.7	136
Normal Planting'	100.0	88.3	21.9	185.5	1026

temperature during the period of sprouting recorded at 1 km from the experimental site was 17-22°C and 30-31°C during 88-89 and 18-20°C and 32-36°C during 1989-90 respectively. After 20 days sprouts were detached from these tubers and planted in nursery beds for rooting, where they were kept for 20 another days. Ridges were prepared at a spacing of 60 cm. Well rooted transplants (prepared from sprouts) were trasplanted on one side of the ridge at a spacing of 20 cm in plots measuring 3 x 1.8 m on 5th and 3rd November during 1988 and 1989 respectively. After two earthings, the transplants were in the middle of ridge like normally planted potato crop.

Survival percentage of sprouts was recorded one week before harvesting. Plant height, number of branches and number of leaves were recorded at 90 days after transplanting. Haulms were cut at 90 days after transplanting and dried in an oven to estimate dry weight.

RESULTS AND DISCUSSION

There was no interaction between plant growth substances and sprouting conditions for any of the growth parameters studied in the present investigation, therefore, only main effect of these treatments are presented here. There were no differences between the years, therefore mean of two years data are presented here.

All the treatments had over 90% survival of transplants (Table 1). Maximum sruvival of transplants was recorded in IBA-5 ppm followed by ethephon-10 ppm and

GA 2 ppm. Hepburn and Mathews (5) also reported that IBA and NAA increased rooting of cuttings significantly.

Sprouts produced under moist sand recorded significantly higher survival percentage of the transplants as compared to sprouts produced under dark and natural light condition (Table 1). Tubers planted as normal check recorded 100% emergence and all of them survived until harvest. It is because, temperature at that time was ideal for sprout emergence. Improvement in plant height over control due to IBA-5 ppm, ethephon-10 ppm, potassium nitrate 1%, thiourea 1% and kinetin-2 ppm was significant. All the PGS except GA-2 ppm significantly increased number of branches per plant over control. IBA-5 ppm recorded highest number of branches followed by ethephon-10 ppm, potassium nitrate 1% and thiourea 1%. Like number of branches, IBA-5 ppm, maintained its superiority over other plant growth substances for number of leaves also. It was followed by ethephon 10 ppm. Both these treatments (IBA-5 ppm and ethephon 10 ppm) were significantly better than control. Shreshtha (7) also reported that sprouts treated with RF and IP (RF as well as IP, contained auxins) before transplanting were significantly taller, had heavier haulms and produced more leaves. Baijal (3) also reported improvement in fresh and dry weight of foliage and number of leaves, when the seed tubers were treated with IAA before planting.

Regarding sprouting conditions transplants developed from sprouts produced under moist sand or under natural light were significantly superior to the sprouts developed under dark for number of leaves/plant and plant height. Differences in number of branches due to sprouting conditions were not significant. Superiority in plant growth in the sprouts produced under sand to other sprouting conditions may be because the transplants from sprouts produced under sand were larger in size at the time of transplanting in the field.

All the PGS improved dry weight of foliage over control. Since IBA-5 ppm recorded its superiority over remaining PGS for plant height, number of branches and number of leaves, therefore, it resulted in highest dry weight of foliage. It was followed by ethephon-10 ppm. Both IBA-5 ppm and ethephon-10 ppm were significantly superior to control.

Regarding sprouting condition the sprouting under sand recorded its superiority for dry weight of foliage also.

The treatments where seed tubers (normal planting) were used for planting, recorded significantly higher number of branches as well as leaves, plant height and dry weight of foliage, when compared with other treatments (Table 1). The better growth in case of normal planted crop is attributed to the availability of food material from the mother tuber, which gave initial boost to the emerging plants. Further in case of normal planting there were 4-5 stems/hill as compared to single stem in the case of single sprout transplanted crop. In addition crop raised from sprouts also received transplanting shock.

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Effect of Time of Planting in Relation to Seed Potato Production in the South-East Region of Bangladesh

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ABSTRACT : Two commercial potato varieties were planted at 10 days intervals at Pahartali, and at Joydebpur for determining the best time of planting for the production of seed tubers and table potatoes. Results indicated that November 10 to 20 is the best time of planting for the production of seed potatoes, whereas for table potatoes planting can be delayed upto 1st December. Seed quality deteriorated after 20th November. However, yields were affected after the 1st December. Late plantings were associated with weaker plant stand due to physiologically old seeds which resulted into early tuberization, smaller tuber production, more virus infection and low yield. Correlation studies showed that there were significant decrease in yields due to high incidence of diseases and late planting.

INTRODUCTION

The most limiting factor for potato production in Bangladesh is scarcity of quality seed. The yield potential of a seed tuber depends largely on seed health, storage conditions and environment in which the crop is grown (8). In Bangladesh, about 150 thousand ton of seed is planted annually of which only 3 to 5% are supplied by BADC as certified seed. The rest is poor quality seed procured by the farmers themselves (7). In order to boost the production, the quality of the locally produced seed needs to be upgraded. Though the best seed growing conditions like, complete aphid vector free zones, presence of high hills for summer crop, and prolonged winter are lacking in Bangladesh, the locations with least aphid prevalence during the year may still be identified to reduce the incidence of degenerative diseases.

In the Chittagong region where aphid population starts to build up around the 2nd week of January, the appropriate time of planting will be of great use minimizing the incidence of viral diseases. Studies were therefore undertaken with two most popular varieties to find out appropriate time of planting for producing quality seed as well as ware potatoes.

MATERIALS AND METHODS

The experiment was set up at Pahartali, Chittagong with two recommended varieties, Cardinal and Kufri Sindhuri and planting was done on 1st, 10th and 20th November and 1st, 10th and 20th December in split plot design with 3 replications. Varieties were in main plots. The plot size was 3.6 m x 4.5 m and planting distance was 60 cm x 30 cm. Recommended cultural practices were applied (1). Data were recorded on emergence, number of stems per plant, plant height, tuber initiation, foliage cover

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tuber yield, grade of tubers and virus incidence. Primary infection of viruses was recorded by visual observation at the age of 40 to 45 days. Plants which were infected later, did not show clear symptoms during the growing season. So one tuber from each hill was collected for planting at Joydebpur during the following season to identify the secondary virus infected plants. The seed for the trial was collected from BADC, Kashempur as certified seed which was supposed to have less than one per cent virus infection. Cardinal was introduced from the Netherlands and multiplied once at BADC Farm, whereas Kufri Sindhuri was an Indian variety multiplied and maintained under disease free condition.

RESULTS AND DISCUSSION

Table 1 shows that the plant stand was highest in the 20th November planting followed by the 10th November and 1st December plantings. The survival was lowest

Table 1 . Performance of Cardinal and Kufri Sindhuri on different dates of plantings

Planting dates	Plant stand	Days to			Plant	No. of	Foliage	Tuber
	% at 60 DAP	1st emergence	80% emergence	tuber initiation	ht. (cm)	stems/plant	coverage (%)	yield (t/ha)
Cardinal								
Nov. 1	80.7	19.7	25.0	37.3	63.7	3.5	100.0	20.9
Nov. 10	86.0	15.7	21.7	35.0	62.3	4.1	100.0	26.2
Nov. 20	88.3	13.0	18.3	33.7	66.7	4.1	98.3	24.3
Dec. 1	88.7	11.7	18.7	34.3	59.7	3.8	86.7	21.5
Dec. 10	88.3	14.3	20.3	33.3	48.7	3.9	63.3	17.3
Dec. 20	83.0	15.7	21.3	35.3	47.7	4.3	51.7	14.3
Mean	85.8	15.0	20.9	34.8	58.1	4.0	83.3	20.7
Kufri Sindhuri								
Nov. 1	82.7	19.3	26.7	42.3	70.0	3.4	96.7	22.6
Nov. 10	86.0	15.7	22.0	40.7	66.0	3.8	100.0	24.8
Nov. 20	89.0	13.3	19.7	39.7	70.7	3.5	98.3	26.4
Dec. 1	89.3	12.3	20.7	38.0	66.7	3.3	88.3	24.7
Dec. 10	88.3	15.0	22.0	36.3	64.3	3.4	73.3	18.6
Dec. 20	83.7	16.7	23.0	37.7	57.3	3.8	61.7	16.2
Mean	86.5	15.4	22.4	39.1	65.8	3.5	86.4	22.2
LSD (5%)								
Variety	NS	NS	NS	0.6	NS	0.2	NS	NS
Planting date	NS	1.3	1.4	1.0	3.2	NS	16.7	6.9
Interaction	NS	NS	NS	0.5	2.2	NS	NS	NS

NS = Non significant at 5% level of probability
DAP = Days after planting

in the 1st November planting. The land was not dry enough during the early November. Plant emergence was quick in later plantings. Tuber initiation was influenced by the physiological age of the seed tuber and the soil temperature (8). Both the varieties responded almost similarly.

Though the average yield of Kufri Sindhuri was higher than Cardinal, the difference was not significant. In Cardinal the highest yield (26.2 t/ha) was obtained in the 10th November planting followed by the 20th November, 1st December and 1st November plantings, whereas Kufri Sindhuri yielded the highest in the 20th November plantings (26.4 t/ha), followed by the 10th November, 1st December and 1st November plantings. Results indicated that the variety Kufri Sindhuri has potentiality to give good yield even if it is planted late in season. The Dutch variety Cardinal seemed to be more sensitive to time of planting than Kufri Sindhuri.

Plant emergence and tuber initiation was quicker in Cardinal than Kufri Sindhuri. Kufri Sindhuri produced more number of tubers per plant but they were smaller in size. Maximum seed sized tubers (28-45 mm) were produced in the 10th November planting in Cardinal and 20th November planting in Kufri Sindhuri. Tuber size decreased gradually in late plantings which might be due to premature death of the plants at higher temperatures (2, 3, 6). (Table 2).

Table 2 . Grade of tubers by weight (%)

Planting date	Cardinal			Kufri Sindhuri		
	above 45 mm	28-45 mm	below 28 mm	above 45 mm	28-45 mm	below 28 mm
Nov. 1	43.4	51.8	4.8	33.1	55.3	11.6
Nov. 10	48.1	48.7	3.2	37.5	50.1	12.4
Nov. 20	47.9	45.1	7.0	38.0	47.8	14.2
Dec. 1	34.1	58.3	7.6	35.5	48.8	15.7
Dec. 10	21.4	66.0	12.6	27.2	52.8	20.0
Dec. 20	18.3	65.9	15.8	14.6	60.8	24.6
Mean	35.5	56.0	8.5	31.0	52.5	16.5

Tenth November was found to be the best sowing time for seed potatoes. Disease incidence increased from 20th November and seed quality deteriorated with further delay in planting. Similar results were described by Khan, *et al.* (3). Virus infection was more in Kufri Sindhuri than Cardinal (Table 3).

Data in Table 4 indicated that there was a close relationship between yield and disease, planting time and disease and planting time and yield. PLRV in general was more responsible for the decrease in the yield in both the varieties than mosaics, but the incidence of mosaics was more in later plantings. Tuber yield was negatively correlated with the time of planting and delayed plantings caused significant loss of yield.

It is concluded that the tubers should be planted in between 10th and 20th November for seed and the crop should be harvested before the 15th January when the aphid population start building up (4, 6).

Table 3 . Percentage of virus infected plants in relation to time of planting

Planting date	Disease	Primary infection		Secondary infection		Total virus (%)	
		Cardinal	Kufri Sindhuri	Cardinal	Kufri Sindhuri	Cardinal	Kufri Sindhuri
Nov. 1	PLRV	2.2	5.9	2.2	2.5	4.4	8.4
	MOS	0.7	0.7	0.4	1.2	1.1	1.9
Nov. 10	PLRV	1.9	3.3	2.2	2.4	4.1	5.7
	MOS	0	0.7	2.2	1.1	2.2	2.9
Nov. 20	PLRV	1.5	3.0	2.2	2.7	3.7	5.7
	MOS	1.1	1.5	1.5	3.2	2.6	4.7
Dec. 1	PLRV	3.0	5.6	2.2	5.6	5.2	11.2
	MOS	1.5	1.5	2.2	5.6	3.7	7.1
Dec. 10	PLRV	3.7	7.8	3.3	7.8	7.0	15.6
	MOS	2.2	3.7	3.3	6.7	5.5	10.4
Dec. 20	PLRV	5.6	12.2	4.4	11.5	10.0	23.7
	MOS	2.6	5.6	5.6	8.9	8.2	13.8
Mean	PLRV	3.0	6.3	2.8	5.4	5.8	11.7
	MOS	1.4	2.3	2.5	4.5	3.9	6.8

PLRV = Potato Leafroll Virus, MOS = Mosaics (PVY, PVX, PVS, PVA, etc.)

Table 4 . Correlation among the yield, disease and planting dates

Variety	Disease x yield	Planting time x disease	Planting time x yield
Cardinal	PLRV = -0.925**	PLRV = 0.853**	-0.761**
	MOS = -0.839**	MOS = 0.960**	
Kufri Sindhuri	PLRV = -0.931**	PLRV = 0.858**	-0.700**
	MOS = -0.818**	MOS = 0.981**	

** Significant at 1% level

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Effect of Addition of N, P and K Fertilizers on the pH of Alkaline Alluvial Soil on Incubation*

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ABSTRACT : An incubation experiment was done to study the effect of eight N, P and K fertilizers on the pH of alkaline alluvial soil. pH was measured periodically (6 hours, 1, 2, 3, 4, 6, 8, 10, 17, 40 and 80 days) after adding normal rates of fertilizers and soil incubation at 50% water holding capacity at room temperature. Within 6-8 days, ammonium sulphate and ammonium chloride progressively reduced pH from 7.6 to 5.9 which remained almost unchanged upto 40 days of incubation but it increased to 6.6. and 6.4 at 80 days of incubation. Calcium ammonium nitrate decreased pH slowly and kept it reduced from 7.6 to 6.8 during 4 to 80 days of incubation. Urea did not affect pH upto 3 days after which it also reduced pH to 6.7. Diammonium phosphate and single superphosphate reduced pH by 0.3 unit whereas muriate of potash and sulphate of potash reduced it by 0.2 to 0.3 unit in 80 days of incubation.

INTRODUCTION

The reaction of soil (pH) is significant in crop production. Soil reaction affects plant growth owing to either a depressed solubility of some element or to an increased solubility of others (1-5, 7, 9, 11). Small change in pH may influence the availability of such micronutrient elements as manganese, zinc, copper, iron and molybdenum (2, 4, 5, 7, 11). Manganese is usually found in a rather insoluble condition in alkaline soils, as are also iron, zinc and copper. A knowledge of the conditions like fertilizer application which cause different soil reaction, therefore is of great value. Altering the soil pH in the rooting zone may be effective in correcting micronutrients (zinc, copper, iron and manganese) deficiencies. The reported incubation study was undertaken to find the effect of eight N, P and K fertilizers on the pH of alkaline alluvial soil.

MATERIALS AND METHODS

A bulk sample of surface soil collected from Central Potato Research Station Farm, Jalandhar was air dried at room temperature and sieved through 2mm sieve. The soil was alkaline (pH 7.85) and sandy loam in texture. It contained 0.32% organic carbon, 106 mg $KMnO_4$-N, 10 mg Olsen P, 128 mg of NH_4OAC extractable K and 11 mg of $CaCl_2$ extractable S/kg soil. The water holding capacity (WHC) of the soil was 60%, (60 ml of water/100g soil).

There were 9 treatments viz. control, four nitrogenous fertilizers (ammonium sulphate, ammonium chloride, calcium ammonium nitrate (CAN) and urea), two

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phosphatic fertilizers (single superphosphate (SSP) and diammonium phosphate (DAP) and two potassic fertilizers (muriate of potash (KCl) and sulphate of potash (K_2O_4). Fertilizers were added @ 70 mg N, 35 mg P_2 O_5 and 55 mg K_2O/kg soil. A 100g of soil was weighed in each of 324 plastic bottles of 250 ml capacity. The required amount of fertilizers were added to soil in solution form and the moisture content of the soil was kept at 50% of water holding capacity. The bottles kept at room temperature were sampled in three replicates at 0, 6 hr, 1, 2, 3, 4, 6, 8,10, 17, 40 and 80 days after the fertilizer application. At the time of sampling, the pH was measured by glass electrode in 1:2 soil water suspension by adding 170 ml of water to each bottle and stirring at 3-4 times for half an hour.

The organic carbon content of soil was determined by the method of Walkley and Black (14) and $KMnO_4$ oxidisable N by method of Subbiah and Asija (12). Water holding capacity of soil was determined by Shaw's method (10).

RESULTS AND DISCUSSION

Effect of nitrogenous fertilizers : All the nitrogenous fertilizers progressively reduced the soil pH by 0.7 to 1.8 units in 6-8 days which then remained almost unchanged upto 40 days. Thereafter it again started increasing slowly but remained 0.8 to 1.3 units lower than control even at 80 days of incubation (Table 1). Within 6-8 days,ammonium sulphate and ammonium chloride progressively reduced pH from 7.6 to 5.9 which remained almost constant upto 40 days but again increased to 6.6 and 6.4 at 80 days of incubation. Calcium ammonium nitrate decreased pH slowly and kept it reduced from 7.6 to 6.8 during 4 to 80 days of incubation. Urea did not affect pH upto 3 days after which it also reduced pH to 6.7 On an average, the effect of different nitrogenous fertilizers on the reduction of soil pH can be rated in the decreasing order as ammonium chloride = ammonium sulphate > calcium ammonium nitrate > urea.

Effect of phosphatic fertilizers : Both single superphosphate and diammonium phosphate reduced the pH by about 0.3 unit in 4-6 days which remained 0.3 unit lower than control upto 80 days of incubation (Table 2).

Effect of potassic fertilizers : Potassic fertilizers decreased pH by 0.2 to 0.3 unit in 6 days as compared to control and it remained so upto 80 days of incubation (Table 3).

The data showed that all the four nitrogenous fertilizers particularly ammonium chloride and ammonium sulphate kept soil pH reduced by more than one unit during 6-80 days of incubation i.e. during active growth period of potato crop. Application of ammonium sulphate (6, 8) and ammonium chloride (8) are known to reduce the soil pH. Phosphatic and potassic fertlizers had little effect (0.2 to 0.3 unit) on pH reduction. The reduction in pH by diammonium phosphate containing ammonical nitrogen was less than other ammonical nitrogen containing fertilizers. This could be due to the addition of less amount of ammonical nitrogen through diammonium phosphate (about

Table 1. Effect of addition of nitrogenous fertilizers on the pH of alkaline alluvial soil

Period of incubation (Days)	Nitrogenous fertilizers*					
	Control (no N)	Ammonium Sulphate	Ammmonium chloride	CAN	Urea	Mean
0	7.9	7.4	7.3	7.5	7.7	7.6
6 hr	7.5	7.2	7.2	7.4	7.7	7.4
1	7.5	6.7	6.7	6.7	7.6	7.0
2	7.4	7.0	7.0	7.2	7.8	7.3
3	7.6	6.7	6.7	7.1	7.5	7.1
4	7.6	6.5	6.4	6.7	6.9	6.8
6	7.5	6.1	6.2	6.5	6.6	6.6
8	7.6	5.9	5.8	6.8	6.9	6.6
10	7.7	5.9	5.9	6.6	6.6	6.5
17	7.6	5.9	5.9	6.6	6.7	6.5
40	7.5	6.1	6.0	6.6	6.7	6.6
80	7.7	6.6	6.4	6.8	6.9	6.9
Mean	7.6	6.5	6.5	6.9	7.1	—

*Amount of nitrogen added = 70 ppm.

Table 2 . Effect of addition of phosphatic fertilizers on the pH of alkaline alluvial soil

Period of incubation (Days)	Phosphatic fertilizers*			Mean
	Control (no P)	Single Super-phosphate (SSP)	Diammonium phosphate (DAP)	
0	7.9	7.5	7.6	7.7
6 hrs	7.5	7.4	7.5	7.5
1	7.5	6.8	6.9	7.1
2	7.4	7.5	7.4	7.4
3	7.6	7.4	7.4	7.5
4	7.6	7.3	7.3	7.4
6	7.5	7.4	7.3	7.4
8	7.6	7.3	7.3	7.4
10	7.7	7.2	7.2	7.4
17	7.6	7.3	7.2	7.4
40	7.5	7.3	7.2	7.3
80	7.7	7.4	7.4	7.5
Mean	7.6	7.3	7.3	—

*Amount of phosphorus added = 35 ppm P_2O_5

Table 3 . Effect of addition of potassic fertilizers on the pH of alkaline alluvial soil

Period of incubation (Days)	Potassic fertilizers*			Mean
	Control (No K)	Muriate of Potash	Sulphate of Potash	
0	7.9	7.4	7.4	7.6
6 hrs.	7.5	7.4	7.4	7.4
1	7.5	6.8	6.8	7.0
2	7.4	7.3	7.5	7.4
3	7.6	7.3	7.5	7.5
4	7.6	7.4	7.5	7.5
6	7.5	7.2	7.4	7.4
8	7.6	7.4	7.5	7.5
10	7.7	7.3	7.5	7.5
17	7.6	7.4	7.7	7.6
40	7.5	7.4	7.5	7.5
80	7.7	7.4	7.5	7.5
Mean	7.6	7.3	7.4	—

*Amount of potassium added = 55 ppm K_2O

12 ppm) than ammonium sulphate (70 ppm), ammonium chloride (70 ppm) and CAN (35 ppm). Tisdale and Nelson (13) also showed that the carriers of phosphorus and potassium had little or no influence on soil acidity but the carriers of nitrogen, had a considerable effect on the soil pH.

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Nutrient Uptake and Tuber Yield of Potato as Influenced by Irrigation and Mulching under Scarce Water Condition in Alfisols*

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ABSTRACT : In field trials conducted on red sandy loam soils (Alfisols) of Bangalore, high frequency irrigation given in smaller quantities (20 mm at 1.00 IW/CPE) was useful to get higher uptake of nitrogen (116.6 kg/ha), phosphorus (16.75 kg/ha) and potassium (169.7 kg/ha) which in turn influenced the tuber yield of potato (cv. Kufri Jyoti). Polythene mulch was superior in tuber yield (182.2 q/ha) and uptake of nutrients (103.2, 13.97 and 156.2 kg/ha of N, P and K, respectively) when compared to no mulching.

INTRODUCTION

In Alfisols of Bangalore region, potato crop is grown during rabi season under well or lift irrigation with limited water availability. Potato being shallow and sparse rooted crop, requires small quantities of water applied at frequent intervals which enhance moisture availability and nutrient uptake (3, 10, 13). Several workers (1, 9, 11, 12) have also reported increase in tuber yields due to increase in frequency of irrigation. Tuber yields and nutrient uptake were reported to be enhanced by mulching due to soil moisture conservation as a result of reduction in evaporation losses (4, 5, 6, 8, 14). Therefore, field experiments were conducted to evaluate the influence of irrigation and mulching on tuber yield and uptake of nutrients in Alfisols under the situations where irrigation water was scarce and costly.

MATERIALS AND METHODS

Field experiments were conducted for two years (1985-86 and 1986-87) during rabi seasons on red sandy loam soil (Alfisol) at Main Research Station of University of Agricultural Sciences, Bangalore. Six irrigation schedules as main plot treatments involving the combination of two depths of irrigation (20 and 40 mm) and three IW/CPE ratios (0.50, 0.75 and 1.00) and three mulches (no mulch, straw and polythene mulch) as sub-plot treatments were tested in a split-plot design with three replications. The plot size adopted was 4.2 m x 3.6 m. Seed tubers of cv. Kufri Jyoti were planted in furrows with a spacing of 45 cm x 20 cm. As per the recommendation, 50 per cent N and entire dose of P_2O_5, K_2O and FYM were applied in furrows at planting. The crop was top dressed with rest half of N, four weeks after planting and later mulching was done with paddy straw (5 t/ha) and 400 gauge thickness black polythene sheet.

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Irrigation was commonly given to the crop upto four weeks and subsequent irrigations were given as per irrigation schedules. Irrigation water was measured and conveyed through polythene lined irrigation channels.

The soil and plant samples were collected and analysed as per the procedures outlined by Jackson (7). Total nutrient uptake by the crop was worked out at harvest. The results obtained on various physical and chemical properties of soil prior to planting are presented in Table 1. Results obtained have been discussed based on pooled analysis (2).

Table 1 . Physical and chemical properties of surface soil of the experimental site

Character	Soil depth (cm)	
	0-15	15-30
Mechanical Composition (%)		
1. Coarse sand	40.08	27.68
2. Fine sand	30.17	24.47
3. Silt	6.38	11.35
4. Clay	20.47	34.15
5. Loss in solution	2.90	2.35
Textural class	Red sandy loam (Alfisol)	
Chemical properties		
1. Soil pH	6.60	6.70
2. EC (mmhos/cm at 25°C)	0.15	0.20
3. Organic Carbon (%)	0.48	0.64
4. Total N (%)	0.04	0.05
5. Total N (kg/ha)	940.8	1232.0
6. Available P_2O_5 (kg/ha)	37.5	23.8
7. Available K_2O (kg/ha)	250.0	175.0

RESULTS AND DISCUSSION

Effect of irrigation and mulching on tuber yield : The tuber yield obtained (216.5 q/ha) was significantly higher in the irrigation schedule with lower depth of water (20 mm) given at higher frequency (1.00 IW/CPE ratio) as compared to other irrigation schedules (115.7 to 186.2 q/ha) (Table 2). Among irrigation schedules with less frequent irrigation, D_2I_3 recorded significantly higher tuber yield (172.5 q/ha) than D_2I_2 (134.8 q/ha) and D_2I_1 (115.7 q/ha). Several earlier workers (1, 9, 11, 12) also reported similar trend of increase in tuber yield with increase in frequency of irrigation.

At a given depth of irrigation, yield levels increased with increase in IW/CPE ratios. Whereas, at a given IW/CPE ratio, there was increase in tuber yields due to frequent

Table 2 . Effect of irrigation schedules and mulching on tuber yield and nitrogen uptake in potato

Treatments	Tuber yield (q/ha)			Nitrogen uptake (kg/ha)		
	1985-86	1986-87	Pooled	1985-86	1986-87	Pooled
Irrigation schedules						
D_1I_1 : 20 mm at 0.50 IW/CPE	139.5	175.9	157.7	85.8	76.2	81.0
D_1I_2 : 20 mm at 0.75 IW/CPE	192.4	180.1	186.2	102.5	99.7	101.1
D_1I_3 : 20 mm at 1.00 IW/CPE	239.5	193.5	216.5	125.9	107.3	116.6
D_2I_1 : 40 mm at 0.50 IW/CPE	118.8	112.6	115.7	74.7	62.2	68.4
D_2I_2 . 40 mm at 0.75 IW/CPE	130.0	139.7	134.8	81.8	74.3	78.0
D_2I_3 : 40 mm at 1.00 IW/CPE	169.5	175.5	172.5	96.8	106.0	101.4
S.Em. ±	14.4	12.0	9.4	10.9	6.7	6.4
C.D. at 5%	45.5	37.7	27.6	NS	21.0	18.8
Mulching						
M_0 : No Mulch	138.3	147.6	142.9	80.7	77.6	79.1
M_1 : Straw Mulch	169.0	164.0	166.5	95.8	87.9	91.8
M_2 : Polythene Mulch	187.5	177.0	182.2	107.3	97.3	102.3
S.Em. ±	6.4	5.6	4.3	6.0	4.1	3.6
C.D. at 5%	18.7	16.4	12.1	17.4	12.0	10.4
Mean	164.9	162.9	163.9	94.6	87.6	91.1

NS = Not significant

irrigation i.e., when the crop was irrigated at lower depth (20 mm) as compared to higher depths (40 mm). Further the available storage capacity of sandy loam soil (Alfisol) is also low and hence, potato crop grown on this soil needs to be frequently irrigated with smaller quantities of water to get higher yields in situations of limited water availability.

The tuber yield obtained was significantly higher in polythene mulch (182.2 q/ha) as compared to straw mulch (166.5 q/ha) and no mulch (142.9 q/ha). Similar increase in yield due to mulching was reported by many earlier workers (5, 6, 8). The beneficial effect of mulches could not only be attributed to the improved soil water status as a result of reduced evaporation, but also to the maintainance of optimum soil temperature regime (4). The interaction between irrigation schedules and mulching was not observed in tuber yield of potato.

Effect of irrigation and mulching on nutrient uptake : Nitrogen uptake by potato crop was significantly higher in high frequency irrigation treatment given in smaller quantities (116.6 kg/ha) and the uptake reduced significantly in low frequency irrigation with lower depth (81.0 kg/ha) as compared to other irrigation schedules (Table 2). This may be attributed to high soil moisture level maintained in frequent irrigations. Nitrogen, unlike phosphorus and potassium is a mobile element in soil and the plant uptake is therefore, higher with greater amounts of moisture available to plants in the root zone. These results are in conformity with the observation made by Pushkaranath *et al.* (10).

High frequency irrigation given in smaller quantity was significantly superior in the uptake of phosphorus (16.75 kg/ha) and potassium (169.7 kg/ha) as compared to other irrigation schedules (Table 3). Similar results were obtained by Singh and Arora (13) and Viets (15).

Polythene mulch was significantly superior in the uptake of nitrogen (102.3 kg/ha), phosphorus (13.97 kg/ha) and potassium (156.2 kg/ha) as compared to no mulching (Tables 2 and 3). Mulching improves soil moisture status, which in turn increases the availability of nitrogen, phosphorus and potassium from the native soil source (14).

Table 3. *Effect of irrigation schedules and mulching on phosphorus and potash uptake in potato*

Treatments	Phosphorus uptake (kg/ha)			Potassium uptake (kg/ha)		
	1985-86	1986-87	Pooled	1985-86	1986-87	Pooled
Irrigation schedules						
D_1I_1 : 20 mm at 0.50 IW/CPE	12.20	9.24	10.72	117.3	114.2	115.7
D_1I_2 : 20 mm at 0.75 IW/CPE	14.04	13.28	13.66	161.4	148.8	155.1
D_1I_3 : 20 mm at 1.00 IW/CPE	18.37	15.13	16.75	181.1	158.4	169.7
D_2I_1 : 40 mm at 0.50 IW/CPE	10.45	8.11	9.28	111.7	100.6	106.2
D_2I_2 : 40 mm at 0.75 IW/CPE	10.57	10.33	10.45	117.9	111.4	114.6
D_2I_3 : 40 mm at 1.00 IW/CPE	13.82	13.12	13.47	144.9	149.3	147.1
S.Em. ±	1.60	0.93	0.93	14.7	10.4	9.0
C.D. at 5%	5.05	2.92	2.73	46.4	32.8	26.6
Mulching						
M_0 : No Mulch	10.84	10.03	10.44	110.4	118.0	114.2
M_1 : Straw Mulch	13.64	11.87	12.76	140.8	126.9	133.8
M_2 : Polythene Mulch	15.24	12.70	13.97	165.9	146.5	156.2
S.Em. ±	0.91	0.57	0.53	9.1	6.1	5.5
C.D. at 5%	2.64	1.66	1.53	26.6	17.9	15.7
Mean	13.24	11.53	12.39	139.0	130.5	134.8

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Dry Matter Accumulation and Growth Attributes of Potato as Influenced by Irrigation and Fertilizer Application *

Abdul Khalak[1] and A.S. Kumaraswamy[2]

ABSTRACT : Field experiments were conducted during rabi seasons of 1985-86 and 1986-87 on red sandy loam soil (Alfisol) to find out the effect of two irrigation schedules and three fertilizer levels on dry matter accumulation and growth attributes of potato cv. Kufri Jyotyi. Improvement in the growth parameters and dry matter accumulation was observed with the increase in frequency of irrigation and fertilizer levels. Under limited water availability, leaf area index (2.3), leaf area duration (48.8 days), dry matter accumulation (55.3 g/plant) and tuber yield (184 q/ha) were significantly higher in high frequency irrigation given in smaller quantity (20 mm) as compared to low frequency irrigation given in larger quantity (40 mm). Higher fertilizer level of 150 : 150 : 150 kg N, P_2O_5 and K_2O per ha significantly increased the LAI (2.5), LAD (53.6 days), dry matter accumulation (52.6 g/plant) and tuber yields (175 q/ha) compared with other fertilizer levels.

INTRODUCTION

Potato is very sensitive to soil moisture. Potato crop is grown during rabi season with well or lift irrigation under limited water conditions in eastern Karnataka. The sandy loam soils (Alfisols) of this region are generally poor in nutrients. Variation in any one of the factors i.e., soil moisture or nutrients considerably affect the growth and development of the crop. Increase in irrigation frequency enhances growth attributes such as, leaf area, leaf area index, dry matter accumulation in potato, thus results in higher tuber yields (5, 6, 9). Fertilizer levels increased the tuber yields of potato due to better growth and dry matter accumulation (3,7). The present study was made to find out an irrigation schedule with appropriate fertilizer level for potato crop under limited water availability.

MATERIALS AND METHODS

Field studies were conducted on red sandy loam soil (Alfisol) of Bangalore during rabi seasons of 1985-86 and 1986-87. The pH of soil was 6.7 with organic carbon (0.56%), total N (0.049%), availablee P_2O_5 (30.7 kg/ha) and K_2O (212.5 kg/ha). Irrigation depths (20 and 40 mm) at a IW/CPE ratio of 0.75 in main plots and three fertilizer levels (50, 100 and 150 kg each of N, P_2O_5 and K_2O along with 20 tonnes of FYM per ha) in sub-plots were tested in a split-plot design with four replications. The net plot size was 6.8 m x 3.2 m. Cut pieces of seed tubers of potato cv. Kufri Jyoti with 2 to 3 eyes (35-40 g) were planted in furrows at 40 cm x 20 cm. As per

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treatments, 50 per cent N and entire dose of P_2O_5, K_2O and FYM were applied in furrows at planting. The remaining N was top dressed four weeks after planting.

The amount of water given in the ratio of irrigation water (IW) and cumulative pan evaporation (CPE) was determined using the evaporation recorded from USWB Class 'A' Open Pan Evaporimeter. Irrigation schedule was common to the crop upto four weeks and subsequent irrigations were scheduled as per treatments shown below :

Irrigation schedule	IW/CPE ratio	IW (mm)	CPE at which next irrigation is due (mm)
D_1	0.75	20	26.67
D_2	0.75	40	53.33

The observations like plant height, number of shoots per plant, leaf area per plant, leaf area duration and dry matter accumulation per plant were recorded. The experimental data was statistically analysed (1) and the data was pooled as per the procedure of Gomez and Gomez (2).

RESULTS AND DISCUSSION

Effect of irrigation schedules : Irrigation schedules had nonsignificant effect of plant height (Table 1.) However, the plants were taller with 20 mm of irrigation water given at 0.75 IW/CPE ratio (31.4 cm) when compared to 40 mm of water given at 0.75 IW/CPE ratio (29.1 cm). Likewise, significant variation was not observed in the number of shoots per plant between irrigation schedules i.e., 2.3 and 2.4 in D_1 and D_2, respectively.

Irrigation schedule D_1, recorded significantly higher leaf area index (2.3) than D_2 (1.9). Similarly, leaf area duration at 30 to 60th day differed significantly between irrigation schedules. Irrigation schedule at D_1, significantly increased leaf area duration (48.8 days) than D_2 (42.0 days). These results are in accordance with the findings of Rab & Willatt (5).

Leaf, stem, tuber and root dry weights were significantly higher in high frequency irrigation (D_1) than low frequency irrigation (D_2). Significant differences were observed between irrigation schedules in the total dry matter accumulation i.e., 55.3 g/plant in D_1 and 41.8 g/plant in D_2 (Table 1). Such increase in dry matter accumulation under wet regime has also been reported by Singh and Arora (9). This was due to high correlation between leaf area duration and final dry matter, suggesting that the effect of water stress on dry matter accumulation was largely a function of effects of leaf area expansion and leaf senescence. Thus, the significant increase in the dry matter accumulation ultimately result in significantly higher tuber yield (184 q/ha) in high frequency irrigation when compared to low frequency irrigation (134 q/ha) (Table 1). High frequency irrigation with lower depth has been reported to be useful in potato crop in situations of limited water availability (6).

Table 1. Effect of irrigation schedules and fertilizer levels on growth characters, dry matter accumulation and tuber yield of potato (Pooled over two years)

Treatments	Plant height (cm)	No. of shoots per plant	Leaf area index at 60 days after planting	Leaf area Duration at 30th to 60th day (days)	Dry matter accumulation/plant (g)					Tuber yield (q/ha)
					Leaf	Stem	Tuber	Root	Total	
Irrigation Schedules (IW/CPE = 0.75)										
D_1 : 20 mm	31.4	2.3	2.3	48.8	14.2	4.5	33.9	2.5	55.3	184
D_2 : 40 mm	29.1	2.4	1.9	42.0	11.2	3.8	25.2	1.9	41.8	134
C.D. at 5%	NS	NS	0.3	6.0	2.7	0.7	6.1	0.5	8.8	13
Fertilizer levels (kg/ha)										
N - P_2O_5-K_2O										
F_1 : 50 50 50	2.1	2.2	1.7	37.3	10.8	3.3	28.2	2.0	44.2	143
F_2 : 100 100 100	2.2	2.3	2.1	45.2	13.2	4.0	29.4	2.1	48.8	160
F_3 : 150 150 150	2.3	2.5	2.5	53.6	14.1	5.1	31.1	2.5	52.6	175
C.D. at 5%	NS	NS	0.6	6.4	1.4	0.6	NS	0.4	5.3	13

NS = Not significant

Effect of fertilizer levels : Data on plant height indicated significant differences among the fertilizer levels at harvest (Table 1). Fertilizer level F_3, recorded significantly higher plant height (32.5 cm) than F_2 (30.2 cm) and was lowest in F_1 (28.1 cm). However, number of shoots per plant did not differ significantly among the fertilizer levels.

Fertilizer levels showed significant variation in leaf area index at 60 days after planting. Among fertilizer levels, F_3 (2.5) was superior to F_1 (1.7). As the fertilizer levels increasd, leaf area duration also increasd significantly (37.3 to 53.6 days). Similarly, fertilizer levels significantly increased the dry matter accumulation in all plant parts of potato except the tuber dry weight per plant at harvest (Table 1). Fertilizer level F_3 record significantly higher dry weight (52.6 g/plant) compared to F_2 (48.8 g/plant) and F_1 (44.2 g/plant) at harvest. In general, there was significant improvement in growth components with the increase in fertilizer levels. The major portion of dry matter was accumulated in tubers which in turn make up the yield of potato. Similar observations were made by many earlier workers (4,8). As per interaction (Table 2) high frequency irrigation with lower depth at higher fertilizer level was significantly superior (237 q/ha) to other irrigation schedules.

Based on the study, it can be inferred that the growth attributes, dry matter accumulation and tuber yields increased with the increase in frequency of irrigation and fertilizer application to potato.

Table 2. Interaction effect of irrigation schedules and fertilizer levels on tuber yield of potato (q/ha) during 1986-87

	Fertilizer levels (kg/ha)			Irrigation schedules		
				D_1	D_2	Mean
	N	P_2O_5	K_2O			
F_1	50	50	50	164	124	144
F_2	100	100	100	185	156	171
F_3	150	150	150	237	159	198
		Mean		195	147	171
						C.D. at 5%
		F x D				17.6
		D x F				28.7

D_1 - 20 mm
D_2 - 40 mm

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Distribution and Control of Pink Rot of Potato in Shimla Hills*

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ABSTRACT : Pink rot infection varied from 1.8% (Matiyana) to 8% (Shimla) in Shimla hills. Mixed infection of pink rot and late blight was also prevalent in tubers in the range of 3.1 - 6.0%. Six out of 21 hybrids/cultivars showed pink rot infection; highest incidence being in Kufri Chandramukhi and lowest in JH-222. Growth of *Phytophthora erythroseptica* on rye agar and colonization in tuber tissue was six times faster than *P. infestans*. Tuber treatment with chemicals prior to their inoculation gave better control than the post inoculation treatment. Pre-inoculation tuber treatment with metalaxyl (0.2%) and oxadixyal (0.2%) were the best and gave cent per cent control in pre-inoculation tuber treatment and 84 – 100% control in post-inoculation treatment, when the tubers were treated within 48 h of inoculation. Possible reasons for flaring up of pink rot in Shimla hills have been discussed.

INTRODUCTION

Pink rot of potato caused by *P. erythroseptica* (syn. *P. himalayensis*) was reported as early as 1948 by Dastur (6) but was not considered important. However since 1977 it has been occurring regularly at Shimla and Kufri (1, 2, 3, 4 and 5) with an incidence in the range of 4 to 6%. Control of pink rot in the field has been attempted (9) but its control in the heaps and stores remained to be worked out. Studies were therefore undertaken to generate data on prevalence of pink rot in Shimla hills, its association with late blight tuber infection in the field and its control measures.

MATERIALS AND METHODS

Survey : Shimla hills were surveyed for five consecutive years (1987-1991) for the prevalence of pink rot infection in potato tubers at harvest. At each location (Table 1) five terraces representing the soil type and topography of the region were selected. In each terrace 5-6 randomly selected plants were examined. Preliminary screening of advanced hybrids/commercial cultivars grown at the Central Potato Research Station, Kufri was carried out in 1991.

Fungal Growth and Colonization : Growth rates of *P. infestans* and *P. erythroseptica*, the causal agents of late blight and pink rot respectively, were determined on rye-B agar medium by the method described by Caten & Jink's (2). Five mm diameter bits were cut from the advancing edge of the fungus colonies and placed in the centre of the rye agar petri plates which were incubated at 18 + 1°C for 7 days.

Rate of Tuber Colonization : Freshly harvested tubers of cv. Kufri Jyoti were inoculated with 7 days old culture of the fungus. Mycelial bits were inserted below the

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tuber skin with dissecting needle. Inoculated tubers were incubated at 18 + 1°C and per cent tuber area infected was measured on every alternate day starting with sixth day of inoculation.

Chemical Screening : Three fungicides, viz. metalaxyl, oxadixyl and benomyl 50 WP and three concentrations of each, viz. 0.1, 0.2 and 0.5% a.i. were used. Ten sprouted tubers and three replications were treated with each concentration of the respective fungicide by dipping for 30 min. In one set, the treated tubers were inoculated while in other set the tubers were first inoculated and one set each was treated after 24, 48 and 72 h of incubation. The inoculated tubers were incubated at 25°C.

RESULTS AND DISCUSSION

Occurrence and Distribution : Pink rot infection was recorded at six out of seven locations surveyed (Table 1) which shows that this disease is wide spread in Shimla hills. Highest pink rot incidence was recorded at Shimla (8%) followed by Fagu, Kufri and Theog (DI 5.0, 4.3 and 4.0%, respectively). Surveys also revealed that *P. infestans* and *P. erythroseptica* may cause mixed infection of potato tubers in the field. This has opened up a possibility of interaction between *Phytophthora* spp. which may have wide ranging repercussions on the diseases that they cause. Mixed infection of pink rot and late blight was upto 6% at Shimla, 3.3% at Kufri, and 3.1% at Fagu. However, when the infected tubers (cv. Kufri Chandramukhi) were stored at room temperature pink rot spread much faster than the late blight. Comparative colonization rate of *P. infestans* and *P. erythroseptica* in inoculated tubers of cv. Kufri Chandramukhi also supports this observation where, *P. erythroseptica* infection was six times faster than that of *P. infestans*. Similar trend was observed with regard to growth of two pathogens on agar medium (Table 3).

Rai (7) had recorded pink rot infection upto 10% in only some plots at Shimla. The present study reveals that the pink rot is wide spread and on an average causes 4-6%

Table 1. Per cent pink rot in Kufri Jyoti tubers in Shimla hills *

Locality	Pink rot (%)	Mixed infection pink rot + late blight (%)
Kufri	4.3	3.3
Fagu	5.0	3.1
Koti	2.6	0.0
Matiyana	1.8	0.0
Shimla	8.0	6.0
Theog	4.0	0.0
Sonarghati	0.0	0.0

*Pooled data of 1987 to 1991.

tuber rot in Shimla hills. Amongst 21 cultivars/hybrids, only 6 showed pink rot infection; the incidence varying from 12% (Kufri Chandramukhi) to 1.5% (JH 222). Kufri Jyoti tubers showed 5% infection (Table 2). It shows that enough variability exists in potato germplasm with regard to pink rot resistance.

Table 2. Per cent tuber infection in potato cultivars/hybrids under natural infection at Kufri

Cvs/Hybrid	Late blight (LB)	Pink rot (PR)	Mixed infection (LB + PR)
Kufri Jyoti	10.0	5.0	3.2
Kufri Chandramukhi	35.0	12.0	8.0
MS/79-34	8.1	2.5	0.0
SLB/U-125	4.7	0.0	0.0
QB/A-9-120	0.0	0.0	0.8
KF-53	1.2	0.0	0.0
MS/79-10	4.5	0.0	0.0
MS/78-46	0.0	6.1	4.7
Kufri Swarna	5.0	0.0	0.0
JH-222	5.0	1.5	0.0
EX/A-680-16	0.0	2.4	0.0
PJ-376	0.0	0.0	2.5
SLV-U-125	1.5	0.0	3.03

No. infection of LB or PR was deteted in hybrids, viz. H-5857, VDS-41, VDS-65, VDS-43, VDS-46, VDS-82, VDS-100 and EB/A-304.

Resurgence of pink rot in 1976 and its build up in subsequent years might be due to change in varietal pattern. Upto 1970, cultivar, Up-to-Date was being grown. Tubers and foliage of this cultivar are highly susceptible to late blight and it is therefore likely that *P. erythroseptica* might not have competed with *P. infestans* and consequently the pink rot infection would have remained low. This hypothesis is supported by the present observations where the incidence of late blight infection was much higher (35%) over pink rot (12%) in susceptible tubers of cv. Kufri Chandramukhi (Table 2). Since 1970, Up-to-Date has been replaced by cv. Kufri Jyoti whose tubers were immune to late blight in early seventies. This would have given *P. erythroseptica* an edge over *P. infestans.*

Chemical Control : The pooled data showed that both metalaxyl and oxadixyl were highly effective at all the concentrations tried in controlling pink rot infection when tubers were treated with these fungicides prior to their inoculation. Benomyl was comparatively less effective (Table 3). Under post-inoculation conditions, metalaxyl gave highest control (69.2%) followed by oxadixyl (59.8%) and benomyl (27.1%). Efficacy of benomyl (45.1%) was better after 48h treatment but it declined after 72h (11.6%). However, the trend was different at 0.2% concentration, where oxadixyl proved better over metalaxyl. Efficacy of metalaxyl and oxadixyl increased upto 0.2%

Table 3. Efficacy of systemic fungicides against pink rot

	% PR inhibition/hours and concentration															
	24*				48*				72*				Pooled over hrs.			
Chemicals	0.1**	0.2**	0.5**	Mean	0.1**	0.2**	0.5**	Mean	0.1**	0.2**	0.5**	Mean	0.1**	0.2**	0.5**	Mean
benomyl	15.0	15.8	42.9	24.6	2.2	63.6	69.6	45.1	11.6	10.9	12.2	11.6	9.6	30.1	41.6	27.1
metalaxyl	100.0	100.0	100.0	100.0	47.0	84.9	91.3	74.4	43.9	25.0	30.6	33.1	63.6	70.0	74.0	69.2
oxadixyl	18.9	87.7	89.4	65.3	36.6	90.4	92.3	73.3	43.9	44.5	34.9	41.1	33.1	74.1	72.2	59.8
Mean	44.6	67.8	77.4	63.3	28.6	79.6	84.6	64.3	33.1	26.8	25.9	28.4	35.4	58.1	62.6	52.0
SE+(Chemical/Concentration)				1.0				1.2	SE+(Chemical/conc.)				1.8			1.4
CD (0.05)				2.2				2.5	CD (0.05)				3.8			2.8
									SE+(interaction : Chemical							
SE+(Interaction : Chemicals									vs. Conc.)				3.1			2.4
vs. Concentration)				1.8				2.0	CD(0.05)				6.6			4.7
CD (0.05%)				3.7				4.3	SE + (Hours)				0.5			
									CD 0.05)				0.4			
									SE + (Hours)				0.5			
									CD (0.05)				0.4			

* = hours after tuber inoculation with *P.erythroseptica,*

** = *% chemical concentration.*

conc. Thereafter, it did not increase significantly (Table 3) indicating that 0.2% concentration is most suitable for controlling pink rot tuber infection. Chemical treatments were also effective upto 48h of tuber inoculation (63.3 - 64.3% inhibition). Thereafter (72 h), their efficacy declined considerably (28.4%). This might be due to high disease pressure (% infection) in tubers inoculated 72 h before treatment (24 - 45% tuber area) as compared to 48 h (15-25%) and 24 h (5-10%).

It is evident from the results that the treatment of tubers with systemic fungicides like metalaxyl and oxadixyl at harvest will take care of pink rot infection which may exist in freshly harvested tubers or may occur later in stored potatoes. These fungicides are also effective in controlling late blight tuber infection (8, 9). Control of pink rot infection in the field is possible by applying systemic fungicide, viz. metalaxyl (40 kg/ha) in furrows at planting (10) but it is an uneconomical proposition.

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Genotypic Variability for Microtubers Production in Potato*

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INTRODUCTION

In vitro microtubers are the potential propagules for increasing the rate of multiplication in potato (2). With the adoption of *in vitro* plantlets for international exchange of potato germplasm, CPRI is receiving *in vitro* germplasm from different countries (3) necessitating the production of sufficient quantities of the tubers in short time for field evaluation. The multiplication of *in vitro* plantlets was carried out through microtuber production because by their use not only higher rate of multiplication but also the maintenance of disease freedom is possible. Transplanting of tender plantlets from *in vitro* conditions to an external environment is also possible but is laborious and involves risk in establishment. On the other hand microtubers harvested from *in vitro* conditions can be conveniently stored and planted in glass house/net house. During the microtuber production, genotypic variability was studied in 55 exotic *in vitro* germplasm accessions.

MATERIALS AND METHODS

Two culture tubes each of fifty-five exotic genotypes recieved as *in vitro* plantlets from International Potato Centre, Lima, Peru during 1988-89 were used in the study. Generally, two culture tubes of each accession are received. The *in vitro* plantlets were first incubated in a culture room under 16h photoperiod of 3000 lux and 22°C temperature to revive from transportation shock. After 4-5 days of incubation, each accession was multiplied in *in vitro* using single node cuttings on PM-103 medium (MS + 2mg/l calcium pentothenate + 0.01 mg/l NAA + 0.1 mg/l GA_3 + 3% sucrose + 0.6% agar). Each accession was multiplied to produce 6-7 culture tubes. Two to three tubes of each accession were kept for *in vitro* conservation. From the remaining tubes the plantlets were taken out aseptically and the stems (with 2-3 nodes) were cut into pieces. Five stem pieces were inoculated in each culture tube (150 x 25 mm size) containing liquid propagation medium PM 103. In all 10 tubes per accession were prepared and incubated in culture room. After 4 weeks, when the test tubes were full with plantlets, the propagation medium was replaced with tuber inducion medium; MS+10 mg/l BA +8% sucrose (10). The culture tubes were incubated in the dark at 18 ± 2°C. Microtubers were harvested after 60 days of incubation in dark. They were

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washed with tap water and dried in the shade on filter paper. After proper drying, the microtubers were kept in plastic petri-dishes sealed with parafilm and stored in a refrigerator. Before planting them in a glass house/field, they were taken out for sprouting. The data on the number of microtubers per culture tube and their average weight were recorded. Analysis of variance was done following the method given by Snedecor (8) for a completely randomized design. For this, the values of each of the 4 culture tubes were used. Genotypic coefficient of variation (GCV) was determined by the formula suggested by Burton (1). The phenotypic variance was taken as sum of the error variance and genotypic variance, the latter being calculated by substracting the error mean square from the genotypic mean square and dividing the remainder by the number of replications. Heritablility was calculated in broad sense by the formula suggested by Johnson *et al.* (6) and the genetic advance by the formula given by Lush (7) and Johnson *et al.* (6). For other statistical computations, the methods outlined by Gomez and Gomez (5) and Steel and Torrie (9) were followed. Analysis of variance and genetic parameters were computed only for number of microtubers. For microtuber weight only variability components were calculated based on genotypic means.

RESULTS AND DISCUSSION

The microtuber initiation was observed in most of the accession after 8-10 days of incubation in dark. However, in 3 genotypes, viz. Rosca, Andina and Gabriela (CP-3049, CP-3130, CP-3141 respectively), the microtuber initiation was observed after 15 days of incubation. In all the genotypes, the microtubers were ready for harvest after 60 days of incubation in dark. Estrada *et al.* (4) have reported that the microtubers were harvested after 40 days of incubation. We have observed that the microtubers could be harvested after 40 days also but if we leave them up to 60 days, the microtuber skin gets matured. Wide genetic variability in number and weight of microtubers produced was observed (Tables 1 to 3; Figures 1 and 2). This is the first report on genetics parameters for number of microtubers in potato. Results also showed that microtubers could be produced in all potato genotypes however, extra care was required for production in some genotypes.

The production of microtubers from a wide range of potato genotypes was reported by Estrada *et al.* (4). They incubated the cultures in 250 ml flasks, whereas, in the present study the cultures were incubated in test tubes of size 150 x 25 mm. The advantage in using test tubes in place of flasks is that less amount (only 10 nodes as against 30 used in their study) of plant material is required for incubation and microtuber production. This ensures that in case of contamination only a small quantity of plant material is wasted.

Estrada *et al.* (4) have used both BA and CCC in the microtuber induction medium while we have used only BA in the induction medium as used by Wang and Hu (10). But in spite of using both BA and CCC, the average microtuber weight of ten

Table 1 . Analysis of variance for number of microtubers in potato

Source	DF	Mean sum of squares
Genotypes	55	30.78**
Error	162	13.46

** P <0.01

Table 2 . Variability components of 55 potato genotypes for number of microtubers and their weight

Component	Trait	
	Number	Weight (mg)
Range	2.75 - 15.50	9.20 -269.2
Mean ±	7.88 ± 0.38	120.30
Coefficient of variation	35.3	46.5
LSD	2.23	*

* Not calculated

Table 3 . Genetic parameters for number of microtubers in potato

Parameter	Value
Phenotypic variance	17.80
Genotypic variance	4.33
Environmental variance	13.46
Phenotypic coefficient of variation	53.33
Genotypic coefficient of variation	26.30
Heritability (%)	24.99
Genetic advance as per cent of mean	47.50

reported genotypes was 97.13 mg while we got average microtuber weight of 120 mg from 55 genotypes of wide genetic base. The average number of microtubers per culture flask (30 nodes/flask), in their study varied from 8.2 ± 3.9 to 20.8 ± 3.3. Whereas, in our study, the number of microtubers produced (from 10 nodes per test tube) varied from 2.75 to 15.5. These studies thus indicated that microtubers can be produced from a wide genetic base using small quantities of plant material and using only BA in microtuber induction medium.

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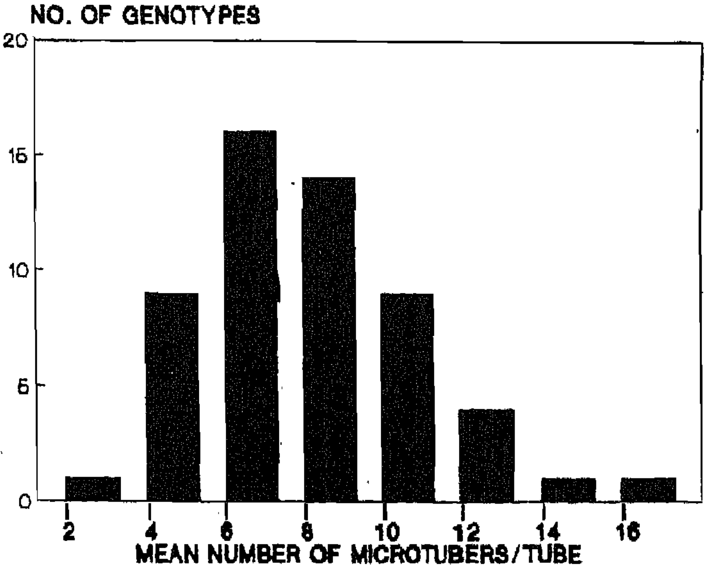

Fig. 1. Frequency distribution for number of microtubers in 55 potato genotypes

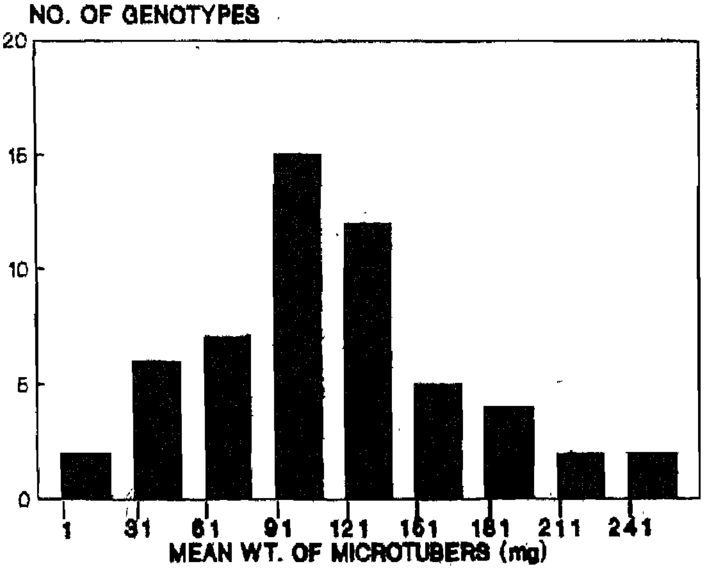

Fig. 2. Frequency distribution for weight of microtubers in 55 potato genotypes

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SHORT NOTE

Field Resistance of Potato against Late Blight in North Eastern Hill Region*

Surendra Ram[1]

Late blight resistant potato varieties were brought under cultivation in early seventies in different regions of India (2, 3, 5). These varieties had R-gene resistance derived from *S.demissum*. Compatible races of the pathogen developed within a short span of 4 to 5 years and the varieties proved unsuitable for the purpose they were bred. Field resistant varieties are required to overcome this problem (8, 9). Hence germplasm collections and hybrid lines developed at the Central Potato Research Station, Shillong were screened for field resistance.

Forty nine germplasm accessions and 89 hybrid lines developed at this station were planted during summer seasons of the year 1985 to 1987 as per design suggested by International Potato Centre (7). After every 4 entries Kufri Jyoti and Up-to-Date were planted as standard varieties. Planting was done either by the end of March or beginning of April, slightly late from the normal planting time, so that the test entries may be exposed to highly congenial environment simultaneously. All the test entries were planted in a rod row of 10 tubers each and replicated twice. In the beginning of each rod row three heels were planted with the susceptible variety Up-to-Date to act as infector, two rows of Up-to-Date were planted around the whole screening plot in order to ensure uniform inoculum supply to the test entries. To record first appearance of disease, the crop was observed daily in the initial stages but there after the disease development was recorded at weekly intervals as per BMS Key (1947). Apparent infection rate in logits (r) was computed (9) and the test entries were grouped into five categories depending on the apparent infection rate. Apparent infection rate was not constant in all the three years of trial, hence highest rate recorded during the experimentation formed the basis of grouping into following categories :

Highly susceptible ($r > 0.45$)

CP-1215, CP-1334, CP-1456, CP-1463, CP-1524, CP-1604, CP-1614, CP-1617, CP-1632, CP-1653, CP-1668, CP-1672, CP-1706, CP-1711, CP-1714, CP-1764, CP-1771, CP-1806, CP-1813, CP-1848, CP-1880, CP-1969, CP-1978, CP-1986, CP-2000, CP-2013, CP-2025, CP-2052, CP-2069, SS/A-59, A-256, C-580, C-643, C-1025, C-2572, O-2111, D-3374, E-309, E-573, E-755, E-968, E-1232, E-1611,

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E-2096, E-2254, E-2338, E-2566, E-2568, E-2608, E-2618, E-2658, E-4381, G-153, G-2299, JH-214, JH-222, M-70, M-100, M-447, M-899, N-212, N-386, N-893, N-1004, EMI-353, KF-4, Kufri Lalima, Kufri Khasigaro, Kufri Bahar, Kufri Chandramukhi.

Susceptible (r = 0.45 to 0.36)

CP-1476, CP-1516, CP-1643, CP-1686, CP-1710, CP-1754, CP-1769, CP-1818, CP-1834, CP-1971, CP-1999, SS/C-649, C-1101, C-1178, D-3402, SS/E-108, E-117, E-503, E-623, E-626, E-861, E-907, E-938, E-957, E-1229, E-1769, E-2076, E-2653, E-2656, E-2732, E-2868, E-3096, E-3490, E-3738, E-3739, E-3745, E-3788, F-11, SS/G-812, G-886, G-2277, JH-1996, N-396, WF-1, WF-18, O-483, Lahtared, Hartha, Kufri Jyoti and Kufri Badshah.

Moderately resistant (r = 0.36 to 0.26)

CP-1341, CP-1401, CP-1427, CP-1646, CP-2002, CP-2015, CP-2068, SS/E-649, 712, 871, 1759*, 2623*, SS/G-1077, 2205, 3009, SS/I-240 and WF-17.

Resistant (r = (0.26 to 0.16)

CP-1699*, CP-1731* SS/E-908*, 2709, SS/M-40*

Immune

SS/C-562, SS/E-606*, 1632*

The above grouping shows that most of the germplasm collections and hybrid lines screened were either highly susceptible or susceptible. One of the possible reason for this low level of field resistance among the hybrids might be the dispersement of field resistance factor during hybridization (4). In the absence of highly resistant germplasm accessions hybrids, the germplasm collections with moderate degree of resistance viz. CP-1401, CP-1427, CP-1646, CP-2002 and CP-2068 and hybrid E-2709 (resistant) may be utilized as donor parents, while hybrids having better agronomic qualities may be recommended for cultivation as field resistant varieties respond fairly well to the chemical control (6).

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SHORT NOTE

Influence of Fertiliser N Rate and Nitrification Inhibitor on the Storage Behaviour of Potatoes

P. Stalin[1] and J. Enzmann[2]

Reports are available on the effect of N fertilization in combination with use of nitrification inhibitors on N transformation in soil, nutrient uptake and yield of various crops (2-4). However, the information on the response of N nutrition from (NH_4-/NO_3-N) on the storage behaviour of agricultural produces is scanty. One of the major constraints in the utilization of tuber crops is the rapid perishability of the tubers after harvest. In the present study an attempt has been made to study the effect of N fertilization in connection with the use of a nitrification inhibitor, CMP (1-Carbamoyl-3 (5)-Methyl Pyrazole) on the storage behaviour of potatoes.

Field experiments were conducted during 1982 and 1983 on sandy less deep loam leached soil at the Probstheida experimental station of the Institute of Tropical Agriculture, University Leipzig, Germany. The treatments were arranged in a factorial experimental design and replicated four times. There were eight treatments comprising four levels of N, viz., 0, 80, 160 and 240 kg/ha as urea alone, and in combination with the nitrification inhibitor CMP (4 kg/ha substance). CMP dissolved in water was directly sprayed and worked immediately 10 cm deep into the soil prior to urea application. All plots received a basal dose of 47.2 kg P/ha as super phsophate and 200 kg K/ha as muriate of potash. Seeds of potato cv. Adretta, a medium duration variety commonly grown in the (former) GDR, were planted in trial plots measuring 6 x 4.8 m.

At physiological maturity, the tubers were harvested and used for this study. Only medium size tubers (41-59 mm) were taken, three tubers per treatment in four replications, and stored separately for seven months in a cool chamber where the temperature (13 ± 1°C) and the relative humidity (90 ± 2%) were maintained constantly throughout the study. The weight of tubers were recorded at periodical intervals and the storage losses were calculated on percentage weight basis.

Data on the effect of different N levels on storage losses of potatoes for two seasons are furnished in tables 1 and 2, respectively. The results show clear seasonal differences. The storages losses were higher in 1983 than in 1982 which might be attributed to the differences in the initial dry matter content of tubers used for the study. At the harvest the dry matter content in tubers were relatively lower by 3 to 4%

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Table 1 . Storage losses of potatoes (%) under various N levels in 1982

N levels (kg/ha)	Storage losses (%) Days after storage								Per cent over control
	34	64	99	130	161	189	221	Mean	
Without CMP									
0	1.7	2.5	3.6	4.2	4.8	5.7	6.7	4.2	—
80	1.9	2.7	3.7	4.4	5.0	5.6	7.2	4.4	5
160	2.3	3.2	4.3	4.9	5.7	6.3	7.7	4.9	17
240	2.7	3.5	4.9	5.3	6.2	7.3	8.1	5.4	29
Mean	2.2	3.0	4.1	4.7	5.4	6.2	7.4		
With CMP									
0	1.8	2.5	3.6	4.1	4.7	5.5	6.5	4.1	—
80	1.9	2.9	4.1	4.5	5.6	6.3	7.1	4.6	12
160	2.1	3.0	4.2	4.8	5.7	6.5	7.5	4.8	17
240	2.5	3.3	4.5	5.1	5.9	7.1	7.9	5.2	27
Mean	2.1	2.9	4.1	4.6	5.5	6.4	7.3		

Table 2 . Storage losses of potatoes (%) under various N levels in 1983

N levels (kg/ha)	Storage losses (%) Days after storage								Pe rcent over control
	31	57	86	121	150	182	214	Mean	
Without CMP									
0	3.7	4.9	5.5	5.9	6.2	6.6	7.0	5.7	—
80	5.0	6.3	7.1	7.4	7.7	8.1	8.6	7.2	26
160	5.3	6.5	7.4	7.7	7.9	8.6	8.9	7.5	32
240	5.6	6.7	7.8	8.2	8.5	8.9	9.4	7.8	37
Mean	4.9	6.1	7.0	7.3	7.6	8.1	8.4		
With CMP									
0	4.0	5.1	5.6	6.2	6.4	6.8	7.1	5.9	—
80	4.9	6.1	6.8	7.1	7.4	7.8	8.3	6.9	17
160	5.1	6.5	7.2	7.5	7.7	8.3	8.7	7.3	24
240	5.4	6.8	7.6	8.0	8.3	8.7	9.2	7.7	31
Mean	4.9	6.1	6.8	7.2	7.5	7.9	8.3		

in 1983 than that in 1982 (data not reported). The reason for the seasonal differences may be the water accumulation of the tubers which was caused by the higher rainfall (177.5 mm) received during the month of August, at the maturity phase in 1983, while the rainfall in August was only 27.6 mm in 1982. The data in the tables 1 and 2 showed further that the storage losses increased gradually in the course of the storage period during both the years which may be based on the biochemical changes like respiration and evaporation of tubers (moisture losses). With increasing the levels of N, the storage losses of potatoes increased clearly at all the periodical intervals. Similar findings were also obtained in potato by Schnieder (5) and Bohmig *et al.* (1). From the tables 1 and 2 it can be seen further that the treatment, viz. 240 kg N/ha without CMP recorded highest losses by 8.1% (1982) and 9.4% (1983) on 221st day and 214th day after storage respectively. The use of CMP reduced slightly the storage losses when a comparison was made with the treatments without CMP use. This phenomenon could be attributed to the dominated ammonium nutrition of potato crop induced by use of CMP.

From the above study, it can be concluded that the application of N specially at higher levels will cause weight losses of tubers to considerable extent during the storage. There is a possibility to minimise the storage losses through use of nitrification inhibitor CMP.

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SHORT NOTE

Studies on Seed Physiology. I-Effect of Temperature on Sprout Growth and Development in Some Commercial Potato Cultivars*

V.N. Banerjee and Rakesh Bhargava[1]

In potato, the sprout growth and development are influenced by large number of factors among which the temperature, during as well as, prior to sprout growth plays the major role. It has been reported that the sprout growth is very slow at temperatures upto 5°C, but increases upto an optimum which depends upon the interaction between internal and external factors (1,2,3,5,7). However, very little information is available on the above aspects on Indian cultivars. Accordingly, an attempt has been made in the present study to find out the optimal temperature for sprout growth and development.

Well chitted potato seed tubers of five cultivars, viz. Kufri Lauvkar, Kufri Jyoti, Kufri Chandramukhi, Kufri Chamatkar and Kufri Badshah were scooped out from the apical end of the tuber. These were treated with 0.2% mancozeb solution and allowed to suberise overnight. Each eye was planted in a plastic cup containing sand and soil mixture in the ratio of 1:1. The cups were then kept, in dark, in B.O.D. incubators maintained at 8, 15, 20°C and room temperature (RT = 22 $\pm$ 2°C/16 $\pm$ 2°C max./min.). In all thirty two plants of each cultivars were used. These were divided into four treatments so that eight plants per treatment were maintained. The observations on the sprout length were recorded at weekly intervals and after 21 days the experiment was terminated and the fresh weight of sprouts were recorded.

The results obtained are presented in table 1. Perusal of the data reveals that the growth of the sprout was very slow at 8°C. In all the cultivars, there was no growth upto seven days after planting, at this temperature, thereafter it increased upto 3.6 to 10.0 mm, in different varieties by 14 days. After 21 days the length of sprouts was 39.2, 63.8, 56.3, 43.1 and 68.6 mm in cvs. Kufri Lauvkar, Kufri Badshah, Kufri Chandramukhi, Kufri Jyoti and Kufri Chamatkar, respectively.

A comparison of sprout growth at different temperatures reveals that the best sprout growth takes place at a constant temperature of 20°C in dark in cvs. Kufri Lauvkar, Kufri Badshah and Kufri Jyoti whereas in Kufri Chandramukhi and Kufri Chamatkar the optimum temperature was 15°C. This is evident by the sprout length at respective temperatures.

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Table 1. Sprout length and weight in five commercial cultivars at different temperatures

Cultivar	Temperature °C			
	8	15	20	RT[3*]
Sprout length (mm) at 14 days				
Kufri Lauvkar	5.2	64.0	158.2	129.7
Kufri Badshah	6.3	61.2	145.5	87.2
Kufri Chandramukhi	7.0	122.5	144.5	136.4
Kufri Jyoti	3.6	92.7	163.3	176.5
Kufri Chamatkar	10.0	198.8	252.3	239.1
CD var.[1*] (0.05) 27.96; CD temp[2*] (0.05) 20:38 CD any two temp. means at same level of var. (0.05) 45.57 CD any two var. means at any level of temp. (0.05) 48.35				
Sprout length (mm) at 21 days				
Kufri Lauvkar	39.2	64.0	283.5	201.9
Kufri Badshah	63.8	189.4	252.9	123.3
Kufri Chandramukhi	56.3	297.1	214.5	150.6
Kufri Jyoti	43.1	220.5	257.5	192.2
Kufri Chamatkar	68.6	362.9	332.1	294.8
CD var. (0.05) 42.02; CD temp (0.05) 27.28 CD any two temp. means at same level of var. (0.05) 61.0 CD any two var. means at any level of temp. (0.05) 67.5				
Sprout weight (g)				
Kufri Lauvkar	0.193	0.810	1.083	0.731
Kufri Badshah	0.379	0.887	1.105	0.491
Kufri Chandramukhi	0.317	1.081	0.911	0.935
Kufri Jyoti	0.208	0.977	0.976	1.141
Kufri Chamatkar	0.318	1.577	1.149	1.113
CD var. (0.05) 0.206; CD temp (0.05) 0.164 CD any two temp. means at same level of var. (0.05) 0.368 CD any two var. means at any level of temp. (0.05) 0.380				

* 1. Cultivar, 2. Temperature, 3. Room temperature.

The effect of temperature on the sprout growth has been studied in past by several workers. Burton (1) while working with cultivar Majestic reported that the sprout growth (g per tuber) increased from 10 to 20°C. Similarly, it has been reported that the rate of elongation of the sprout is positively related to temperatures from about 5 to 25°C (2, 4, 6). The present result also demonstrates that a linear relationship exists between the length of sprouts and temperature (Table 1). The inferences drawn on the basis of sprout length are further supported by the data obtained on the sprout weight taken at 21 days after planting. Perusal of table 1 reveals that maximum sprout weight was recorded at 20°C in cvs Kufri Lauvkar, Kufri Badshah whereas in Kufri Chandramukhi and Kufri Chamatkar the maximum sprout weight was recorded at 15°C. The foregoing account suggests that there exist varietal differences in response to temperature for sprout growth and development.

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SHORT NOTE

Influence of Seed Size and Spacing on the Economics of Potato Production in cv. Kufri Jawahar (JH 222*)

D.N. Nandekar, T.R. Sharma, R.C. Sharma and S.K. Choubey[1]

Seed is one of the major input in potato production accounting for almost 50 % of the cost of cultivation. Present investigation was undertaken at Zonal Agricultural Research Station, Chhindwara to ascertain proper seed size and spacing for potato production in cv. Kufri Jawahar.

A field experiment was conducted during rabi 1989-90 and 1990-91, under All India Co-ordinated Potato Improvement Project at Chhindwara (M.P.). The experiment was laid out in randomized block design with three (1989-90) and four (1990-91) replication having a plot size of 4.0 x 3.0 m. Manuring and irrigation was given as per recommendation of the region. The planting of Kufri Jawahar (JH-222) was done on 7th Nov. 1989 and 31st Oct. 1990. The treatments are enumerated in Table 1. Germination and number of stems were recorded at 30 and 50 days after planting, respectively. Crop was dehaulmed at 100 days after planting and harvested at full maturity. The produce of each plot was graded into large (above 75 g), medium (25-75 g) and small (below 25 g) categories. Net-return and cost-benefit ratio was calculated on the basis of investment on seed.

There were no significant differences in yield among different seed sizes. However 30 g tubers planted at 20 cm gave highest yield followed by 15 g tubers planted at 12.5 cm and 45 g tubers planted at 25 cm. Lowest yield was obtained when 15 g tubers were planted at 15 cm. No significant differences were recorded among the treatments in respect of plant emergence after 30 days of planting.

Seed size and spacing did not differ significantly with respect to percentage of different grades of tubers (Fig. 1). An increase in spacing increased percentage of large size tubers in the produce with a corresponding decrease in medium and small size tubers (1, 2).

Maximum net-income (Income of produce-expenditure on seed) was obtained when 15 g size tubers were planted at 12.5 cm (Rs. 43627) followed by 30 and 45 g size tubers planted at 20 and 25 cm respectively.

Planting of potato crop with 15, 30 and 45 g seed size tuber at wider i.e. 15, 25 and 30 cm intra row spacing respectively, gave maximum returns over investments on seed

* The hybrid has been tentatively christend as 'Kufri Jawahar'.

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Table 1. The tuber of potato/Cv. Kufri Jawahar (JH-222) and economic analysis of different treatment combinations of seed size and spacing

Symbol	Treatments			Germination % at 30 DAP			Total Yield (t/ha)			Net	CB
	Seed size (g)	Spacing within row (cm)	Seed rate (g/ha)	89-90	90-91	Mean	89-90	90-91	Mean	Income** (Rs/ha)	Ratio*
T_1	15	15	15	76.5	73.5	75.0	40.03	25.06	32.82	40252	12.27
T_2	15	12.5	20	70.8	76.2	73.5	39.83	31.31	35.57	43627	10.18
T_3	15	10	25	75.7	71.0	73.4	39.09	28.30	33.71	39719	7.68
T_4	30	25	20	83.5	99.4	91.5	31.87	29.76	30.81	37489	8.89
T_5	30	20	25	86.0	75.0	80.5	40.35	31.01	35.68	42539	8.16
T_6	30	15	30	78.3	71.0	74.7	39.77	29.85	34.81	39984	6.63
T_7	45	30	25	93.0	95.9	94.5	40.91	27.50	34.20	40257	7.77
T_8	45	25	30	84.2	91.3	87.7	37.89	32.78	35.33	41142	6.77
T_9	45	20	35	88.5	75.3	82.0	39.35	28.40	33.87	37694	5.52
		S.E. m±		—	—	—	3.62	1.77	—	—	—
		C.D. (%)	—	—	—	NS	NS				

* Cost benefit ratio per Rs. returns on investment of seed were caculated on the basis of two year mean of Income expenditure on seed.

** Seed tubers were purchased @ Rs. 2250 and 2500/t during 89-90 and 90-91, respectively. Produce was sold @ 1250 and 1500/t during 89-90 and 90-91, respectively.

a) Days after planting.

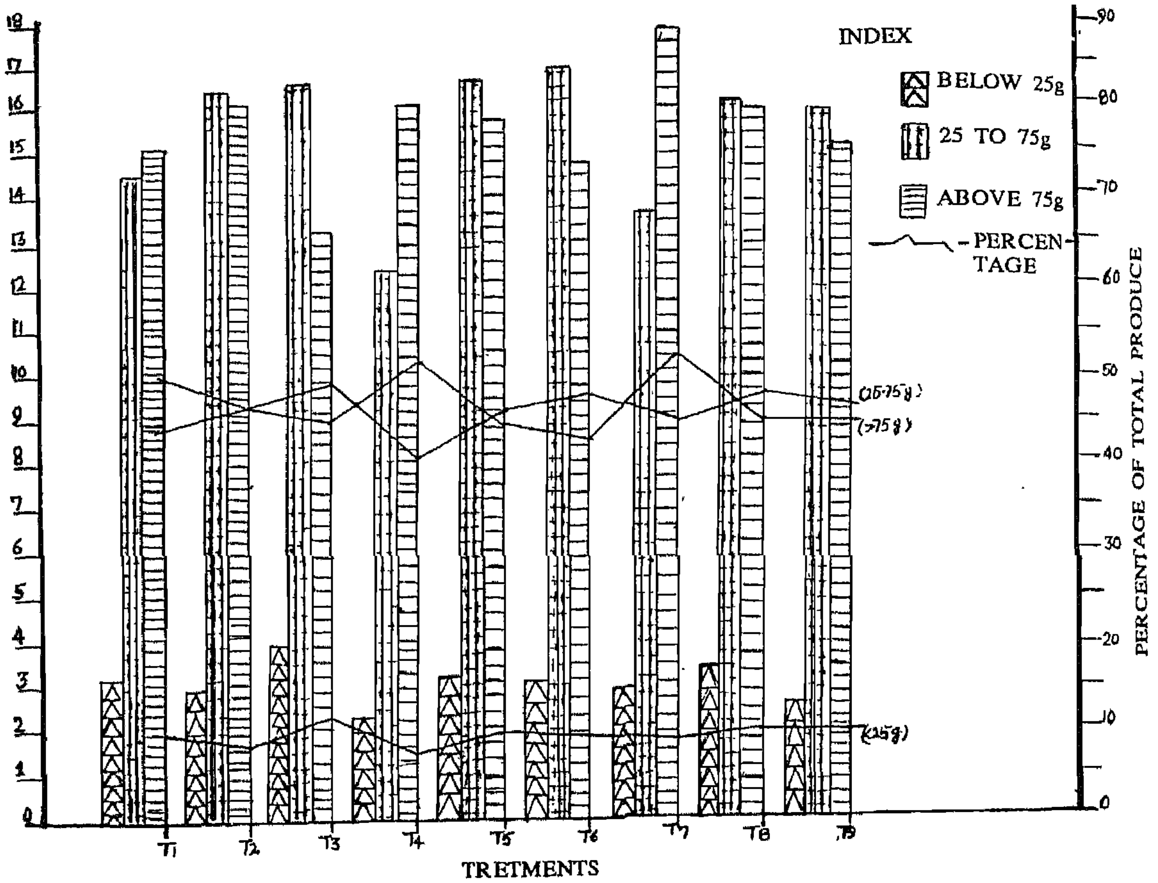

Fig. 1 : Mean yield of three grades of potato produce (1989-90 & 1990-91)

i.e. Rupees 12.27, 8.98 and 7.77, respectively. The cost benefit ratio (investment on seed) increased progressively with increase in spacing as well as with decrease in seed size.

It can be concluded from the above study that planting of potato crop at 15 and 12.5 cm intra row spacing with 15 g seed size of tuber gave maximum cost benefit ratio 12.27 with 15 cm spacing (15 q/ha) and maximum net-income Rs. 43627/ha with 12.5 cm spacing (20 q/ha).

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SHORT NOTE

Effect of Application of Magnesium on Potato Yield in Acid Soils of Nilgiris

R. Shanmugasundaram and K Nanjan[1]

Magnesium is an essential element for the development of chlorophyll in leaves and eventually plant growth and metabolism. Potatoes are more sensitive to deficiency of Mg than other crops (1). In Nilgiris (2500 MSL) where rainfall exceeds 1200-1500 mm every year, most of the soluble salts especially Ca and Mg get leached from the soil. Consequently their availability to plants is hindered. Hence, the present study was undertaken to see the response of potato to applied Mg.

Two field experiments were carried out during 1989-90 and 1990-91 in acid soils of Nilgiris. The experimental soils had 3.81 and 3.85% organic carbon, pH 4.2 and 4.0, available nitrogen 462 kg and 458 kg/ha, Bray's p^1 of 1.06 and 0.58 ppm, available potassium 180 and 165 kg/ha, exchangeable Ca 2.8 and 3.8 meq/100 gm soil, and exchangeable Mg 0.40 and 0.59 meq/100 gm soil in 1989 and 1990 respectively. There were five treatments consisting of three levels of Mg at the rate of 20, 40 and 60 kg/ha, foliar spray of 1% magnesium sulfate thrice on 40, 60 and 80 days after planting and control. The recommended doses of N, P and K @ 120 : 240 : 120 kg/ha were applied to all the treatments. The experiment was conducted in randomised block design with four replications. Soil and plant analysis was done as per the procedures outlined by Jackson (3).

The potato seed tubers of Kufri Jyoti were planted with a spacing of 50 x 20 cm during main season (May-April) of 1989 and 1990 and harvested in the month of July 1989 and 1990. Plant dry matter was calculated by sampling at random at the time of harvest. Plant and soil samples were collected for analysis of magnesium content.

Dry matter production : Though no significant difference in the dry matter was observed yet numerical increase in DMP was recorded with the levels of Mg. Foliar spray of 1% magnesium sulfate was found to record dry matter yield of 647 kg/ha and 1603 kg/ha in 1989 and 1990 respectively (Table 1).

Mg concentration and uptake : The data in Table 1 shows that percentage of Mg in plant was increased with the increase in level of Mg in soil. The increase in Mg concentration was significant in the year 1990. Foliar spray of 1% magnesium sulfate also increased the level of Mg in plants. This is in line with the work of Mondy *et al.*

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Table 1. Effect of application of magnesium on dry matter production (DMP), Mg content and uptake (haulms)

Treatments (kg Mg/ha)	DMP (kg/ha) 1989-1990	DMP (kg/ha) 1990-1991	Mg conc (%) 1989-90	Mg conc (%) 1990-91	Mg uptake (kg/ha) 1989-90	Mg uptake (kg/ha) 1990-91
20	604	1511	0.51	0.85	3.06	12.69
40	615	1555	0.54	1.01	3.27	15.71
60	621	1786	0.66	1.13	4.21	18.39
1% $MgSO_4$	647	1603	0.65	1.06	4.17	17.00
Control	525	1238	0.46	0.75	2.36	8.96
C.D.	NS	NS	NS	0.26*	1.35*	6.50*

* Signficant at 5% level

(5) who reported that application of magnesium sulfate increased the Mg content of potatoes.

Soil application of Mg significantly increased the Mg uptake of haulms. Highest uptake of 4.21 kg and 18.39 kg/ha was recorded with 60 kg Mg/ha in 1989-90 and 1990-91 respectively (Table 1). The increase in Mg uptake of haulms was mainly associated with higher dry matter production as a result of applied Mg. This was also reported by Singh and Sharma (4).

Soil exchangeable Mg : Post harvest analysis of soil samples showed that increase in dose of Mg significantly raised the exchangeable Mg over the control in both the years. It ranged from 1.43 – 1.44 meq/100 g soil in 20 kg/Mg/ha to 1.73 meq/100gm soil in 60 kg/Mg/ha (Table 2).

There was significant increase in tuber yield due to different treatments (Table 2). Soil application of Mg increased the yield from 10.93 and 12.38 t/ha in 20 kg Mg/ha

Table 2. Data on soil exchangeable magnesium and tuber yield

Treatments (Kg Mg/ha)	Soils ex. Mg (meq/100g/soil) 1989	Soils ex. Mg (meq/100g/soil) 1990	Yield of Tuber (t/ha) 1989	Yield of Tuber (t/ha) 1990
20	1.44	1.43	10.93	12.38
40	1.49	1.65	12.65	13.63
60	1.73	1.73	13.28	15.00
1% $MgSO_4$	0.89	1.12	13.43	14.12
Control	0.80	1.06	9.46	11.25
CD	0.55*	0.38*	2.23*	1.30*

* *Significant at 5% level*

to 13.28 t/ha and 15 t/ha in 60 kg Mg/ha in 1989 and 1990 respectively. These results corroborate the findings of Singh and Sharma (4) who reported that application of Mg at two levels (2.5 kg and 5 kg Mg/ha) increased the tuber yield. However, significant increase in tuber yield was observed upto 40 kg Mg/ha. Foliar application of 1% magnesium sulfate recorded comparable yield of 13.43 and 14.12 t/ha in 1989 and 1990 respectively. It was also reported by Chuck and Brown (2) that use of 10 lbs of epsom salt in 100 gallons of Bordeaux mixture applied as a spray resulted in substantial yield increase of potato.

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SHORT NOTE

Rapid Multiplication of Potato Tubers using Sprouts

S.C. Khurana and M.L. Pandita[1]

Tuber to tuber multiplication rate ranges between 3-10 times in potato depending upon variety, agronomic practices and agro-climatic conditions. Anamica and Singh (1), Singh *et al.* (7). Naik *et al.* (6), Van Ho *et al.* (8) and Kaley and Singh (2) suggested the use of sprouts for increasing the multiplication rate in potato tubers. In most of the studies carried out so far only one flush of sprouts has been taken and sproutlings have been developed in nursery beds or polythene bags. In the present paper, we report a simple method of developing sproutlings on the mother tuber itself. We decided to harvest more than one flush of sprouts from the same tuber and used different tuber sizes in two commercially grown potato varieties to see their effect on multiplication rate.

During 1988-89, tubers of six sizes (25, 50, 75, 100, 125 and 150 g) of two commercial varieties, viz., Kufri Badshah and Kufri Chandramukhi were used. Tubers removed on 15th October, 1988 from the cold store and after having kept for two days in diffused light were spread in a plain bed in the field from end to end and covered with a 5 cm thick layer of sand. The sand was kept moist by sprinkling water from time to time. Tubers were taken out from the sand bed on 8th November for harvesting sprouts. These were again covered by the sand for resprouting as mentioned above. Sprouts were reharvested on 22nd November, 19th December and 18th January, 1989 from these mother tubers. The sprouts detached from tubers of different sizes on different dates were mixed variety-wise before planting into the field at 60 x 12 cm spacing. Separate trials were conducted for the two varieties tested. Four planting dates were replicated four times and arranged in randomized block design.

During 1989-90, the effect of intra row spacings was studied for multiplication through sprouts. Tubers of Kufri Badshah were used for this study. Procedure for collecting the sprouts was the same as above taking only two sprout harvests on 4th and 20th November, 1989. The sprouts were planted at intra row spacings of 7.5, 10.0, 12.5 and 15.0 cm. in ridges, 60 cm apart. Eight treatments (Combinations of four spacings and two planting dates) were replicated four times in randomized block design. The mother tubers after removal of sprouts two times were planted in the field at a spacing of 60 x 25 cm. Plot size during both the years was 1.80 x 3.0 m (3 rows of 3.0 m each). Crop was dehaulmed at 90 days after planting (DAP) in case of Kufri

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Chandramukhi and 110 DAP in case of Kufri Badshah. Sprouts were planted on one side of the ridge and after establishment brought to the centre of the ridge by earthing up.

Number of sprouts per tuber increased with an increase in tuber size in both the varieties (Table 1). In Kufri Badshah, number of sprouts per tuber decreased with every successive harvest. Difference between first two harvests was little but there was sharp decline thereafter. The decline in sprout number was more in large size than in small size tubers. Therefore, relationship between tuber size and sprout number was significant only for first two harvests (r = 0.88, 0.96, 0.60 and 0.64 for first, second, third and fourth harvests, resepectively). In Kufri Chandramukhi, there were no differences in first two harvests but number of sprouts decreased thereafter (Table 1). Unlike Kufri Badshah, relationship between tuber size and sprout number was significant in Kufri Chandramukhi for all the four harvests (r = 0.97, 0.92, 0.93 and 0.93 for first, second, third and fourth harvests, respectively).

Differences in tuber yield of Kufri Chandramukhi and Kufri Badshah were much higher than those recorded earlier at Hisar (5) and yield of Kufri Chandramukhi was lower. Tuber number per sq m were also much lower in Kufri Chandramukhi, however, there were no differences between varieities for the proportion of different tuber sizes and mean tuber weight (Table 2). Low tuber yield in Kufri Chandramukhi

Table 1. Effect of tuber size on number of sprouts per tuber (88-89)

Tuber size (g)	Avg. No. of sprouts removed (Mean ± S.E.) on			
	8-11-88	22-11-88	19-12-88	18-1-89
Kufri Badshah				
25	4.3 ± 0.4	3.9 ± 0.4	4.1 ± 0.4	2.9 ± 0.6
50	6.0 ± 0.5	5.8 ± 0.7	5.1 ± 0.4	2.4 ± 0.7
75	8.0 ± 0.6	5.8 ± 1.0	4.7 ± 1.0	2.4 ± 0.6
100	8.4 ± 0.6	6.8 ± 0.7	5.2 ± 1.1	2.3 ± 0.5
125	8.8 ± 0.8	7.8 ± 0.8	5.0 ± 0.9	3.4 ± 0.9
150	17.5 ± 0.3	10.0 ± 0.5	5.0 ± 0.9	4.0 ± 1.1
Kufri Chandramukhi				
25	3.6 ± 0.4	3.4 ± 0.6	3.0 ± 0.3	2.1 ± 0.2
50	4.3 ± 0.3	3.9 ± 0.5	3.0 ± 0.4	1.7 ± 0.3
75	5.4 ± 0.7	5.4 ± 0.4	5.0 ± 0.4	2.5 ± 0.5
100	5.9 ± 0.8	6.2 ± 0.7	5.9 ± 0.6	3.6 ± 0.5
125	6.8 ± 0.5	5.8 ± 0.8	5.2 ± 0.4	3.5 ± 0.8
150	9.4 ± 0.7	9.0 ± 0.7	7.3 ± 0.5	4.1 ± 0.6

Table 2. Tuber yield and other parameters of yields as influenced by planting dates of sprouts (1988-89)

Date of planting	Total tuber yield (q/ha)	% different tuber size		Mean tuber weight (g)	Tuber number per sq.m.
		>25 g	<25 g		
Kufri Badhsah					
8.11.88	231.5	88.0	12.0	57.8	40.1
22.11.88	223.8	78.0	22.0	43.4	51.6
19.12.88	172.5	63.4	36.6	30.8	56.1
18.1.89	77.8	40.2	59.8	16.7	46.7
C.D. at 5%	16.2			3.8	5.4
Kufri Chandramukhi					
8.11.88	40.3	77.6	22.4	62.3	6.5
22.11.88	35.2	84.5	15.5	35.6	8.2
19.12.88	28.2	55.0	45.0	27.2	12.6
18.1.89	22.0	46.7	63.3	15.3	14.4
C.D. at 5%	8.2			3.4	1.4

might be due to delayed planting which affect tuber yield more in Kufri Chandramukhi than in Kufri Badshah (3, 4). Mean tuber weight had also decreased with delay in planting, however, tuber number did increase slightly with delay in planting.

Multiplication rate (MR) was calculated for different tuber sizes. In Kufri Chandramukhi MR ranged from 1 : 4-10 on weight basis and 1 : 8-20 on number basis (Table 3). In Kufri Badshah it was 1 : 29-80 on weight basis and 1 : 53-104 on number basis. These results are in agreement with the findings of Naik *et al.* (6). Lower MR in Kufri Chandramukhi is attributed to its low tuber yield and fewer number of sprouts per tuber as compared to Kufri Badshah (Table 1, 2). MR on weight basis decreased with an increase in tuber size. It was probably because number of sprouts on per unit weight of tuber decreased with increase in tuber size (Table 1). As expected, on number basis MR increased with increase in tuber size, because large size tubers yielded more sprouts per tuber.

Tuber yield per unit area increased with decrease in spacing (Table 4). However, increase in yield with decrease in spacing from 10.0 to 7.5 cm was insignificant. Planting of sprouts on Nov. 28, 1989 recorded lower yield as compared to planting on 3rd Nov. Tubers planted after harvesting sprouts twice gave an yield of 405.2 g/plant. While calculating MR, this yield was also included. MR decreased with decrease in spacing (Table 4), it ranged from 1 : 19.7-29.6. For this study 100 g tubers were used and MR was comparable with that of previous trial, where sprouts were harvested four times (Tables 3, 4).

From this study, it may be concluded that in Kufri Badshah, sprouts may be harvested twice before planting tubers to increase multiplication rate.

Table 3. Effect of seed size on multiplication rate (88-89)

Tuber size (g)	Weight basis		Number basis	
	KBD	KCM*	KBD	KCM
25	80.6	10.3	53.1	8.1
50	54.2	6.1	67.8	8.7
75	39.7	5.8	71.3	12.8
100	31.0	5.0	75.2	15.4
125	27.4	4.0	84.9	15.0
150	29.1	4.7	104.6	20.5

* KBD = Kufri Badshah; KCM = Kufri Chandramukhi.

Table 4. Tuber yield and multiplication rate as influenced by spacing and date of planting (1989-90)

Spacing (cm)	Tuber yield (q/ha)	Multiplication rate on weight basis
7.5	244.3	19.7
10.0	238.4	24.4
12.5	223.5	27.9
15.0	200.3	29.6
C.D. at 5%	12.9	
Date of Planting		
3.11.89	229.0	
20.11.89	224.0	
C.D. at 5%	NS	

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SHORT NOTE

Control of Potato Late Blight with Systemic and Contact Fungicidal Mixtures in North West Indian Plains

K.K. Sharma[1]

Late blight incited by *Phytophthora infestans* (Mont.) de Bary is a serious disease of potato occurring regularly in Indian hills and plains. Due to rapid development of the disease, conventional fungicides fail to control the disease, if not applied at the appropriate time. On the other hand, because of high risk of fungal resistance to systemic fungicides (3,4) indiscriminate use of such fungicides is not advisable. Keeping this in view, the efficacy of some fungicidal mixtures of systemic and contact fungicides were tested against late blight.

The experiment was conducted at the Central Potato Research Station, Jalandhar during autumn 1987-89. In all six treatments, viz. mancozeb @ 0.2%, oxadixyl 8% + mancozeb 64% @ 0.2%, oxadixyl 10% + copper oxychloride 40% @ 0.25%, metalaxyl 8% + mancozeb 64% @ 0.25%, metalaxyl 4% + ziram 24% @ 0.5% and unsprayed check were evaluated in a randomized block design having four replications each on cultivar Kufri Chandramukhi. Sprays were given at 15 days interval with first spray starting just before the normal appearance of late blight. Owing to late appearance of blight in both years, only two sprays were given with Maruti foot sprayer (1000 l/ha). Final disease intensity was recorded 7-10 days before the dehaulming on BMS scale (1). Tuber yield was recorded at harvest.

All the combined formulations of systemic and contact fungicides were significantly superior to the unsprayed check in controlling late blight. However, the trend (average of both years) showed that metalaxyl + ziram was the best (0.03% D.I.) followed by metalaxyl + mancozeb, oxadixyl + copper oxychloride and oxadixyl + mancozeb where the mean disease intensity was 0.53, 0.82 and 1.52% respectively as compared to 12.39% in unsprayed control.

The conventional fungicide, mancozeb, although was found effective in checking the disease during 1988-89 over control, it did not reduce blight significantly during 1987-88. In the present studies all the four fungicidal mixture having matalaxyl and oxadixyl as systemic components gave effective control of potato late blight. These findings are similar to earlier workers (2,5,6) who reported fungicidal mixtures of metalaxyl and oxadixyl to be more effective in controlling *P. infestans*. However, in this study no significant increase in tuber yield was observed. This may be due to the

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reason that the blight appeared late in the season when most of the bulking phase was over. From the present studies, it can be concluded that for control of late blight in the plains systemic fungicides should preferably be used only in blight epidemic years, whereas in normal years the use of systemic fungicides may not be of much relevance. Moreover, their indiscriminate use may aggravate the problem of creating resistance to the pathogen.

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SHORT NOTE

Effect of Levels of Nitrogen, Phosphorus and Potassium and their Interacton on Yield and Nutrient Uptake of Potato on Acid Soils

U.C. Sharma[1]

Interaction of nutrients in soils and plants is an important factor in determining the yield of various crops (4, 5). The application of a particular nutrient may suppress or enhance the availability of others which may affect the productivity. The nutrients have antagonistic as well as synergistic effects and it is necessary to consider this aspect while recommending the dose of a particular nutrient for a specific crop in order to achieve maximum productivity (3,4,8).

A field experiment was conducted in 1987 at the Upper Shillong farm of Central Potato Research Station. The experimental soil *(Typic hupludalf)* was sandy loam in texture with pH 5.1 and available N, P and K, 219, 5.0 and 62 kg/ha, respectively. The nitrogen was applied @ 0, 60, 120 and 180 kg/ha, phosphorus @ 0, 26, 52 and 78 kg P/ha and potassium @ 0, 50, 100 and 150 kg K/ha in all their possible combinations. Tubers of potato cv. Kufri Jyoti were planted at an inter and intra-row spacing of 60 and 20 cm, respectively, in plots measuring 3.6 m x 3.0 m. Tuber yield was recorded at harvest and tuber and haulms samples were taken and processed for analysis. Soil and plant analysis for N, P and K was done as per methods suggested by Jackson (7).

The tuber yield increased significantly upto the application of 120 kg N, 78 kg P and 50 kg K/ha (Table 1). Since nitrogen is required for the formation of chlorophyll and phosphorus for cell division and elongation, the increase in yield with their application in N and P deficient soils was expected. The results corroborate the findings of Singh & Grewal (11) and Dubetz & Bole (2). The response to potassium was observed only upto 50 kg K/ha, indicating low requirement of K for potato in these soils. Significant increase in the tuber yield was found only upto 52 kg P/ha in absence of N and 78 kg P/ha in presence of 120 kg N/ha. Similarly, response to N was observed upto 60 kg/ha in absence of P and 120 kg/ha in presence of P, indicating interaction between the two. Application of nitrogen upto 60 kg/ha significantly increased its content in tubers and haulms, however it did not significantly change the P and K content in both the plant parts (Table 2). Phosphorus significantly increased its content in tubers upto 26 kg/ha and in haulms upto 52 kg/ha but had a non-significant effect on the K content of tubers and haulms and N content of tubers. A significant decrease in N content of haulms was found with increase in the level of applied P. This may be ascribed to the dilution effect as a result of increase in the

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Table 1. Effect of N, P and K on the yield of potato tubers (q/ha)

N (kg/ha)	P (kg/ha)				
	0	26	52	78	Mean
0	52	78	110	104	86
60	74	136	167	168	136
120	81	164	221	252	179
180	75	162	215	262	178
Mean	70	136	177	196	

C.D. (0.05) N = 15; P = 15; N x P = 30

K (kg/ha)	P (kg/ha)				
	0	26	52	78	Mean
0	60	105	133	162	115
50	72	141	185	206	151
100	73	149	196	206	156
150	75	150	197	211	158
Mean	70	136	177	196	

C.D. (0.05) K = 15; K x P = 30

K (kg/ha)	N (kg/ha)				
	0	60	120	180	Mean
0	76	109	138	138	115
50	91	148	185	180	151
100	87	146	193	199	156
150	91	144	201	197	**158**
Mean	86	136	179	178	

C.D. (0.05) K = 15; N x K = 30

biomass with applied P. Application of potassium did not show any effect on N or P content of haulms upto 50 kg/ha of its application. Similar results were reported earlier (1,6,9,10,12). Application of nitrogen, phosphorus and potassium significantly increased their uptake by potato crop (Table 3). Increase in uptake of N (r = -.87**), P (r = 0.82**) and K (r = 0.85**) significantly correlated with the tuber yield. The recovery of N, P and K at 120, 78 and 50 kg/ha of N, P and K application was found to be 42.4, 6.6 and 39.4%, respectively, Similar results have been reported earlier (1,10,12).

Table 2. Effect of N, P and K on their content in potato tuber and haulms

Treatment	N content (%)		P content (%)		K content (%)	
	T	H	T	H	T	H
N (Kg/ha)						
0	1.59	1.42	0.121	0.128	1.92	2.32
60	1.80	2.02	0.119	0.135	1.90	2.31
120	1.84	2.10	0.120	0.131	1.93	2.21
180	1.83	2.09	0.121	0.134	1.92	2.23
C.D. (P=0.05)	0.10	0.11	NS	NS	NS	NS
P (kg/ha)						
0	1.79	2.00	0.108	0.102	1.90	2.28
26	1.76	1.93	0.124	0.125	1.92	2.21
52	1.75	1.88	0.123	0.145	1.95	2.30
78	1.75	1.80	0.126	0.156	1.90	2.26
C.D. (P= 0.05)	NS	0.11	0.007	0.012	NS	NS
K (kg/ha)						
0	1.79	1.92	0.120	0.128	1.88	2.06
50	1.75	1.90	0.119	0.137	1.91	2.26
100	1.74	1.92	0.121	0.129	1.94	2.32
150	1.76	1.88	0.122	0.134	1.96	2.40
C.D. (P = 0.05)	NS	NS	NS	NS	NS	0.16

T = Tubers, H = Haulms

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Table 3. Effect of N, P and K application on their uptake by potato crop (kg/ha)

Treatment	N uptake			P uptake			K uptake		
	T	H	Total	T	H	Total	T	H	Total
N (kg/ha)									
0	28.7	12.4	41.4	2.19	1.12	3.31	34.7	20.2	54.9
60	51.3	20.7	72.0	3.39	1.38	4.77	54.1	23.6	77.7
120	65.8	26.5	92.3	4.34	1.71	6.05	69.8	29.0	98.8
180	66.9	26.7	93.6	4.43	1.78	6.21	70.2	29 6	99.8
C.D. (P = 0.05)	4.46	1.6	5.0	0.27	0.09	0.32	3.1	1.9	4.7
P (Kg/ha)									
0	26.1	14.1	40.2	1.57	0.72	2.29	27.7	16.2	43.9
26	50.4	20.1	70.5	3.55	1.30	4.85	55.0	23.1	78.1
52	64.4	25.7	90.1	4.52	1.98	6.50	71.7	31.5	103.2
78	71.1	20.4	97.5	5 15	2.29	7.44	77.7	33.1	110.8
C.D. (P = 0.05)	4.6	1.6	5.0	0.27	0.09	0.32	3.1	1.9	4.7
K (kg/ha)									
0	42.6	20.5	63.1	2.84	1.38	4.22	44.0	22.1	66.1
50	54.7	22.0	76.7	3.72	1.58	5.30	59.7	26.1	85.8
100	56.6	22.0	78.6	3.94	1.55	5.49	63.1	26.8	89.9
150	57.6	21.5	79.1	4.00	1.53	5.53	64.3	27.5	91.8
C.D. (P = 0.05)	4.6	1.6	5.0	0.27	0.09	0.32	3.1	1.9	4.7

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SHORT NOTE

Evaluation of Different Chemicals for Control of Black Scurf of Potato in the West Bengal Plains

B.K. De and P.C. Sengupta[1]

Black scurf of potato caused by *Rhizoctonia solani* Kuhn is a common disease in the plains of West Bengal. It can be controlled to a limited extent through crop rotations (2,3). Studies conducted in different places indicate that tuber treatment with mercurial compounds effectively control the disease (5,7). In view of the very limited work on the control of black scurf of potato in this region, the present studies were undertaken to evaluate the impact of tuber treatment with different fungicides and chemicals.

The experimental trials were conducted at University Farm, Kalyani of Bidhan Chandra Krishi Viswavidyalaya for four consecutive years in rabi seasons of 1980-81 to 1983-84 in the sandy loam soil (pH 6.35) free of *R. solani* infestation. The experiments were laid out in randomized block design with four replications. Black scurf affected tubers of variety Kufri Chandramukhi were treated with the chemicals as given in table 1 before planting. After treatment tubers were kept in shade for 24 hours for drying. T_1, T_2 and T_3 were tested for four seasons, T_4, T_5 and T_6 were tested for three seasons and T_7 + T_8 were tested for one season only.

The crop was grown under irrigated conditions following the normal cultural practices. Each tuber was observed for infection and data was collected on percentage of infected tubers and yield of healthy and infected tubers.

Tuber treatment with fungicides did not affect the plant germination, but significantly reduced the percentage of scurfed tubers, (Table 1). The per cent scurfed tubers were minimum in the Emisan treated tuber for 30 minutes, followed by Bavistin, Emisan for 20 minutes, Brassicol, Agallol, boric acid, acetic acid.

Bavistin and Agallol consistently gave good control. Similar observations were made by Dutt and Gupta (1). Boric acid and acetic acid had no adverse effect on emergence and both these acids can eradicate the seed borne inoculum.

From the above observation it can be concluded that both the organo mercurials viz. Agallol, Emisan and Bavistin can be used for the control of black scurf in West Bengal. Three chemicals are already known for their efficacy against black scurf (4,6,8).

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Table 1 . Effect of tubers treatment on black-scurf of potato (plant germination, percent of securfed tubers (nos.) and yield) (Mean data of four years)

Treatments	Percent Germination	Percent scurfed tubers (nos.)	Yield in qtl/ha		
			Healthy (wt)	(Scurfed (wt)	Total (wt)
T_1 = No tuber treatment	94.7	53.2 (46.83)*	69.1	110.82 (61.59)*	179.9
T_2 = Tuber treatment with Agallol (0.5%) for 10 min.	95.8	25.8 (30.53)	184.0	36.8 (16.66)	220.8
T_3 = Tuber treatment with Acetic acid + $ZnSO_4$	95.5	32.1 (34.51)	124.4	64.3 (34.07)	188.7
T_4 = Tuber treatment with Boric acid	96.2	27.9 (31.88)	139.2	58.6 (29.62)	197.8
T_5 = Tuber treatment with Bavistin	95.2	20.5 (26.92)	213.4	32.96 (13.37)	246.4
T_6 = Tuber treatment with Brassicol	95.0	23.5 (29.00)	192.1	41.06 (17.60)	233.2
T_7 = Tuber treatment with Emisan-6 (0.5%) for 20 minutes)	93.7	21.5 (27.62)	120.8	36.2 (23.0)	157.0
T_8 = Tuber treatment with Emisan-6 (0.5%) for 30 minutes	92.5	18.7 (25.62)	110.0	30.2 (21.4)	141.2
S. Em ±		1.35	2.45	1.92	3.9
C.D. (0.05)		3.97	8.14	6.34	12.97

*Figures in the parenthesis denote angular transformed values.

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SHORT NOTE

Influence of P carriers on Growth and Yield of Potato in Acid soils of Nilgiris

R. Shanmugasundaram[1], K. Nanjan[2] and Habibullah[3]

Phosphorous is an indispensable nutrient only next to nitrogen, for plant growth. It has been shown to increase the percentage of large tubers in potatoes (7). In acid soils, water soluble P is converted to insoluble form of Fe-P and Al-P. Several workers, (3,6) have pointed out that Mussorie rock phosphate is suited for acid soils for crop production as it is less soluble. Hence, in the present study Mussorie rock phosphate (MRP) and diammonium phosphate (DAP) were compared with single superphosphate (SSP) for potato crop.

Field experiments were conducted during autumn seasons of 1989 and 1990 in acid soils of Nilgiris. The soil had a pH of 3.8 with 4.8% organic carbon in '89 and a pH of 4.1 with 5% organic carbon in '90. The soil contained 420 and 448 kg/ha available nitrogen, 1.18 and 0.92 ppm Bray's P_1 – Pand 240 and 250 kg/ha available potassium in '89 and '90, respectively. There were ten treatments (Table 1) replicated thrice and arranged in RBD. The recommended dose of N and K each @ 120 kg/ha were applied to all the treatments except DAP treatment namely T_7, T_8 and T_9 for which the urea-N was reduced to compensate 'N' added through DAP. Potato seed tuber of cv. Kufri Jyoti were used with a spacing of 50 x 20 cm.

Plant height was measured and samples were collected at the time of harvest. The samples were dried in hot air oven at 65°C to 75°C and ground samples were digested with a 9:3:1 mixture of HNO_3, H_2SO_4 and $HClO_4$. The analysis of plant and soil samples were done as per procedure outlined by Jackson (1).

Significant increase in plant height was observed when phosphorus was applied in the form of SSP and that too only during 1989 (Table 1). Application of phosphorus as SSP and DAP significantly increased drymatter yield (Biomass). At 240 kg P_2O_5/ha, they registered 918 and 1079 kg/ha and 838 and 1138 kg/ha in '89 and '90, respectively. Low drymatter yield (Biomass) was recorded in MRP at all the three levels. Though water soluble P would have been fixed in the soil in the initial period of plant growth after saturation point, remaining amount of P would have been sufficient to increase DMP biomass in SSP and DAP plots. In the case of MRP, slow rate of solubility may have hinedred P supply to plant growth and affecting total

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Table 1. Effect of levels of P, through phosphatic sources on growth and tuber yield of potato in acid soils of Nilgiris

Sources of P	P_2O_5 (kg/ha)	Plant Height (cm)		Dry matter production (Biomass) (kg/ha)		Tuber yield (ton/ha)	
		1989	1990	1989	1990	1989	1990
Single superphosphate							
	120	24.9	27.8	810	1072	7.34	9.3
-do-	180	25.0	30.3	881	1086	9.68	10.7
-do-	240	28.4	35.9	915	1079	11.40	11.3
Mussorie Rockphosphate							
	-120	16.5	23.2	515	625	4.37	5.0
-do-	180	16.6	24.1	585	641	5.15	5.0
-do-	240	18.2	27.5	591	677	7.50	6.1
Diammonium phosphate							
	120	19.8	30.9	705	897	7.81	7.7
-do-	180	19.7	29.9	748	1001	10.00	9.2
-do-	240	19.7	30.9	838	1138	10.46	11.0
Control	NOP	15.6	23.0	429	590	3.75	4.6
CD at 5% level		5.2	NS	245	427	4.38	4.25

production. Solubility of MRP depended upon time, temperature and moisture regime of soil.

Significant increase in tuber yield was recorded by SSP and DAP treatments over MRP. Highest tuber yield of 11.4 and 11.3 ton/ha was registered by SSP at 240 Kg P_2O_5/ha in '89 and '90, respectively. In the present study, there was no significant increase in tuber yield beyond 120 kg P_2O_5/ha applied through SSP and DAP. The higher tuber yield in SSP and DAP treatments might be due to sufficient amount of P released by these sources during crop growth period as evidenced by higher biomass production in these treatments. It was also reported by Kori *et al* (3) that water soluble phosphate fertilizer was the best P carrier for potato in acid soils.

Phosphorus applied at 120 kg to 240 kg/ha in the form of MRP registered low yield of 4.4 to 7.5 ton/ha and 5 to 6.1 ton/ha in '89 and '90, respectively. Since MRP releases P slowly especially under rainfed condition, the lack of required amount of P for crop growth is reflected in poor crop growth and biomass production. The same trend was reported by Lal *et al.* (4) and Prasad *et al.* (5). According to Lal *et al* (4), potato responded better to rock phosphate in a wet year than in a dry year. In an incubation study there was not much improvement in available P even though 1000 ppm as rock phosphate was incubated with the soil for 90 days.

From the above study, it may be seen that instead of 240 kg P_2O_5/ha, as applied by farmers at present, 120 kg P_2O_5/ha as SSP is sufficient along with recommended dose of N and K for potato crop in acid soils of Nilgiris.

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SHORT NOTE

Use of Ordinary Sugar in *in vitro* Production of Potato Microtubers*

R. Chandra, G.J. Randhawa and D.R. Chaudhary[1]

The transplanting of tender plantlets from *in vitro* conditions to external environment is laborious and involves the risk in establishment (3). Potato microtubers are the potential propagules for quick multiplication of uniform progeny (1). However, the *in vitro* produced microtubers would demand the cost of production to be competitive with the *in vivo* multiplication techniques with regard to cost and simplicity as well as ease of availability of local ingredients. This logic was the guiding factor to look into different components of *in vitro* microtuber production and in this study an attempt has been made to replace sucrose in the medium with ordinary sugar.

Ordinary sugar from open market was used in four different concentrations (8,10,12 and 14%) in microtuber induction medium (4). 8% sucrose was used in microtuber induction medium as control. Nodal cuttings from plantlets of three Indian Potato varieties, Kufri Jyoti, Kufri Badshah and Kufri Sindhuri were used. Three shoot pieces having 2 nodes each were placed in liquid PM - 103 propagation medium in test tubes (25x150 mm) and incubated in culture room at 22±2°C under 16h photoperiod of 3000 lux light intensity. Six replications were made in each treatment. After four weeks of incubation when the test tubes were full with plantlets, the liquid propagation medium was replaced with microtuber induction medium, containing different concentrations of ordinary marketed cane sugar and 213mM sucrose AR (T_0). The culture tubes were incubated in continuous dark at 18-20°C. The data on number of microtubers per culture tube was recorded after 60 days of incubation. The microtubers were harvested, washed with water, dried in shade and kept in petridishes sealed with parafilm. Petridishes were stored in refrigerator. The data was statistically analysed using Duncan's multiple range test.

The microtuber initiation was observed after one week of incubation in all the three cultivars. In all the treatments the microtubers were formed and there were no statistical differences among the treatments. It indicates that the lowest sugar concentration i.e. 8% sugar can replace 231 mM sucrose AR in the microtuber induction medium (Fig-1.) The sucrose AR costs approx. Rs. 300/- per kg in comparison to ordinary marketed sugar which costs approx. Rs. 10/- per kg. This replacement will thus reduce the cost of microtuber production.

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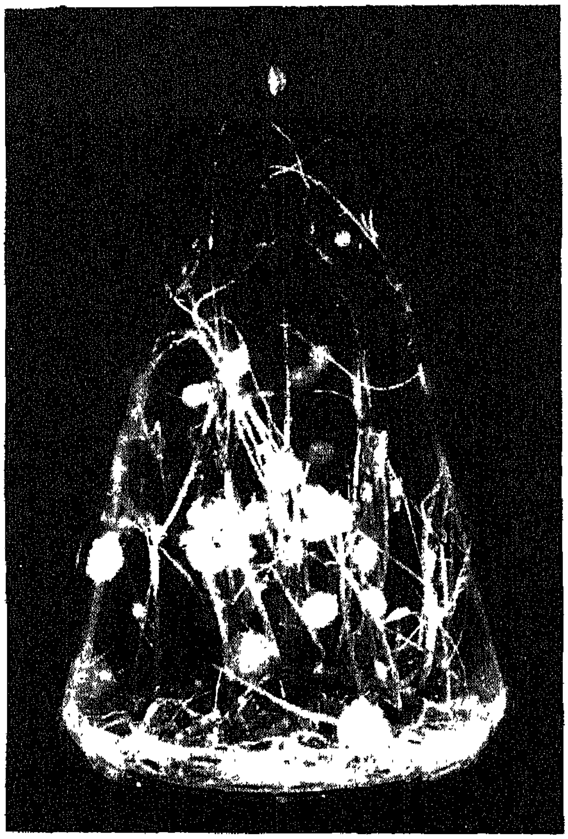

Fig. 1 : Microtubers produced *in vitro*

Among the varieties, Kufri Sindhuri produced significantly more number of microtubers than Kufri Jyoti and Kufri Badshah (Table 1). This variety produces more number of tubers in *in vivo* under short day conditions (2) but in the present study more number of microtubers were formed under continuous dark.

Table 1. Effect of different concentrations of ordinary sugar on microtuber production

Treatments	Av. No. of microtubers/tube			
	K. Jyoti	K. Badshah	K. Sindhuri	Mean
MS+44.0 µM BAP+231 mM Sucrose	10.17	10.33	13.33	11.27
MS+44.0 µM BAP+8% Sugar	8.33	6.67	16.50	10.50
MS+44.0 µM BAP+10% Sugar	8.67	8.67	19.67	12.33
MS+44.0 µM BAP+12% Sugar	6.67	7.17	13.33	8.89
MS+44.0 µM BAP+14% Sugar	7.50	4.50	17.17	9.72
	8.167	7.467	16.000	

LSD (5%), Treatments=NS, Variety= 3.262, TreatmentxVariety=NS, Cv = 46.54%.

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SHORT NOTE

Control of Brown Rot Diseases of Potato through Cultural Practices in West Bengal Plains

B.K. De and P.C. Sengupta[1]

In the Indo-Gangetic plains of West Bengal brown rot or bacterial wilt caused by *Pseudomonas solanacearum* E.F. Smith is one of the most important diseases of potato. The disease may cause 30-70% reduction in yield due to wilting (5). Infested soil and seed tubers form the main sources of the primary infection of bacterial wilt. In the plains where the summer temperature is higher (45°C), chances of survival of bacteria is less. Therefore, brown rot affected tubers are an important source of infection (4). Studies conducted in different parts of India revealed that best control lies in planting of disease free potatoes and crop rotation with cereals etc. (3, 6). The disease can also be effectively controlled by growing disease free seed and full earthing up in addition to stable bleaching powder in the soil at the time of planting or, growing of disease free seed potatoes and ploughing just after harvesting (1, 2, 7 & 8). The present experiment was conducted to find out suitable cultural practices for controlling brown rot disease in this region.

The experiment was conducted for two consecutive years during *rabi* season of 1987-88 and 1988-89 at the University Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia in sandy loam soil with pH 6.3. The experiment was laid out in randomized block design with four replications. In all seven treatments were followed (Table 1). The basal fertilizer dose consisting of 75 kg N, 150 kg P_2O_5 and 150 kg K_2O/ha were applied in furrows as urea, single super phosphate and muriate of potash respectively. Nitrogen 75 kg/ha as urea was also applied as top dressing during the first earthing up on 25 days after planting. Medium sized tubers (40-50 gm) of variety Kufri Jyoti were planted 60 cm inter and 20 cm intra row spacing in 4.2 x 2.4 m plot in the 4th week of November and was harvested in the fourth week of February. Seed tubers were treated with (OMC) Emisan-6 0.5% concentration for 30 min before sowing. The crop was grown in irrigated conditions following the normal cultural practices as per recommendations for the region. Observations on plant emergence, wilt incidence and tuber yield were recorded and statistically analysed.

The data (Table 1) indicated that there was no significant difference in plant emergence among the treatments. The wilt incidence differed significantly among the

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Table 1 . Comparative efficacy of different cultural practices in the control of brown rot of potato

Treatment	Plant emergence (%)			Wilt incidence (%)			Total yield (q/ha)		
	1987-88	88-89	Mean	1987-88	88-89	Mean	1987-88	88-89	Mean
T_1 = Seeds from bacterial wilt free area	97.5	96.4	96.9	1	8	4.5	286	296	291
T_2 = T_1 + Full earthing up at planting + Grammaxone	97.5	97.5	97.5	1	7	4.0	295	307	301
T_3 = T_1+ Bleaching powder @ 12 kg/ha	97.5	96.4	96.9	2	7	4.5	291	313	302
T_4 = T_1+ Full earthing up + Bleching powder @ 12 kg/ha	97.5	97.5	97.5	1	4	2.5	294	318	306
T_5 = T_1 + ploughing after harvest	98.7	96.4	97.5	1	4	2.5	279	305	292
T_6 = T_1 + Grammaxone	98.7	97.5	98.1	3	8	5.5	282	300	291
T_7 = Apparently healthy tubers from diseased crops	98.7	94.0	96.3	12	18	15.0	232	240	236
S.Em (±)				1	1	1.2	8.1	10.4	7.6
C.D. (0.05)				2.7	3	3.5	17.1	21.9	16.5

treatments. Minimum wilt incidence (2.5%) was observed in T_4 and T_5 treatments. Maximum wilt incidence (15%) was noted in treatment T_7. All the treatments significantly increased the tuber yield over control. Maximum yield was obtained in T_4 treatments i.e. seeds from bacterial wilt free area with full earthing up at planting and bleaching powder application @ 12 kg/ha at the time of planting. The results of this experiment are in agreement with earlier reports.

Based on the above findings it can be recommended that brown rot or bacterial wilt of potato may be effectively controlled by using disease free seed, obtained from bacterial wilt free area, coupled with full earthing up at planting and addition of bleaching power @ 12 kg/ha during planting. Another way was using disease free seeds and ploughing the field after harvest.

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"Potato Viruses and Viral Disease-1992" by Dr SM Paul Khurana Technical Bulletin No. 35, 23pp. Central Potato Research Institute, Shimla-171 001 (India)

The potato is a crop of world wide importance. It is known to be ravaged by a large number of viral disease which cause degeneration of seed stocks, if not prevented.

The present Technical Bulletin is an ample proof of the insight and commitment of Dr Khurana to potato viruses and the useful work done at the Central Potato Research Institute over the decades.

This short bulletin briefly touches all major aspects of potato viruses and viral diseases like importance, distribution, symptoms, characteristics, detection. interaction among viruses and other pathogens, epidemiology, management and also contains excellent three photoplates, of which two are in colour showing symptoms. It is essentially and legitimately a succinct catalogue of the research carried out on potato viruses, mainly in India, which is synonymous with CPRI, Shimla.

The importance of potato viruses can be judged well by the fact that an average 40-50% infection causes upto 40% reduction in yield amounting to almost Rs. 5000-6000 millions per annum in India. Even though a large number of viruses infect potatoes, only some of them are important. Depending on their distribution and occurrence, different typs of mosaics, and leafroll are most common, of which 16 potato viruses/viroid have been documented either from the point of view of their prevalence under subtropical climate or quarantine value. The viruses have greater importance in subtropical/tropical climate mainly because of round the year availability of initial source(s) of infection and also greater activity of aphid vectors. Several viruses may attack potatoes at the same time leading often to complex synergistic effects. It is a great complicating factor and often PVX, the main culprit, has increased multiplication and concentration, incites the synergistic reaction.

The symptoms, key for important viruses, provided as a table, is very useful and may help in tentative field diagnosis even by the novice. It is, however, to be borne in mind that the identification of causal viruses merely on the visual symptoms is not easy, primarily because of the proven complex interaction between the host, viruses and the environment governing the symptoms. Therefore, the final identification of the viruses need to be based on other characterstics mainly virus particle's morphology and serological relationships for which a table has rightly been provided. Another table in the bulletin, very useful from several angles, is the one that gives stepwise schedule of integrated control for potato viruses.

No doubt, the bulletin is going to be a very useful basic literature on the subject from which, besides the experts, a new entrant in the field will gain much. It will be a jumping board for him. The bulletin offers kaleidoscopic view on potato viruses & viral diseases and will be a useful guide for further reading.

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