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THE INDIAN POTATO ASSOCIATION

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(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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PREVALENCE OF SEED-BORNE FUNGI OF TRUE POTATO SEED (TPS) IN BANGLADESH

T.K. Dey, A.H.M. Jafar, A.L. Khan and M.S. Ali[1]

ABSTRACT: Thirteen to fifteen fungal sp. representing nine genera were found to be associated with true potato seed (TPS) during 1989-90 and 1990-91, respectively. The most commonly occurring fungi were : *Fusarium oxysporum, Curvularia lunata, Aspergillus niger, A. flavus, Cladosporium sp., Alternaria tenuis, Fusarium solani and F. moniliformae.*

INTRODUCTION

Traditionally, farmers in Bangladesh use seed tubers to raise potato crop which alone accounts for 25 to 50 per cent of production cost. By using true potato seed (TPS), seed rate can be reduced from two tons (tuber seeds) to 100 g (1, 10, 15). Under this situtation, International Potato Center (CIP), Lima, Peru, has developed TPS technology as an alternative method of potato production which is now being used for commercial potato production in many countries (3, 9, 11). From TPS, Martin and Torres (11) isolated 16 different fungi, out of which eight were tested and found pathogenic. In Bangladesh, till now no report is available about the pathogens associated with true potato seeds. The present investigation was, therefore, initiated to study the prevalence of seed-borne fungi associated with TPS in Bangladesh.

MATERIALS AND METHODS

Prevalence of seed-borne fungi: Twenty five and 38 seed samples of TPS were collected from Tuber Crops Research Centre (TCRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during 1989-90 and 1990-91, respectively. The seed samples were tested for the prevalence of fungi.

Fungi were detected by blotter and potato dextrose agar (PDA) method following the International Rules for Seed Health Testing (ISTA, 1976) with some modifications. The modifications made were incubation of pertidishes containing seeds at 22-26^{o}C under fluorescent tube light instead of 20^{o}C under near ultraviolet light (NUV). All the fungi were identified by observing the growth characters under stereobinocular microscope following the key outlined by Neergaard (12), Booth (2) and Ellis (55). When identification was not possible by observing the growth characters under stereoscopic microscope, the associated fungi were identified under the compound microscope.

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RESULTS AND DISCUSSION

During 1989-90 and 1990-91, a total of 3084 and 6042 seed-borne fungal infections were recorded on blotter from 5000 and 7600 seeds, respectively (Table 1). Seed-borne fungal infection was more in 1990-91 than in 1989-90. Thirteen and 15 different fungi representing 9 genera were identified during 1989-90 and 1990-91, respectively. The predominent fungi in order of prevalence during 1989-90 were *Fusarium oxysporum, Curvularia lunata, Aspergillus niger, A ocharaceous, A. calvatonanica, A. flavus* and *F. solani* constituting 90.67% of the total seed-borne fungal infections while in 1990-91 they were *F. oxysporum, A. niger, C. lunata, Cladosporium* sp., *A. tenuis, F. solani* and *F. moniliformae* constituting 83.60% of the total seed-borne fungal infections. Fungus which constituted at least 4% of the total seed-borne fungal infection and at least 3% of the seed yield was considered as predominent one.

Table 1. Prevalence of seed-borne fungi on true potato seed during 1989-90 and 1990-91 (Blotter test)

Fungi	Per cent infection		Per cent seeds yielding[1]	
	1989-90	1990-91	1989-90	1990-91
Alternaria tenuis	3.78	8.37	2.38	6.65
Aspergillus clavatonanica	9.16	0 93	5.76	0.74
A. flavus	6.20	3.72	3.90	2.96
A. niger	16.4	19.86	10.14	15.79
A. ochraceous	9.45	2.68	5.94	2.13
Chaetomium sp.	1.43	1.06	0.90	0.84
Cladosporium sp.	2.0	8.94	1.26	7.11
Curvularia lunata	16.40	13.40	10.40	10.65
Drechslera sp.	0.95	3.97	0.60	3.16
Fusarium moniliformae	-	4.30	-	3.42
F. oxysporum	28.69	23.07	18.04	18.39
F. semitectum	-	1.49	-	1.18
F. solani	4.13	5.66	2.60	4.50
Penicillium sp.	0.66	1.94	0.40	1.54
Rhizopus sp.	0.51	0.60	0.32	0.47

1. Total fungal infection was 3084 and 6042 during 1989-90 and 1990-91, respectively.
2. Percentage of seeds yielding different fungal organisms was calculated on the basis of 5000 and 76000 seds during 1989-90 and 1990-91 respectively.

'-' indicates not detected.

The number of samples infected by an individual fungus and its range of infection on infected seed samples varied greatly depending on seed health testing method (Tables 2, 3). Blotter method was more effective than PDA method for detecting the pathogens. In 1989-90, out of 25 seed samples, respectively, 22, 18, 15, 12 and 10 were found infected by *F. oxysporum, C. lunata, A. flavus, A. clavatonanica* and *F. solani;* while the corresponding number of samples during 1990-91 by these fungi were 34, 30, 15, 7 and 18. The highest infection of *F. oxysporum* in an infected sample recorded in 1989-90 was 64.0% and 34.0% on blotter and PDA, respectively. The maximum seed-borne infections of *A. tenuis*, *A. niger*, *A. ochraceous*, *Cladosporium* sp., *C. lunata*, *Drechslera* sp. and *F. solani* were 26%, 66%, 52%, 28%, 23% and 20% (Table 2). In 1990-91, the maximum infection on blotter and PDA of *F. oxysporum* in an infected sample was 50% and 40%, respectively (Table 3).

Table 2. Seed-borne fungi observed on TPS (1989-90)

Fungi	Percentage of infection			
	Range		Average	
	Blotter	PDA	Blotter	PDA
Alternaria tenuis	6.0-26.0	4.0-10.0	17.0	7.0
A. clavatonanica	16.0-40.0	1.0-20.0	24.0	8.0
A. flavus	4.0-28.0	1.0-42.0	13.0	22.0
A. niger	16.0-66.0	3.0-63.0	47.0	45.5
A. ochraceous	6.0-61.0	4.0-52.0	33.0	28.5
Chaetomium sp.	4.0-6.0	12.0	5.0	12.0
Cladosporium sp.	10.0-39.0	1.0-28.0	21.0	16.0
Curvularia lunata	6.0-43.0	2.0-28.0	29.0	19.0
Drechslera sp.	30.0	23.0	30.0	23.0
Fusarium oxysporum	10.0-64.0	4.0-34.0	41.0	21.0
F. solani	6.0-25.0	2.0-20.0	13.0	11.5
Penicillium sp.	20.0	4.0-12.0	20.0	8.0
Rhizopus sp.	8.0	2.0-3.0	8.0	2.5

Table 3. Seed-borne fungi observed on TPS (1990-91)

Fungi	Percentage of infection on sample			
	Range		Average	
	Blotter	PDA	Blotter	PDA
Alternaria tenuis	12.0-33.0	11.0-18.5	22.0	27.0
A. clavatonanica	3.0-13.0	4.0-16.0	8.0	6.0
A. flavus	11.0-21.0	6.0-19.0	15.0	12.0
A. niger	18.0-69.0	13.0-39.0	50.0	27.0
A. ochraceous	8.0-29.0	6.0-23.0	18.0	13.0
Chaetomium sp.	3.0-12.0	3.0-08.0	8.0	5.0
Cladosporium sp.	5.0-42.0	9.0-28.0	27.0	13.0
Curvularia lunata	15.0-47.0	12.0-31.0	27.0	21.0
Drechslera sp.	11.0-39.0	7.0-13.0	24.0	11.0
Fusarium oxysporum	21.0-50.0	14.0-40.0	41.0	32.5
F. moniliformae	9.0-26.0	13.0-29.0	13.0	17.5
F. semitectum	3.0-13.0	9.0-16.0	10.0	12.0
F. solani	6.0-31.0	8.0-25.0	19.0	13.0
Penicillium sp.	9.0-17.0	8.0-13.0	13.0	9.0
Rhizopus sp.	4.0-11.0	2.0-06.0	6.0	3.0

The present study indicates that a wide range of fungi occurred on TPS in Bangladesh. Among the various fungi only seven fungi i.e. *Alternaria tenuis, Aspergillus niger, Drechslera* sp., *Cladosporium* sp., *Curvularia lunata, Fusarium oxysporum* and *Penicillium* sp. have been reported from TPS (11). Earlier no work on seed health of TPS has been carried out in Bangladesh. Thus *A. tenuis, A. clavatonanica, A. flavus, A. niger, A. ochraceous. Chaetomium sp., Cladasporium* sp., *C. lunata, Drechslera* sp., *F. moniliformae, F. oxysporum, F. semitectum, F. solani,* Penicillium sp. and *Rhizopus* sp. are reported for the first time as seed-borne fungi of TPS in Bangladesh. The seed-borne behaviour of *A. tenuis, Aspergillus* sp., *Cladosporium* spp., *C. lunata. Drechslera* spp., *F. moniliformae, F. oxysporum, F. semitectum, F. solani, Penicillium* spp. and *Rhizopus* sp. have been reported on different vegetable crops including potato by many workers (4, 6, 13).

LITERATURE CITED

1. Accatino, P. and P. Malagamba. 1982. *Potato Production from True Potato Seed.* International Potato Center, Lima, Peru, 20 pp.
2. Booth, C. 1971. *The genus Fusarium.* Commonwealth Mycol. Inst. Kew, Surrey England. 236 pp.
3. Brown, K.J. 1987. Strategies and current status of TPS research worldwide. *Proceedings of the workshop on True Potato Seed Research in Bangladesh.* PRC, BARI, Joydebpur, Gazipur. 3-5 pp.
4. Droby, S., D. Prusky, A. Dinoor and R. Barkai-Golam. 1981. *Alternaria alternata:* A new pathogen on stored potatoes. *Plant Disease* 68: 160-61.
5. Ellis, M.B. 1971. *Dematiaceous Hypomycetes.* Commonwealth Mycol. Inst. New, Surrey, England. 608 pp.
6. Fakir, G.A. 1980. *An annotated list of seed-borne diseases in Bangladesh.* Agriculture Information Service, Dhaka, Bangladesh 17p.
7. ISTA. 1976. *Proc. Int. Seed. Test. Acco.* 180 pp.
8. Kuczynska, J. 1986. Mycoflora of necrotic leaf spot of potato at Bonin. *Rev. Plant Path.* 65(3): 151.
9. Kushnareva, V.A. 1976. Cultivation of potato from true potato seed. *Referativnyi Zhurnal* 9-55-286 (in Russian).
10. Martin, C. 1983. Control of *Rhizoctonia* damping-off on seedlings grown from true potato seed. *CIP Circular* 11(4): 1-4.
11. Martin, C. and H. Torres. 1989. Control of *Rhizoctonia* and soil borne disease of TPS. *Fungal Diseases of Potato.* CIP, Lima Peru., pp. 191-205.
12. Neergaard, P. 1945. *Danish species of Alternaria and Stemphyllum,* Einar Hunksgaard Publisher, Copenhagen. 560 pp.
13. Singh, B.P., B.B. Nagaich and S.K. Saxena. 1990. Fungi associated with dry rot of potatoes, their frequency and distribution. *Rev. Plant Path.* 69(4): 224-25.
14. Tivoli, B., H. Torres and E.R. French. 1989. Inventory, distribution and aggressiveness of spp. of *Fusarium* present on potato or in its environments in different agroecological zones in Peru. *Rev. Plant Path.* 68: 579.
15. White, J.W. and S. Sadik. 1983. Potatoes from true potato seed. A promising alternative. *SPAN* 26: 23-25.

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EVALUATION OF POTATO CULTIVARS FOR SALINITY TOLERANCE

J.L. Mangal[1] A.C. Yadav[1], R.K. Singh[2] and A. Singh[1]

ABSTRACT: Salinity tolerance in potato cultivars was studied in polythene bags of 30 cm size. A 50% yield reduction occurred at 4.81-5.70 dSm^{-1} depending on cultivar. It was estimated that if soil salinity exceeds 1.92 dSm^{-1}, the mean potato yield declined by 14.78% per unit increase in soil salinity. Cultivar Kufri Sindhuri showed maximum tolerance to salinity followed by Kufri Badshah and Kufri Chandramukhi. The minimum yield decline was 13.91% with per unit increase in soil salinity in cultivar JH-222 as compared to other cultivars.

INTRODUCTION

Techniques to evaluate cultivars for micro-environmental factors such as soil salinity are important for identifying cultivars tolerant to salinity and for use in future breeding programmes. Potato is grown throughout the country and many arid and semi-arid zones often have an indigenous salinity hazards and the problem is increasing due to indiscriminate use of ground water and poor soil and water management. Therefore, there is a need for assessing crop varieties suitable for growing in saline conditions. Experiments conducted by the U.S. Salinity Laboratory Staff (7) and Mangal *et al.*, (5) have shown that potato is a medium salt tolerant crop. The present study was conducted to compare the salt tolerance of five commercial potato cultivars.

MATERIALS AND METHODS

The experiments were conducted at the Research Farm, Haryana Agricultural University, Hisar during 1989-90 and 1990-91. The soil used was sandy loam with 0.85% organic carbon, 8.25 pH (1:2), ECe 0.75 $dSm,^{-1}$ and cation exchange capacity, 4.5 m equiv./100 g of soil. A mixture of sodium chloride, sodium sulphate, magnesium chloride and calcium chloride (1:1:1:1) in solution form was used to develop salinity levels of ECe 0, 4, 6, 8 and 10 dSm^{-1}.

The artificially salinized soil was placed in polythene bags of 30 cm diameter at the rate of 25 kg soil per bag. Five commercially grown cultivars, Kufri Chandramukhi, JH-222, Kufri Badshah, Kufri Bahar and Kufri Sindhuri were used in the study. One pre-sprouted tuber, weighing 30-50 g of each variety was planted per bag in the 2nd

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week of October each year. All the 25 treatment combinations were replicated five times in a completely randomized block design. Nutrients were provided at two weekly intervals by supplying 200 ml/ bag of nutrient solution (Arnon and Hoagland, 1). The pots were irrigated with canal water having an ECe of 0.25 $dSm.^{-1}$ The data was analysed by regression method and by the analysis of variance as described by Fisher (3).

RESULTS AND DISCUSSION

As no significant differences were recorded between the two crop years, the data were pooled for further analysis. A significant decrease in plant height (cm) and number of leaves/plant was recorded with increased salinity (Table 1). But number of stems/hill was not affected by increasing salinity. Cultivars also differed with respect to various growth characters at same salinity level. A significant decline in plant height was noticed when soil salinity reached 4.0 dSm^{-1} ECe in all cultivars except in case of JH-222 where significant decline was noticed only when growing media exceeded 4.0 dSm^{-1} salinity level. Maximum reduction was noticed at 10 dSm^{-1}

Table 1. Effect of different salinity levels on vegetative growth of five potato cultivars

Soil ECe (dSm^{-1})	Characters	Cultivars					
		Kufri Chandramukhi	JH-222	Kufri Badshah	Kufri Bahar	Kufri Sindhuri	Average
Control (0.85)	plant height (cm)	24.7	18.3	32.7	27.3	27.3	26.1
	No. of stems/hill	3.0	4.7	3.3	4.3	4.7	3.9
	No. of leaves/plant	30.0	55.7	42.7	40.7	57.3	45.3
4.0		21.3	18.3	26.3	24.3	24.3	22.9
		3.0	4.3	5.3	4.0	4.7	4.6
		28.3	51.0	54.7	41.3	44.7	43.9
6.0		19.7	16.7	25.00	25.7	23.7	22.1
		3.3	5.7	2.7	4.3	3.3	3.8
		30.0	48.3	30.0	38.0	46.7	38.6
8.0		17.3	15.0	19.00	22.7	20.7	18.9
		3.00	3.3	2.7	4.0	4.3	3.5
		23.7	33.0	19.7	33.7	26.7	29.3
10.0		8.00	6.0	8.7	10.6	11.0	8.8
		2.3	2.0	2.3	3.7	3.0	2.7
		7.7	14.0	17.7	18.7	20.0	15.6
Average		18.2	14.8	22.3	22.15	21.4	
		2.9	3.9	3.2	4.1	4.00	
		29.9	40.4	32.9	34.5	39.06	-

		Plant height	*No. of stems/hill*	*No. of leaves/plant*
C.D. at 5% for	(i) Varieties	1.046	N.S.	6.20
	(ii) Salinity	1.167	N.S.	3.35
	(iii) Varieties x salinity	2.610	0.766	7.49

ECe in all cultivars. Correlation analysis showed a direct bearing on various characters like plant height, stems/hill, number of leaves/plant and tuber yield per plant under increasing salinity stress but number of tubers/plant did not affect tuber yield; r = 0.21 (Table 3).

Data presented in table 2 indicate that the number of tubers per plant and tuber weight per plant decreased significantly only when soil salinity exceeded 6.0 dSm^{-1} in all cultivars except Kufri Sindhuri and Kufri Bahar where decrease was noticed even at 4.0 dSm^{-1} ECe. Tuber yield (weight) was also found to be inversely related to soil salinity. Harden (4) and Bilski *et al* (2) have reported that potato yield was significantly reduced (23-25%), when crop was grown under mildly (4-6 dSm^{-1}) saline conditions. Paliwal and Yadav (6) also reported that tuber weight and number/hill were found to decrease with an increase in the salinity.

Table 2. Effect of different salinity levels on tuber number and weight (g) per plant on five potato cultivars

Soil ECe (dSm^{-1})	Cultivars / Tuber number & tuber weight					
	Kufri Chandra-mukhi	JH-222	Kufri Badshah	Kufri Bahar	Kufri Sindhuri	Average
Control (0.85)	3.7 (150.3)	7.3 (158.3)	4.0 (176.6)	6.6 (151.6)	9.7 (170.6)	6.3 (161.4)
4.0	3.3 (146.3)	7.0 (180.7)	5.0 (163.)	6.0 (158.3)	7.7 (165.6)	5.8 (139.4)
6.0	3.0 (88.3)	6.7 (125.0)	5.3 (162.7)	4.3 (92.7)	5.0 (115.0)	4.9 (116.7)
8.0	2.7 (60.0)	5.0 (104.3)	3.7 (74.7)	4.0 (61.6)	5.0 (107.3)	4.0 (81.6)
10.0	1.6 (14.0)	1.0 (11.7)	2.3 (7.3)	1.0 (5.7)	2.3 (7.0)	1.6 (9.1)
Average	2.9 (91.8)	5.19 (116.0)	4.1 (116.8)	4.4 (93.9)	5.9 (113.1)	

C.D. at 5% for	*Tuber number*	*Tuber weight*
(i) Varieties =	0.095	(26.19)
(ii) Salinity =	1.089	(20.37)
(iii) Varieties x salinity =	2.430	(45.50)

( ) = Data for tuber yield (g) per plant)

Table 3. Salt tolerance of five potato cultivars

Cultivars	Tuber yield control (g)	Estimated yield (g/plant)	Tolerance* (dSm^{-1})	Threshold** (dSm^{-1})	Slope***	Correlation coefficient
Kufri Chandramukhi	150.3	170.8	5.33	1.44	-14.10	-0.93
JH 222	158.3	193.9	4.88	2.55	-13.91	-0.81
Kufri Badshah	170.7	204.5	5.37	2.13	-15.87	0.84
Kufri Bahar	151.7	178.3	4.81	1.77	-15.07	-0.90
Kufri Sindhuri	170.7	196.9	5.70	1.75	-14.97	-0.87

* Soil salinity at which 50% yield decline
** Soil salinity at which initial yield decline begins
*** Per cent yield change per unit salinity increase.

Slopes and intercepts for the relationship between soil salinity and tuber yield/hill differed with variety (Table 3). Out of five cultivars, JH-222 had the lowest reduction (13.91%) in yield per unit increase in salinity, whereas Kufri Badshah and Kufri Bahar had the highest decrease in yield with per unit increase in salinity. The 50% reduction in potato yield, the criterion for its salt tolerance, is associated with a soil ECe value of 4.81 - 5.70 dSm^{-1} and this classifies potato as a moderately salt tolerant crop.

LITERATURE CITED

1. Arnon, D.I. and D.R. Hoagland. 1940. Crop production in artificial selection and in soils with special reference to factors influencing yield and absorption of inorganic nutrients. *Soil Sci.* 50 : 463-68.
2. Bilski, J.J., D.C. Nelson and R.L. Conlon. 1988. The response of four potato cultivars to chloride salinity, sulphate salinity and calcium in pot experiments. *Am. Potato J.* 65 : 85-90.
3. Fisher, R.A. 1950. *Statistical Methods for Research Workers*. Oliver and Boyd, London.
4. Harden, A. 1976. Irrigation with saline water under desert condition. *University Lu-bock Texas*, 8 : 165-69.
5. Mangal, J.L., A.C.Yadav, S. Lal, P.S. Hooda and S.C Khurana. 1991. Response of potato genotypes to different levels of soil salinity. *Haryana J. Hort. Sci.* 20(1-2): 98-101.
6. Paliwal, K.V., and B.B. Yadav. 1980. Effect of saline irrigation water on the yield of potato. *Indian J. Agric. Sci.* 50 : 31-33.
7. U.S. Salinity Laboratory Staff. 1954. Diagnosis and improvement of saline and alkali soils. *USDA Handbook* No. 60, pp 65-68.

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EVALUATION OF LEAF ANALYSIS AS AN INDEX FOR JUDGING NITROGEN NEEDS OF FOUR POTATO CULTIVARS IN SHIMLA HILLS

K.C. Sud, J.S. Grewal and B.S. Bist[1]

ABSTRACT: Field study was undertaken on slightly acidic soil of Shimla (Palehumults) with four potato cultivars to study the effect of N application on leaf composition at various growth stages and to work out critical limits for NO_3-N (petioles) and total N (leaf blades). Potato cultivars did not differ significantly among themselves with regard to nutrient content in leaves and petioles at 75, 95 and 115 DAP. N application significantly increased NO_3-N (petioles) and total N (leaf blades) but decreased K content. Both NO_3-N in petioles and total N in leaf blades showed a curvilinear relationship with final tuber yield and correlation coefficients were significant in early growth stages.

INTRODUCTION

Nitrogen is the first limiting nutrient in potato production. Nutrient availability to plant from soil and fertilizer is often reflected in nutrient accumulation in different plant parts. Although information is available with regard to critical concentration of nitrogen in leaf and petiole under short day condition (6, 7, 8) but no such work has been reported on potato crop grown under long day conditions in Shimla hills. Therefore investigation was undertaken to study the effect of N on nutrient accumulation in leaf at different growth stages and to work out the critical limits of NO_3-N (petioles) and total N (leaf blades) so as to use them as an index for judging nitrogen need of potato.

MATERIALS AND METHODS

The other details are described in earlier communication (11). Leaf samples after washing were separated into petioles and leaf blades, dried and analysed for total N, P and K by standard methods. NO_3-N in petioles was determined colorimetrically using brucine (1). Quadratic and linear regressions were fitted between leaf N indices and tuber yield (9). The critical concentrations, for NO_3-N and total N in petioles and leaf blades at each stage were taken to be their mean at 95% of the maximum tuber yield.

RESULTS AND DISCUSSION

Leaf blade composition: Mean value of nitrogen contents in leaf at 55, 75, 95 and 115 days after planting (DAP) was 5.31, 5.36, 4.58 and 4.47%, respectively (Table 1). At initial stages of plant growth, Great Scot and Kufri Jyoti had significantly higher

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Table 1. Effect of nitrogen on the leaf blade composition at various stages of growth (%)

Treatment/DAP*	Nitrogen				Phosphorus				Postassium			
	55	75	95	115	55	75	95	115	55	75	95	115
Cultivars												
Great Scot	5.40	5.51	4.77	4.62	0.392	0.372	0.470	0.352	3.05	4.66	4.05	3.87
Kufri Chandramukhi	5.06	5.29	4.61	4.41	0.392	0.357	0.454	0.334	3.04	4.28	3.96	3.50
Kufri Jyoti	5.55	5.30	4.54	4.35	0.468	0.341	0.455	0.352	2.70	4.68	3.92	3.56
SLB/Z-405 (a)	5.04	5.35	4.47	4.48	0.399	0.334	0.421	0.326	3.02	5.03	4.06	4.08
C.D. (0.05)	0.31	NS	NS	NS	0.039	*NS*	*NS*	*0.043*	*NS*	*0.48*	*NS*	*NS*
N levels (kg N/ha)												
0	4.64	4.73	4.32	4.21	0.386	0.353	0.448	0.341	3.01	4.93	4.28	3.79
50	5.32	5.14	4.34	4.19	0.411	0.343	0.425	0.343	3.03	4.72	4.09	3.77
100	5.62	5.49	4.78	4.75	0.423	0.338	0.470	0.347	2.88	4.63	3.92	3.82
150	5.67	5.90	4.88	4.65	0.433	0.370	0.456	0.356	2.89	4.27	3.50	3.56
C.D. (0.05)	0.31	0.42	0.32	0.31	0.031	NS	NS	NS	NS	0.33	0.32	NS

*DAP = Days after planting

N content than Kufri Chandramukhi and SLB/Z-405(a) but at later stages, differences were not significant. Nitrogen application significantly increased nitrogen content in leaf blades upto 100 kg N in all the 4 cultivars and at all the 4 growth stages. At still higher doses of N, the N content tended to increase but increase was not significant. The nitrogen content fell significantly at 75 DAP as there was greater translocation of N from shoots to tubers. The mean P content in leaf blades at four stages was 0.413, 0.351, 0.450 and 0.346 %, respectively (Table 1). Kufri Jyoti had significantly higher P content than others. Higher doses of N marginally increased P content in leaf blades. The P composition was maximum at 95 DAP.

Potassium content in leaf did not differ significantly amongst the cultivars but Great Scot and SLB/Z-405 (a) recorded higher K content in leaf blades, throughout their growth period. N application at high doses tended to decrease K content in leaf blades, significant decrease being observed at 75 and 95 DAP. Negative interaction between N and K in high rain fall areas had also been reported by Boyd and Dermott (2).

Table 2. Regression equations and critical concentrations of NO_3-N (petioles) at various growth stages

Cultivar	Days	Regression	Multiple Regression coefficient (R^2)	Critical concentration NO_3-N (petiole) (%)
	55	$Y = 297.9 - 39.037x + 30.1513x^2$	0.976**	2.04
	75	$Y = 286.9 + 10.290x + 12.2873x^2$	0.861*	1.78
Great Scot	95	$Y = 286.3 + 54.251x + 12.4116x^2$	0.991**	0.90
	115	$Y = 264.2 + 555.856x - 817.3918x^2$	0.934**	0.21
	55	$Y = 839.3 - 850.046x + 289.4345x^2$	0.937**	2.16
	75	$Y = 265.5 + 144.465x - 199.9837x^2$	0.997**	0.73
Kufri	95	$Y = 264.3 + 269.537x - 199.9837x^2$	0.968*	0.42
Chandramukhi	115	$Y = 85.9 + 4637.483x - 19330.338x^2$	0.993**	0.09
	55	$Y = 249.4 + 281.037x - 98.6430x^2$	0.964**	2.20
	75	$Y = 308.2 + 236.691x - 84.0100x^2$	0.999**	0.68
Kufri Jyoti	95	$Y = 157.2 + 1960.426x - 3070.2680x^2$	0.836*	0.20
	115	$Y = 88.40 + 3310.762x - 7354.0030x^2$	0.999**	0.16
SLB/Z-405 (a)	55	$Y = 183.66 + 87.919x - 16.3577x^2$	0.732	2.58
	75	$Y = 157.75 + 154.884x - 34.6012x^2$	0.947**	1.54
	95	$Y = 212.5 + 169.956x - 57.2752x^2$	0.903**	0.83
	115	$Y = 188.52 + 379.842x - 213.9928x^2$	0.952**	0.44

NO_3-N content in petioles: NO_3-N contents in 4 potato cultivars have been depicted graphically in Figs. (1) a and (1) b. Mean NO_3-N content varied from 0.20% in control to 2.10% at 150 kg N at 55 DAP which fell to 0.08 to 0.50 per cent at later stages. It was maximum at 55 days when the translocation of nutrients from roots to haulms was more and plant need for NO_3-N was high. Between 75 and 115 DAP the NO3-N content decreased depending upon the N dose. Similar results have also been reported by Gardner and Jones (4). N application had highly significant effect on NO3-N content in petioles at all the four growth stages and in all the 4 cultivars. NO3-N content in Kufri Chandramukhi decreased more rapidly than other cultivars.

Critical NO3-N concentration in petioles: The potato yields during early bulking stages were significantly but negatively correlated with corresponding NO3-N content in leaf petioles. The mean correlation coefficient values (r) for Great Scot, Kufri Chandramukhi, Kufri Jyoti and SLB/Z-405(a) were (-0.74**), (-0.67**), (-0.57*) and (-0.69**), respectively. The negative association of yield with NO3-N (petioles) at early stages was due to higher shoot/tuber ratio with increasing N levels (3). However, with final tuber yield (Y), NO3-N content (X) showed a highly significant association at 55, 75, 95 and 115 DAP in all the four cultivars (Table 2). The results are in agreement with findings of Sharma and Arora (7), and Sud and Grewal (10). Critical concentration of NO3-N in petioles (Table 2) revealed that during tuber initiation stage (55 DAP), N needs was same for all the cultivars but during tuber bulking phase, critical concentrations were higher in Great Scot and SLB/Z-405 (a) than others. These values were higher than those reported by Sharma and Arora (7) as the crop was taken under long day conditions and N needs were high in view of luxuriant vegetative growth. There was rapid decrease in critical concentration of NO3-N in petioles with time as more of N was utilized by tubers.

Table 3. Regression equations and critical concentrations of total N (leaf blades) at various growth stages

Variety	Days	Regression	R^2	Critical concentration Total N (leaf blades) (%)
	55	$Y = -3696.16 + 1485.85x - 136.555x^2$	0.599	5.38
Great Scot	75	$Y = 914.48 - 279.52x + 31.152x^2$	0.914**	5.84
	95	$Y = 24122.86 - 9992.09x + 1041.157x^2$	0.230	5.25
	115	$Y = 803.02 - 247.61x + 36.884x^2$	0.901*	44.91
Kufri	55	$Y = -3882.93 + 1616.52x - 154.027x^2$	0.974*	4.92
Chandramukhi	75	$Y = -1824.46 + 796.99x - 72.963x^2$	0.922*	5.09
	95	$Y = 3451.56 - 1397.82x + 154.819x^2$	0.712	5.06
	115	$Y = -974.01 + 528.43x - 52.241x^2$	0.619	4.39
Kufri	55	$Y = -4172.27 + 1632.35x - 143.884x^2$	0.999**	6.10
Jyoti	75	$Y = -9788.26 + 3684.65x - 328.880x^2$	0.944**	6.16
	95	$Y = -20658.40 + 9212.33x - 1003.704x^2$	0.721	4.81
	115	$Y = -10733.55 + 5027.54x - 565.089x^2$	0.931*	4.27
SLB/Z-405 (a)	55	$Y = -5413.12 + 2246.158 - 218.853x^2$	0.766	5.54
	75	$Y = -1122.63 + 452.925x - 35.298x^2$	0.873*	5.76
	95	$Y = -3120.81 + 1437.762x - 150.726x^2$	0.853	4.88
	115	$Y = -1725.04 + 800.577x - 78.505x^2$	0.867	4.74

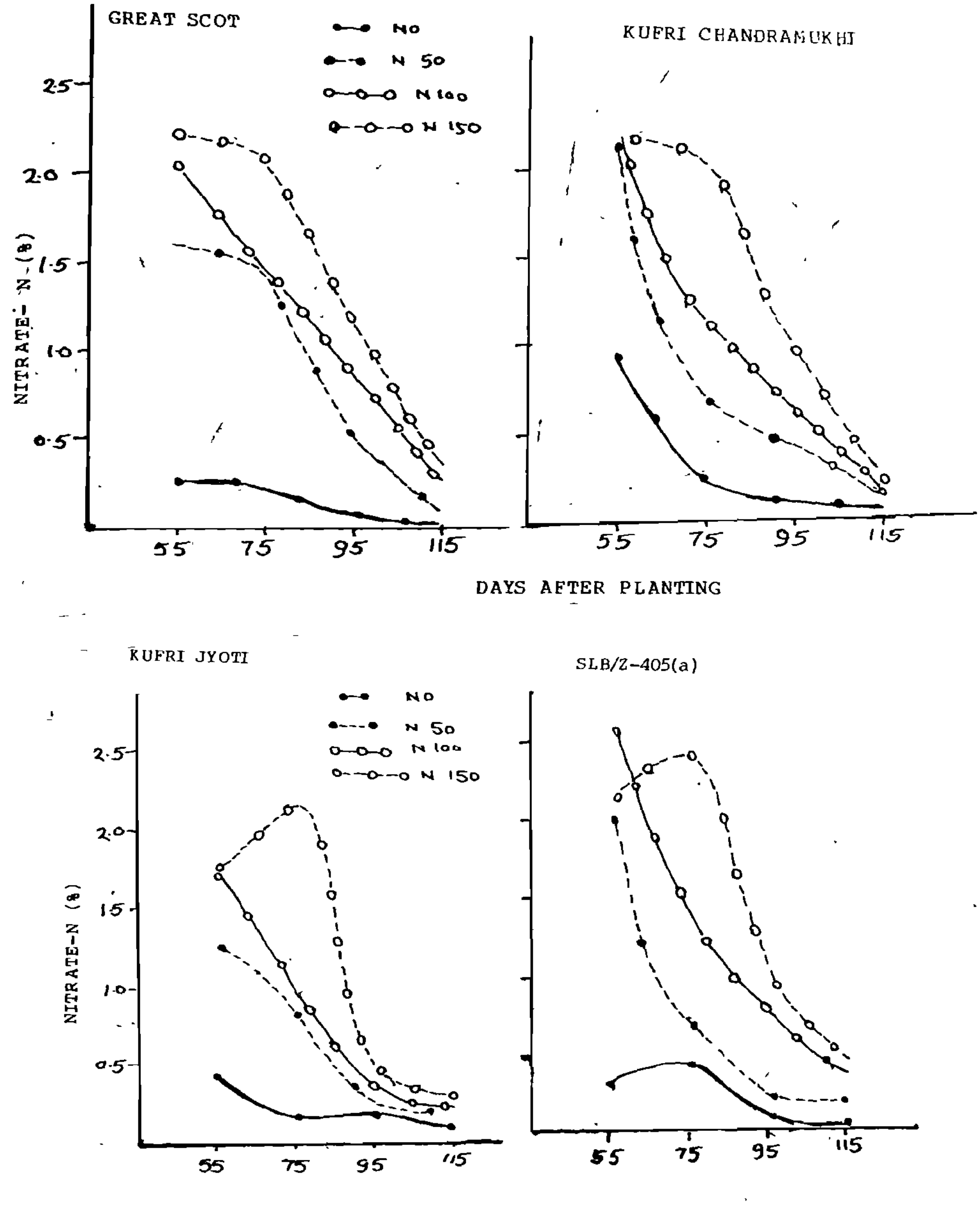

Fig. 1 (a) & 1 (b). Effect of N levels and growth stages on nitrats-N (%) content in potato cultivars

Critical N concentration in leaf blades: The multiple regression coefficients (R^2) between N content in leaf blade (X) and final tuber yields (Y) were significant at early bulking stage (75 DAP) in all the cultivars (Table 3). In potato cv. Kufri Jyoti and Kufri Chandramukhi, the association was equally good at tuber initiation (55 DAP). Gupta and saxena (5) have also reported similar results with Kufri Sindhuri grown under short day conditions. The R^2 values indicate that varietal behaviour was inconsistant in later bulking period (Table 3). The critical N concentration in leaf blades vary with cultivar and was maximum at 75 days. Compared to rapid fall of NO_3-N concentration in petioles (Table 2) with time, critical N concentration in leaf blades did not change appreciably with growth.

Above results showed that petioles serve as better index than leaf blades for judging N needs of potato in Shimla hills due to wide variation in NO'_3-N concentration in petioles. Tuber initiation and early bulking period was ideal for tissue testing in potato grown under long day conditions.

LITERATURE CITED

1. Baker, A.S. 1983. Colorimetric determination of nitrates in soils and plant extracts with Brucine. *J. Agr. Food Chem.* 15: 802-05.
2. Boyd, D.A. and W. Dermott. 1964. Fertilizer experiments on the main crop potatoes 1955-61. *J. Agric. Sci.* (Camb.) 63: 249-59.
3. Dyson, A.N. and D.J. Watson. 1971. An analysis of the effects of nutrient supply on the growth of potato crops. *Ann. Applied Biol.* 69: 47-63.
4. Gardner, B.R. and J.P. Jones. 1975. Petioles analysis and the nitrogen fertilization of Russet Burbank potatoes. *Am. Potato J.* 52: 195-200.
5. Gupta A. and M.C. Saxena. 1976. Total nitrogen concentration in leaves of potatoes (*Solanum tuberosum* L) as an index of nutritional status. *J. Agri. Sci.* (Camb.) 87: 293-96.
6. Gupta, A. and M.C. Saxena. 1981. Effect of nitrogen and phosphorus fertilization on P and K accumulation in different plant parts of potato. *J. Indian Potato Assoc.* 8: 45-52.
7. Sharma, U.C. and B.R. Arora. 1987. Critical NO_3-N concentration in potato leaves and petioles for higher yields. *J. Indian Soc. Soil Sci.* 35: 661-66.
8. Singh, J.P. 1987. Leaf analysis for balanced nutrition of potato. *J. Indian Potato Assoc.* 14: 88-91.
9. Snedecor, G.W. and W.G. Cochran. 1968. *Statistical Methods*. Oxford & IBH Publishing Co. Calcutta.
10. Sud, K.C. and J.S. Grewal. 1987. Evaluation of plant tissue tests for nitrogen application to potato. *Proc. National Symp. "Macronutrients in Soils and Crops"* PAU Ludhiana (Punjab). pp. 148-55
11. Sud, K.C., J.S. Grewal and B.S. Bist. 1991. Response of potato to nitrogen application at different grwoth stages. *J. Indian Potato Assoc.* 18: 135-41.

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EFFECT OF TUBER SIZES AND PLANT GROWT. SUBSTANCES ON NUMBER AND SIZE OF SPROUTS AT DIFFERENT FLUSHES

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ABSTRACT: Effect of tuber sizes (61.1 and 156.8 g) and plant growth substances (GA3-2 ppm, GA3-2 ppm + thiourea 1% and control) was studied on number and size of sprouts at different flushes. Sprouts were detached thrice (30th September, 16th October and 4th November) from the same tuber. First (5.3) and second (5.5) flushes gave higher number of sprouts as compared with third flush (3.7). Although number of sprouts per tuber were significantly higher in over size tubers (6.0/tuber/flush) when compared with seed size tubers (3.7/tuber/flush), number of sprouts on per unit weight basis were higher in seed size tubers (186.7/kg) as compared to over size tubers (114.4/kg). Plant growth substances did not influence number of sprouts and sprout size. Sprout weight and diameter was highest in case of first flush and lowest in case of third flush. Tuber sizes did not influence sprout size.

INTRODUCTION

In potato seed, tuber multiplication rate is low and diseases tend to increase with each generation. Recently whole and cut sprouts have been used to raise a potato crop with a view to increase multiplication rate (2, 5, 6). If the sprouts of about 8-10 cm are developed with roots on the tuber itself, then these sprouts after detachment can directly be transplanted in the field. In most of the studies carried out so far only one flush of sprouts has been taken. Plant growth substances and tuber sizes have been found to influence growth and stems/hill (1, 3, 4). In the present investigation, sprouts were detached when they were about 8-10 cm in length and more than one flush of sprouts were taken. Different tuber sizes and plant growth substances were also used to study their effect on number and size of sprouts at different flushes.

MATERIALS AND METHODS

The investigation was carried out during 1990 at Vegetable Research Farm, C.C.S.H.A.U., Hisar. Treatments consisted of combination of two tuber sizes (seed size, 61.14 ± 5 and over size, 156.85 ± 5 g) and two plant growth substances (GA3-2 ppm, GA3-2 ppm + thiourea 1%) in addition to control. Treatments were replicated 25 times and arranged in C.R.D. Tubers of cv. Kufri Badshah were taken out of cold store on 8th September. After five days exposure to diffused light, tubers were dipped for half an hour in the solution of plant growth substances, whereas in the case of control,

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tubers were dipped in water. The treated tubers were kept from end to end in plain beds on 13th September, 1990 and covered with 5 cm layer of sand. Beds were covered with '*Sirki*' to lower down the temperature and sand was kept moist by sprinkling water as and when needed. All the tubers were taken out on 30th September, 1990, sprouts detached and necessary observations were recorded. These tubers were again kept under sand and the process of detaching sprouts was repeated on 15th October and 4th November for taking second and third flush of sprouts.

RESULTS AND DISCUSSION

Number of sprouts per tuber did not show significant variation at first (5.3) and second (5.5) flush, whereas significant reduction in sprout number was recorded at third flush (3.7). Over size tubers yielded more number of sprouts per tuber as compared to seed size tubers due to the presence of more number of eyes. However, number of sprouts on per unit weight basis were higher in seed size tubers (186.7/kg) as compared to over size ones (114.4/kg).

Table 1. Effect of sprouting and tuber sizes on mean sprout weight (g)

Sprout flushes	Tuber size	
	Seed size	Over size
1st flush	4.4	4.2
2nd flush	3.0	4.1
3rd flush	3.3	3.1
C.D. at 5% = 0.55		

Weight of individual sprout as well as its diameter was significantly higher at first flush compared with second and third flushes. This may be due to the reduction in the availability of food material from the mother tuber at subsequent flushes for the growth of sprouts. Sprouts from oversize tubers wieghed more compared with sprouts from seed size tubers at second flush (Table 1). This is because number of sprouts per unit weight of seed tubers harvested at first flush were higher in seed size tubers (seed size and over size tubers produced 67.2 and 41.3 sprouts/kg, respectively) as compared to over size tubers, which reduced the availability of food for growing sprouts in seed size tubers. Plant growth substances neither influenced sprout weight nor diameter of sprouts. The interactions between tuber sizes, sprout flushes and plant growth substances for diameter of sprouts were significant (Table 2). The untreated seed size tubers recorded the maximum diameter at first flush whereas lowest value was recorded for third flush of over size tubers treated with GA-2 ppm. Dry matter content in sprout was 8.7% and was not influenced by any treatment.

Table 2. Effect of sprouting, tuber sizes and plant growth substances on diameter of sprouts (cm)

Treatments	Seed size			Over size		
	GA_3-2ppm	GA_3-2 ppm+ thiourea-1%	Control	GA_3-2ppm	GA3-2ppm + thiourea -1%	Control
Sprout flushes						
1st flush	0.60	0.71	0.78	0.76	0.77	0.69
2nd flush	0.65	0.66	0.58	0.59	0.70	0.73
3rd flush	0.65	0.65	0.51	0.44	0.54	0.70
Mean	0.63	0.67	0.62	0.60	0.67	0.71

C.D. at 5% ; Tuber sizes x plant growth substances = 0.07;
Sprout flushes x tuber sizes x plant growth substances = 0.12.

Table 3. Effect of sprouting and plant growth substances on mean sprout length (cm)

Treatments	Plant growth substances		
	GA_4-2 ppm	GA_4-2 ppm + Thiourea-1%	Control
Sprout flushes			
1st flush	11.7	10.8	9.7
2nd flush	12.9	11.6	12.9
3rd flush	8.6	10.3	11.4

C.D. at 5% = 1.5

Although sprout weight was maximum at first flush, sprout length at second flush was significantly higher when compared with first and the third flush. It shows that sprout length is not only affected by the availability of food from the mother tuber but on environmental conditions also. Temperatures during the growth of first flush of sprouts were 33.9 and 23.6°C (maximum and minimum, respectively) which gradually fell to 30.9 and 11.2°C in the first week of November. Plant growth substances increased sprout length only at first flush (Table 3). This is attributed to the cell elongation affect of GA3 on sprouts. At second and third flush availability of food from the mother tuber might also have become a limiting factor.

LITERATURE CITED

1. Baijal, B.D., P. Kumar and M.A. Siddiqui. 1983. Interaction of growth regulartors and photoperiods on growth, flowering, stolon development, tuber initiation and yield in potato (*Solanum tuberosum* L.). *Indian J. Plant Physiol.* 26: 61-67.

2. Bhatia, A.K. 1991. Studies on rapid multiplication techniques in seed potato production. Ph.D. Thesis, Deptt. of Veg. Crops, H.A.U., Hisar.

3. Khurana, S.C. and M.L. Pandita. 1987. A note on the effect of gibberellic acid on growth and development of two commercial potato varietieis. *Haryana J. Hort. Sci.* 16: 151-53.

4. Khurana, S.C., M.L. Pandita and V.K. Srivastava. 1991. Effect of seed size and seed rate on potato yield. *J. Indian Potato Assoc.* 18: 167-68.

5. Naik, P.S., B.S Bhullar, H.S. Chauhan and A.K. Verma. 1990. Possible use of sprouts in potato seed production (abstract). In : *National Symposium on Strategies for Potato Production, Marketing, Storage and Processing*, IPA, New Delhi, 21-23, Dec., 1990, pp 58.

6. Singh, S.V., M.D. Jeswani and Jagpal Singh. 1990. Rapid multiplication - A way out to bridge the gap *of demand and supply in seed potatoes (abstract). In : National Symposium on Strategies for Potato Production, Marketing, Storage and Processing.* IPA, New Delhi. 21-23 Dec., 1990, pp 58.

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DIFFERENCES AMONG POTATO GENOTYPES IN STORABILITY AT HIGH TEMPERATURE AFTER DIFFERENT PERIODS OF STORAGE*

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ABSTRACT: Ten advance stage hybrids and varieties of potato were stored at ambient temperatures in North-western plains of India. The variances due to genotype, storage period and genotype x storage period interaction were highly significant. Till 45 days of storage all the genotypes were at par in per cent weight loss. At 70 days, JI 5857, Kufri Badshah and Kufri Bahar were at par, but had significantly higher weight loss than that in other genotypes. At 140 days, Kufri Lalima, Kufri Lauvkar and JF 5106 showed better storability than all other genotypes. Effect of storage period on weight loss was almost linear. However, weight loss was somewhat slower in the initial period of observations. Average weight loss was less than 10 per cent and rottage was nil, upto 70 days. After 100 days of storage, rottage was a significant contributor to weight loss. The results indicated that it won't be desirable to store potatoes at room temperature beyond 70 days i.e. about May end. However, for identifying parents for use in breeding programmes, the evaluation must be done for longer periods, as differences in storability widen with the passage of time.

INTRODUCTION

In the plains of India, potato harvest is followed by 7-8 months of hot and dry weather. Due to insufficient refrigerated storage capacity, more than half of the produce is stored at ambient temperatures for varying periods before it is disposed off/consumed (2, 4). Thus it is important to evaluate the advance stage hybrids and varieties of potato for storability under non-refrigerated storage. Little is known about the genotype x storage period interaction for storability in potato. These aspects were studied in 10 advance stage hybrids and varieties of potato and the results are reported here. The association between rottage and total weight loss during storage, was also examined.

MATERIALS AND METHODS

The study was conducted at Central Potato Research Station, Jalandhar (Pb.). Four advance stage hybrids viz., E 4486, JE 808, JF 5106 and JI 5857 and six varieties viz., Kufri Badshah, Kufri Bahar, Kufri Chandramukhi, Kufri Jyoti, Kufri Lalima and Kufri Lauvkar were grown under similar conditions following normal cultural practices during autumn seasons (October-January) of 1983-84 and 1984-85. The haulms were cut when the crop was 90 days old. Irrigation was stopped 10 days before haulms

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cutting and the crop was harvested 20 days after haulms cutting (first week of February) in both the years.

The produce was kept in gunny bags in an ordinary room till the start of the experiement. Apparently unbruised and undamaged tubers of uniform size (40-60g) were randomly selected for each of the hybrids/varieties. Five replications of 10 kg tubers each, for each of the 10 hybrids/varieties kept in airy heassian cloth bags, were stored at room temperature on 12th March during both the years. The maximum and minimum temperature in the store during the period of study ranged between 26.0 and 46.0°C and between 13.5 to 33.0°C, respectively in 1984. They were in the range of 26.0 and 43.5°C and 13.0 to 34.0°C, respectively in 1985. The relative humidity was in the range 30 to 75 per cent in both the years. The first observation was taken after one month of the start of the experiment. The next two dates were at 15 days interval. The subsequent dates of observations were at 10 days interval. Sprouts were not removed, but the tubers showing even the slightest sign of rottage were discarded. Cumulative per cent weight loss and per cent rottage at each date was calculated.

The data were transformed using arcsine transformations. Both original and transformed data of weight loss, were analyzed according to completely randomized design. The results of transformed and original data were identical. Hence, keeping in view the simplicity and meaningfulness of presentation, the original data are reported here.

RESULTS AND DISCUSSION

Analysis of variance of per cent weight loss during storage showed highly significant ($P < 0.01$) mean squares for each of the three factors i.e. genotype, storage period and genotype x storage period interaction, in both the years. Thus, all the three factors were important for controlling weight loss during storage.

Effect of genotype on weight loss: The per cent weight loss in various hybrids/varieties during the period of study (140 days) varied between 25.6 to 49.2 in 1984 and between 27.0 to 55.2 in 1985 (Table 1). The per cent weight loss in the population (averaged over hybrids/varieties) was 34.4 in 1984 and 35.5 in 1985. This indicated that overall performance in two years was similar. However, the relative performance of individual hybrids/varieties varied in the two years. The lowest weight loss was recorded in Kufri Lauvkar in 1984 and in JF 5106 in 1985. The highest weight loss was in JI 5857 in both the years followed by JE 808 in 1984 and E 4486 in 1985. Variety Kufri Lalima was second best in storability in both the years. The variation in relative performance of the genotypes in two years could not be attributed to any specific factor, but it could be due to the genotype x year interaction for storability. Such year to year differences in relative performance of the genotypes for storability have been observed in earlier study also (3). To know the extent of

Table 1. Effect of genotype on per cent weight loss at different periods of storage

Hybrid/ Variety	Per cent weight loss after different periods (days) of storage						
	45		70		140		
	1984	1985	1984	1985	1984	1985	Average
E 4486	5.4 a	1.2 a	9.0 bc	10.6 abc	32.2 cd	43.0 b	37.6
JE 808	5.0 a	2.4 a	10.0 bc	9.8 bcd	40.8 b	37.4 c	39.1
JF 5106	3.4 a	1.4 a	7.4 c	7.8 d	31.6 cd	27.0 g	29.3
JI 5857	6.4 a	2.6 a	14.0 a	12.8 a	49.2 a	55.2 a	52.2
Kufri Badshah	6.2 a	2.4 a	11.0 ab	12.0 ab	34.6 c	37.6 c	36.1
Kufri Bahar	4.2 a	1.6 a	11.2 ab	10.8 ab	38.0 b	33.8 D	35.9
Kufri Chandramukhi	4.6 a	1.2 a	9.8 bc	9.6 bcd	31.0 d	30.0 ef	30.5
Kufri Jyoti	4.0 a	2.4 a	8.4 bc	9.2 cd	33.6 cd	30.0 ef	31.8
Kufri Lalima	4.4 a	1.6 a	7.0 c	7.7 d	27.2 e	29.0 fg	28.1
Kufri Lauvkar	5.8 a	1.6 a	9.2 bc	9.6 bcd	25.6 e	32.2 de	28.9
CD (0.05)	NS	NS	3.2	2.5	3.2	2.5	-
Population	4.9	1.8	9.7	9.9	34.4	35.5	34.7

consistency in the relative performance of the hybrids/varieties in the two years, rank correlation coefficient was calculated which was equal to 0.67 and highly significant ($P < 0.01$). Thus the performance of the individual genotypes in the two years can be considered as comparable. The weight loss (averaged over years) in the hybrids/varieties ranged from 28.1 to 52.2 per cent at 140 days of storage. The hybrids/varieties JF 5106, Kufri Lalima and Kufri Lauvkar were the three good keepers with weight loss less than 30 per cent. JI 5857 was a poor keeper with weight loss 52.2 per cent. The weight loss in other genotypes was between 31 to 40 per cent and thus they had average storability. In earlier studies (3, 4) though Kufri Lalima was reported to be a good keeper, Kufri Lauvkar was found to be poor.

Table 2. Effect of storage period on per cent weight loss and rottage

Storage period (days)	Per cent weight loss*		Per cent rottage*	
	1984	1985	1984	1985
30	2.9 j	1.2 j	0.0 e	0.0 f
45	4.9 i	1.8 j	0.0 e	0.0 f
60	8.7 h	7.2 i	0.0 e	0.0 f
70	9.7 h	9.8 h	0.0 e	0.0 f
80	14.7 g	14.7 g	0.0 e	0.1 e
90	17.7 f	15.9 f	0.4 e	0.5 f
100	20.6 e	18.8 e	1.6 d	1.1 e
110	22.8 d	24.0 d	3.9 c	2.4 d
120	26.6 c	27.9 c	6.3 b	5.7 c
130	30.3 b	32.2 b	7.3 b	8.9 b
140	34.5 a	35.1 a	9.5 a	10.8 a

* Average over hybrids/varieties.

Effect of storage period on weight loss: A progressive increase in weight loss (averaged over hybrids/varieties) was observed with increase in the period of storage (Table 2). This conformed the observations of other workers (3, 4, 6, 7) who studied weight loss under different storage conditions.

A plot (Fig. 1) of per cent weight loss versus storage period (days) indicated that response was linear and the fit was reasonably good. However, the weight loss was somewhat slower in the initial period of storage. The weight loss was below 10 per cent up to 70 days (by 3rd week of May) of storage in both the years. But it increased to about 20 per cent in next 30 days (by 3rd week of June) and to about 35 per cent in another 40 days (by July end). The lower rate of weight loss up to 70 days of storage may be because of lower average temperature in the initial period and the dormant condition of tubers. The weight loss during that period was mainly due to respiration and evaporation, whereas in the later part, sprouting and rottage also contributed to the total weight loss. Schippers (5) had also found a nearly linear increase in weight loss with increase in storage period. Butchbaker *et al.* (1) had reported a non-linear response of weight loss with time, with greater variation as time increased.

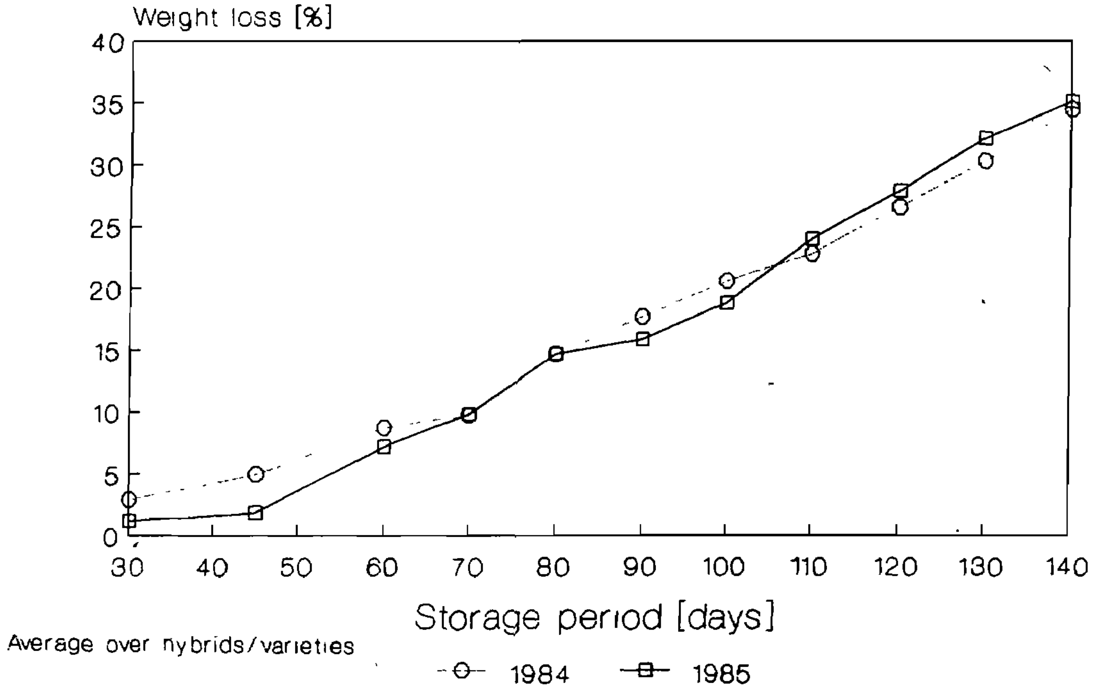

Fig. 1. Main effect of storage period on weight loss

The present and the earlier study show that storing the potatoes at room temperature beyond May, may not be desirable. For judging the commercial acceptability of the storability of genotypes at room temperature, 70 days period (upto 3rd week of May) should be the limit. For storing potatoes beyond this period, use should be made of evaporatively cooled stores, diffused light stores or cold stores (2, 3, 4).

Genotype x storage period interaction for weight loss: Regression coefficients (b) between per cent weight loss and period (days) of storage were highly significant for all the hybrids/varieties in both the years. The values ranged from 0.20 to 0.45 in 1984 and 0.25 to 0.50 in 1985. The differences between "b" values of any of the two hybrids/varieties in any of the two years were highly significant ($P < 0.01$). Thus, change in rate of per cent weight loss/day (b value) with change in the period of storage was not same in any of the two varieties/hybrids.

The relative performance of various hybrids/varieties was examined at different periods of storage. The results of three important periods are presented in Table 1. It was found that upto 45 days of storage, differences in weight loss in various hybrids/varieties were non-significant in both the years. Thus all the hybrids/varieties had equal storability for 45 days of storage. As discussed above, it was found that rate of weight loss was lower up to 70 days of storage and normally potato should not be stored beyond this period at room temperatures as average weight loss then becomes higher than 10 per cent which affect the market value of the tubers due to shrinkage. At this important period of storage, it was found that hybrid JI 5857 was at par with the popular commercial varieties Kufri Badshah and Kufri Bahar. These three genotypes, however, had significantly higher weight loss than that of Kufri Lalima which had the lowest weight loss in both the years. This genotype x storage period interaction effect showed that for comparing the storability of various hybrids/varieties, the evaluation must be done for different periods of storage. For identifying hybrids/varieties for use as parents in breeding programmes aimed at improving storability, the evaluation must be done for long periods, as the differences in storability become clearer as the period of storage increases.

Weight loss vs. rottage: The data on per cent rottage (averaged over hybrids/varieties) at different periods of storage (Table 2) showed that rottage was nil upto 70 days of storage. Thereafter, rottage started and it was more than 1 per cent in next 30 days and about 10 per cent by another 40 days. Thus after 100 days of storage, rottage is a significant contributor to the per cent weight loss. The correlation coefficients between per cent weight loss and per cent rottage at different periods of storage ranged from 0.71 to 0.89 in 1984 and 0.76 to 0.87 in 1985 for various hybrids/varieties and the population average were 0.79 and 0.82, respectively. This showed that on an average 62 to 67 per cent of variability in per cent weight loss was accounted for by the per cent rottage of tubers.

In conclusion, storability is effected by genotype as well as period of storage. Cumulative weight loss increases almost linearly during storage. Genotype x storage period interactions are important for comparing the storability. Because the genotypes which may have quite different storability after a certain period of storage, may have equal performance for this trait at a shorter period of storage. Tuber rottage is a major contributor to weight loss in potatoes stored without refrigeration for long periods.

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LITERATURE CITED

1. Butchbaker, A.F., W.J. Promersberger and D.C. Nelson. 1973. Weight loss of potatoes as affected by age, temperature, relative humidity and air velocity. *Am. Potato J.* 50: 124-32.
2. Kaul, H.N. and Ashiv Mehta. 1988. Evaluation of passive cooling for storage of potato (*Solanum tuberosum*). *Indian J. Agric. Sci.* 58: 928-31.
3. Mehta, A. and H.N. Kaul. 1989. Differences among potato (*Solanum tuberosum* L.) cultivars in northern-India in performance of diffused light stored seed potatoes. *Potato Res.* 32: 197-202.
4. Mehta, A. and H.N. Kaul. 1987. Storage behaviour of potato cultivars in evaporatively cooled store. *J. Indian Potato Assoc.* 14: 69-71.
5. Schippers, P.A. 1971. The influence of storage conditions on various properties of potatoes. *Am. Potato J.* 48: 234-45.
6. Terman, G.L., G. Michael and C.E. Cunningham. 1950. Effect of storage temperature and size on french fry quality, shrinkage and specific gravity of Maine potatoes. *Am Potato J.* 27: 417-24.
7. Verma, S.C., T.R. Sharma and S.M. Verma. 1974. Effects of extended high temperature storage on weight loss and sugar content of potato tubers. *Indian J. Agri. Sci.* 44: 702-06

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BALANCE SHEET OF NITROGEN, PHOSPHORUS AND POTASSIUM AS INFLUENCED BY IRRIGATION AND FERTILIZER APPLICATION IN POTATO-BASED CROPPING SYSTEMS*

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

ABSTRACT: The balance sheet of nitrogen, phosphorus and potassium was worked out from the potato-based cropping systems' experiments conducted during 1985 to 1987 on Alfisols of South-eastern dry region of Karnataka. Potato-finger millet cropping system removed lower N, higher P and K than potato-groundnut system. Nutrient uptake in both the cropping systems, increased with increase in frequency of irrigation and fetilizer level given to preceding potato crop. The balance sheet of nutrients indicated net gains of total N and K, and a net loss of P in both the potato-based cropping systems.

INTRODUCTION

Profitable potato-based cropping systems require readily available nutrients to maintain yields. The fertility status of soils in cropping systems is likely to go down unless adequate quantities of plant nutrients are added to the soil. In this regard, nutrient balance sheet approach was used to monitor the nutrients in cropping systems (6). Inclusion of legumes in the cropping system was found to decrease net loss of nitrogen (1, 5). Net gain of total soil nitrogen (8) and net loss of available phosphorus (6) was observed in various cropping systems. Studies of Sadanandan and Mahapatra (7) showed that there was a gain in balance sheet of available potassium under all the crop sequences and fertility management practices.

The work on the influence of irrigation and fertilizer application on the balance sheets of nutrients has not been done in potato-based cropping systems on Alfisols of Karnataka. Therefore, the present investigation was undertaken to generate information on the extent to which the crops in potato-based cropping systems would enrich or exhaust the soil in relation to irrigation and fertilizer application.

MATERIALS AND METHODS

The balance sheet of N, P and K in potato-based cropping system was worked out from the field experiments conducted during *rabi* and summer seasons of 1985 to 1987 at the Main Research Station, University of Agricultural Sciences, Bangalore.

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Soil samples from surface 0 to 30 cm were collected before starting experiment as well as after harvest and were analysed for total N, available P and K as per the procedures described by Jackson (2).

The details of irrigation and fertilizer application given to potato-finger millet as well as potato-groundnut cropping systems are indicated in tables 1 and 2. The plant samples were analysed for nutrient content and the uptake was calculated (2). The expected nutrient balance was calculated by substracting the amount of nutrients absorbed by different crops in a cropping system from the initial soil nutrients and the amount of nutrients added in the form of FYM, fertilizers and recycling of potato haulms. Net loss or gains in nutrient was worked out based on the difference in expected and actual balance of nutrients in soil at the end of each cropping system.

RESULTS AND DISCUSSION

Balance sheet of nitrogen: In both the potato-based cropping systems, lower depth of irrigation given at frequent interval resulted in higher N recovery compared to higher depth of irrigation given at less frequent intervals. Total removal of N by potato-finger millet cropping system as well as potato-groundnut cropping system increased with increase in the fertilizer levels given to potato. Total N harvested by potato-groundnut cropping system was higher than potato-finger millet system (Tables 1, 2). Potato-groundnut system may meet its higher requirement of N from soil and biological N-fixation compared to potato-finger millet system which may derive N from soil alone. Similar results were reported earlier by Rao and Sharma (4).

The net gain of total soil N was maximum in the balance sheet of N with lower depth of irrigation given at frequent intervals and the net gain increased with increase in the fertilizer level given to potato in both the cropping systems. When the cropping systems are compared, potato-groundnut system resulted in higher net gain of N (384.7 kg/ha) than potato-finger millet system (64.3 kg/ha). Inclusion of groundnut in the cropping system may decrease the net loss of N. Further, the biological N-fixation and subsequent decomposition of plant roots might have resulted in an increase in total soil N after completion of crop cycles. These results are in agreement with the findings of earlier workers (1, 5, 8).

Balance sheet of phosphorus: Uptake of P by both the potato-based cropping systems was higher in high frequency irrigation with lower depth compared to low frequency irrigation with higher depth. Similar results have been reported by Rami Reddy *et al.* (3). By irrigating finger millet crop at frequent intervals, nutrients and soil moisture interact leading to higher uptake of untrients due to increase in the soil moisture content. It was further observed that the uptake of P by potato-finger millet cropping system as well as potato-groundnut system increased with increase in the

Table 1. Balance sheet of total soil nitrogen, available phosphorus and potassium (kg/ha) in potato-finger millet cropping system during 1985 to 1987

Treatment details		Initial status of total N, available P_2O_5 & K_2O	Addition of nutrients through FYM, potato haulms and fertilizers					Removal of nutrients by crops					Expected balance	Actual balance	Net loss (-) or gain (+)
			1985-86 Potato	1986 Finger millet	1986-87 Potato	1987 Finger millet	Total	1985-86 Potato	1986 Finger millet	1986-87 Potato	1987 Finger millet	Total			
Irrigation schedule (IW/CPE = 0.75)															
D_1 : 20 mm	N	1086.4	200	49.3	200	61.1	510.4	94.5	163.2	64.1	173.4	495.2	1101.6	1209.6	+108.0
	P	30.6	140	3.3	140	7.0	290.3	11.5	42.4	13.4	60.0	127.5	193.5	59.2	-134.3
	K	212.5	200	57.0	200	70.0	527.0	97.0	179.5	126.3	291.1	694.7	44.8	123.0	+78.2
D_2 : 40 mm	N	1086.4	200	26.9	200	56.3	483.2	57.0	162.1	61.2	148.7	429.0	1140.6	1161.2	+20.6
	P	30.6	140	2.1	140	5.4	287.6	6.9	36.6	11.6	52.1	107.3	210.9	45.4	-165.4
	K	212.5	200	37.9	200	60.0	497.9	63.8	167.3	92.2	253.7	577.0	133.4	142.0	+8.6
Fertilizer levels in potato + (N, P_2O_5 & K_2O kg/ha)															
F_1 : 50-50-50	N	1086.4	150	29.3	150	54.9	384.2	74.3	141.7	52.6	129.7	398.3	1072.3	1098.4	+26.1
	P	30.6	90	2.6	90	5.1	264.2	9.1	35.0	10.9	48.6	103.8	191.1	46.2	-144.7
	K	212.5	150	41.2	150	49.1	390.3	77.3	151.2	116.1	217.1	561.7	41.1	131.5	+90.4
F_2 : 100-100-100															
	N	1086.4	200	31.2	200	50.0	481.2	71.8	157.4	64.8	167.8	461.8	1105.8	1160.5	+54.6
	P	30.6	140	2.64	140	6.0	288.7	8.7	38.7	13.2	59.7	120.5	198.8	46.3	-152.5
	K	212.5	200	49.6	200	64.4	514.0	75.5	165.8	97.	291.4	630.6	95.9	137.5	+41.6
F_3 : 150-150-150															
	N	1086.4	250	53.7	250	71.2	624.9	81.1	188.9	70.6	195.7	526.3	1185.0	1297.3	+112.3
	P	30.6	200	2.9	200	7.5	410.4	9.7	44.9	13.3	59.9	127.9	313.1	64.4	-248.7
	K	212.5	250	51.5	250	80.9	412.4	89.7	203.2	113.8	308.7	715.4	-90.5	128.0	+218.5
Mean	N	1086.4	200	38.1	200	58.7	496.8	75.7	162.7	62.7	161.0	462.1	1121.1	1185.4	+64.3
	P	30.6	140	2.7	140	6.2	288.9	9.2	39.5	12.5	56.1	117.4	202.2	52.3	-149.9
	K	212.5	200	47.4	200	64.8	512.2	80.8	173.4	109.3	272.4	635.9	88.8	132.0	+43.2

+ 20 tonnes of FYM was common # Contributed from potato haulm incorporation.

Table 2. Balance sheet of total soil nitrogen, available phosphorus and potassium (kg/ha) in potato-groundnut cropping system during 1985 to 1987

Treatment details		Initial status of total N, available P_2O_5 & K_2O	Addition of nutrients through FYM, potato haulms and fertilizers: 1985-86 Potato	1986 Groundnut	1986-87 Potato	1987 Groundnut	Total	Removal of nutrients by crops: 1985-86 Potato	1986 Groundnut	1986-87 Potato	1987 Groundnut	Total	Expected balance	Actual balance	Net (-) or gain (+)
Irrigation schedule (IW/CPE = 0.75)															
D_1 : 20 mm	N	1086.4	200	49.3	200	61.1	510.4	94.5	396.7	64.1	320.2	875.5	721.3	1198.4	-477.1
	P	30.6	140	3.3	140	7.0	290.3	11.5	33.7	13.4	31.1	89.8	231.1	54.6	-176.5
	K	212.5	200	57.0	200	70.0	527.0	97.8	119.5	126.3	332.7	676.3	63.2	142.0	+78.8
D_2 : 40 mm	N	1086.4	200	26.9	200	56.3	483.2	57.0	352.6	61.2	266.0	736.8	832.8	1120.0	+287.2
	P	30.6	140	2.1	140	5.4	287.6	6.9	30.9	11.6	25.8	75.3	242.9	64.6	-178.3
	K	212.5	200	37.9	200	60.0	497.9	63.8	98.5	92.2	273.7	528.2	182.2	206.4	+24.2
Fertilizer levels in potato + (N P_2O_5 & K_2O kg/ha)															
F_1 : 50-50-50															
	N	1086.4	150	29.3	150	54.9	384.2	74.3	343.1	52.6	278.4	748.4	722.2	1232.0	+509.8
	P	30.6	90	2.65	90	5.1	264.2	9.1	30.2	10.9	26.5	76.9	217.8	56.9	-160.9
	K	212.5	150	41.2	150	49.1	390.3	77.3	98.9	116.1	270.2	562.5	40.3	109.6	+69.3
F_2 : 100-100-100															
	N	1086.4	200	31.2	200	50.0	481.2	71.8	402.9	64.8	304.1	843.6	724.0	1198.4	+474.4
	P	30.6	140	2.6	140	6.0	288.7	8.7	33.8	13.2	30.8	86.7	232.6	59.4	-173.2
	K	212.5	200	49.6	200	64.4	514.0	75.5	111.4	97.9	313.0	597.8	128.7	244.0	+115.3
F_3 : 150-150-150															
	N	1086.4	250	53.7	250	71.2	624.9	81.1	378.0	70.6	296.8	826.5	884.8	1075.2	+190.4
	P	30.6	200	2.9	200	7.5	410.4	9.7	32.8	13.3	28.1	84.1	356.9	62.5	-294.4
	K	212.5	250	51.5	250	80.9	412.4	89.7	116.8	113.8	326.4	646.7	-21.8	169.0	+190.8
Mean	N	1086.4	200	38.1	200	58.7	496.8	75.7	374.6	62.7	290.1	803.1	780.1	1164.8	+384.7
	P	30.6	140	2.73	140	6.2	288.9	9.2	32.3	12.5	28.5	82.5	237.0	59.6	-177.4
	K	212.5	200	47.4	200	64.8	512.2	80.8	109.0	109.3	303.2	602.3	122.4	174.2	+51.8

+ 20 tonnes of FYM was common # Contributed from potato haulm incorporation.

fertilizer level. Removal of P by potato-finger millet cropping system was higher (117.43 kg/ha) than that of potato-groundnut system (82.59 kg/ha) (Tables 1, 2). The higher harvest of P by finger millet in the system may be related to its moisture utilization efficiency from deeper layers i.e., even from 90 cm depth along which nutrients were also taken up.

In the balance sheet, the net loss of P has occured in all the irrigation and fertilizer treatments in both the potato-based cropping systems. This may be attributed to the fixation of available P in sandy loam soils, ultimately resulting in net loss of P in the cropping systems (6, 9).

Therefore, addition of extra P may be advantageous in both the potato-based cropping systems to build up the soil reserves.

Balance sheet of potassium: Irrigation of crops in both the cropping systems with small quantities of water at frequent intervals encouraged the uptake of P. Similar observation was recorded by Rami Reddy *et al.* (3). It was further observed that the uptake of K by potato-finger millet cropping system as well as potato-groundnut system increased with increase in the fertilizer level given to potato. Removal of K by potato-finger millet cropping system (635.9 kg/ha) was higher than that of potato-groundnut system (602.3 kg/ha) (Tables 1, 2). Crops removed more K from soil than that is normally applied through fertilizers, and this may bring about a reduction in K status of a soil. These results corroborate with the findings of Suchdeva (10). The K might have been released from the labile pool and made available for the crops succeeding potato as extra fertilizers were not applied. Hence, high rates of K application are necessary to check further depletion of potash reserve in soil.

The balance sheet of K indicated a gain in K under both the potato-based cropping systems at various levels of irrigation and fertilizer management practices. This may be related to the shifting of dynamic equilibrium of potash in the soil. Similar results were obtained by Sadanandan and Mahapatra (7). When the cropping systems are compared, higher net gain in K was observed in potato-groundnut cropping system (51.8 kg/ha) than potato-finger millet cropping system (43.2 kg/ha). As the K might have been utilized for stiffness of straw in finger millet and hence, there was less gain in K under potato-finger millet system compared to potato-groundnut system.

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LITERATURE CITED

1. Chakravorti, S.P., M.V. Rao and B.K. Mondal. 1980. Effect of fertility levels on yield and N, P and K uptake of few crop sequences. *Oryza* 17: 169-174.

2. Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice.Hall of India Pvt. Ltd., New Delhi.

3. Rami Reddy, S., N. Ramachandra Reddy, R. Veera Raghavaiah and G.H. Sankara Reddi. 1983. Effect of irrigation frequency and nitrogen on NPK uptake and yield of finger millet. *Andhra agric. J.* 31: 16-19.

4. Rao, M.M. and K.C. Sharma. 1978. Balance of soil nitrogen and P as influenced by different cropping sequence and fertlizer constraints. *J. Indian Soc. Soil Sci.* 26: 44-48.

5. Sadanandan, M. and I.C. Mahapatra. 1973a. Studies on multiple cropping-balance sheet of N in various cropping patterns. *Indian J. Agron.* 18: 323-27.

6. Sadanandan, N. and I.C. Mahapatra. 1973b. Studies on multiple cropping-balance sheet of total and available phosphorus in various cropping patterns. *Indian J. Agron.* 18: 459-63.

7. Sadanandan, N. and I.C. Mahapatra. 1976. Study of the change in exchangeable potassium in soil due to multiple cropping in upland rice areas. *Indian J. Agron.* 21: 405-7.

8. Sharma, K.N., D.S. Rana, M.K. Kapur and A.L. Bhandari. 1987. Crop yield and nutrient uptake under different multiple-cropping sequences. *Indian J. Agric. Sci.* 57 : 250-55.

9. Sharma, U.C. and B.R. Arora. 1988. Residual effect of applied nitrogen, phosphorus and potassium on potato on the soil properties. *J. Indian Soc. Soil Sci.* 36: 106-12.

10. Suchdeva, P.D. 1973. Genetic, geochemistry and clay minerology of the soil series of Punjab. M.Sc. *Thesis*, PAU, Ludhiana.

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ELISA FOR DETECTION OF VIRUSES FOR SEED POTATO PRODUCTION*

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ABSTRACT: Enzyme-linked Immunosorbent Assay (ELISA) was employed on large scale for potato tuber indexing in India for the first time and its efficacy was compared with chloroplast agglutination test for detection of potato viruses PVX, PVY and PVS. Seven thousand three hundred thirty five tubers of seven potato cultivars from three seed producing regions were indexed. ELISA was superior to chloroplast agglutination test by 1.9 times (97.2%), 5.4 times (436.5%) and 3.6 times (264.4%) for detection of PVX, PVY and PVS, respectively. The incidence of PVX, PVY and PVS ranged 3.4 to 20.0; 1.2 to 13.3 and 29.5 to 92.0%, respectively in different cultivars. The total incidence of these viruses was less in cultivars Kufri Badshah and Kufri Jyoti as compared with Kufri Lalima, Kufri Chandramukhi, Kufri Sindhuri, Kufri Lauvkar and Gulmarg Special. The incidence was higher in the tubers collected from Patna (97.6%) followed by Gwalior (72.4%) and Jalandhar (71.0%).

INTRODUCTION

Potato viruses, X (PVX), Y (PVY) and S (PVS) are widespread in commercial stocks of potato causing 10-50% yield losses in different cultivars (5, 8). In most cultivars the infection of these viruses is latent (without foliage symptoms). Therefore, a most reliable method for virus detection is essential to select virus free seed tubers for potato production. The present study was aimed at comparing the efficacy of chloroplast agglutination test with Enzyme-linked Immunosorbent Assay (ELISA) for detection of potato viruses and for determining the virus incidence in potato cultivars grown in different agroclimatic regions.

MATERIALS AND METHODS

The tubers were collected from seed crop at three locations namely Jalandhar, Patna and Gwalior representing North-western, North-eastern and central plains, respectively. The cultivars and the number of tubers selected and indexed are given in table 1. Each tuber was marked with individual index number. Single eyes from crown end of each tuber were scooped and planted individually in earthen pots (15 cm dia) in glasshouse at Shimla during March and July 1987. After 5 to 6 weeks of plant emergence, leaf samples from all the plants were tested separately for detection of PVX, Y and S by ELISA (1) and chloroplast agglutination (13).

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'ELISA Kits' containing antibodies for PVX, Y and S and their conjugates, sample conjugate and wash buffer concentrates and polysterene microtitre plates were obtained from M/S Boehringer Mannheim, West Germany. Assays were performed at room temperature (18-25°C). The incubation of antibody coating solution and anti-body-AP-conjugate solution was done at 37°C for 2 and 4 hr, respectively and that of leaf sap at 4°C for overnight. The plates were evaluated visually half an hour after adding the substrate solution.

RESULTS

Comparison of virus detection by ELISA and chloroplast agglutination tests: The incidence of PVX and PVY was 7.2 and 2.8% with ELISA as against 3.6 and 0.5% by agglutination test. PVS incidence was 60.1% with ELISA as compared with 16.5% by agglutination test (Table 2). The results thus show that ELISA testing is superior to agglutination test by 97.2% for PVX, 436.5% for PVY and 264.4% for PVS.

Incidence of viruses in different cultivars: The mean per cent incidence of PVX, PVY and PVS in the 7 cultivars was 7.2, 2.8 and 60.1, respectively (Table 3). Thus the incidence of PVY was the least in these cultivars, except Gulmarg Special which showed high incidence (13.3%) of PVY. The PVX was minimum (3.4%) in Kufri Badshah and maximum (20.0%) in Gulmarg Special. PVS was the highest in almost

Table 1. Cultivar and number of tubers collected from various locations

Cultivar	No. of tubers from			Total
	Jalandhar	Patna	Gwalior	
Kufri Chandramukhi	1900	400	912	3212
Kufri Jyoti	1332	199	300	1831
Kufri Sindhuri	360	388	296	1044
Kufri Badshah	596	-	-	596
Kufri Lauvkar	-	-	392	392
Kufri Lalima	-	200	-	200
Gulmarg Special	60	-	-	60
Total	4248	1187	1900	7335

Table 2. Comparison of virus detection by ELISA and chloroplast agglutination

Test	% Virus incidence*		
	PVX	PVY	PVS
ELISA	7.16	2.79	60.12
Chloroplast agglutination	3.63	0.52	16.50
% increase in detection by ELISA	97.2	436.5	264.4

* based on testing of 7335 tubers of 7 cultivars.

all the cultivars, minimum (26.66%) being in Kufri Jyoti and maximum (92.0%) in Kufri Lalima.

Table 3. Incidence of potato viruses X, Y and S in tubers of different cultivars detected by ELISA

Cultivar	No. of tubers	% Tubers infected with				Total	% Healthy tubers
		PVX	PVY	PVS	(PVS+X and/orY)		
Kufri Chandramukhi	3212	5.73	1.37	81.94	(4.61)	88.04	11.96
Kufri Jyoti	1831	6.06	5.95	26.66	(6.22)	38.67	61.33
Kufri Sindhuri	1044	11.69	1.15	69.54	(11.68)	82.38	17.62
Kufri Badshah	596	3.36	2.68	29.53	(1.34)	35.57	64.43
Kufri Lauvkar	392	17.35	2.04	46.94	(9.18)	66.33	33.67
Kufri Lalima	200	4.00	4.00	92.00	(8.00)	100.00	0.0
Gulmarg Special	60	20.00	13.33	33.33	(0.0)	66.67	33.33
* Mean		7.16	2.79	60.12	(6.05)	69.63	30.37

* Weighted mean; weights being number of tubers.

The mixed virus infection (PVS+X and/or Y) was 11.6% in Kufri Sindhuri while Gulmarg Special was free from such infections. Among the cultivars, the total incidence of the viruses was minimum (35.5%) in Kufri Badshah followed by Kufri Jyoti (38.6%), Kufri Lauvkar (66.3%), Gulmarg Special (66.6%), Kufri Sindhuri (82.3%), Kufri Chandramukhi (88.0%) and Kufri Lalima (100%). Three cultivars viz., Kufri Jyoti, Kufri Sindhuri and Kufri Chandramukhi were common to three locations and Kufri Jyoti consistantly had low virus incidence (1.0-45.7%) in tubers from all the three locations (Table 4).

Table 4. Incidence of viruses in tubers of 3 potato cultivars from 3 locations during 1987

Location	% Incidence in								
	Kufri Chandramukhi			Kufri Jyoti			Kufri Sindhuri		
	PVX	PVY	PVS	PVX	PVY	PVS	PVX	PVY	PVS
Jalandhar	1.47	0.63	100.00	4.42	7.38	33.25	2.22	1.11	57.77
Patna	3.00	1.00	100.00	1.00	2.01	45.72	6.18	0.0	100.00
Gwalior	15.78	3.07	49.12	10.66	2.66	22.66	31.08	2.70	85.13

Incidence of viruses in different agroclimatic regions: The minimum (2.9%) incidence of PVX was at Jalandhar followed by Patna (5.3%) and Gwalior (17.6%). However, the incidence of PVY was minimum (1.3%) at Patna followed by Gwalior (2.7%) and Jalandhar (3.2%). In contrast to the above, the minimum (52.0%) incidence of PVS was at Gwalior followed by Jalandhar (64.8%) and Patna (90.9%). The total incidence of these viruses however, was higher at Patna (97.6%) as compared to Jalandhar and Gwalior (71.0-72.4%) (Table 5).

Table 5. Locationwise average incidence of viruses

Location	No. of tubers	% Incidence of virus			
		PVX	PVY	PVS	Total
Jalandhar	4248	2.99	3.25	64.85	71.07
Patna	1187	5.39	1.35	90.90	97.64
Gwalior	1900	17.68	2.74	52.00	72.42

Chi-Square test showed significant (at 1%) difference among the locations in respect of the incidence of individual and total viruses.

DISCUSSION

Chloroplast agglutination test for detection of potato viruses is frequently used for its simplicity and quickness to perform. The comparison of this test with ELISA, revealed that ELISA was 1.97 to 5.4 times more sensitive particularly when the virus concentration in the plant was low (1, 4, 7, 10). Application of ELISA therefore, can improve health standards of potato seed (7, 11). The present study also revealed a wide range of variation in incidence of different viruses among the cultivars. This may be due to differences in susceptibility of individual cultivars to different viruses (2, 6, 11, 12). Kufri Jyoti and Kufri Badshah registered the least incidence of contagious viruses PVX and PVS which may be due to their low virus susceptibility (14). PVS is highly contagious (3) and its infection remains latent in almost all the cultivars, hence spreads rapidly in the field (2, 12). Most of the strains/mutants of PVY and PVX causing visible symptoms are eliminated in field inspection by roguing the infected plants. In the agglutination test, leaf sap of PVX, bu not PVY infected plants agglutinates rapidly. Also, aggregates of the floculation of PVX is large and readily visible while those of PVS are minute (13) and difficult to discern. de Bokx (2) and Scholz (9) showed that an initial PVS infection increases rapidly during growing season. These facts explain the reasons for higher incidence of PVS and low incidence of PVY observed by us. The higher average incidence of PVY in the Jalandhar region may be due to the cultivar Gulmarg Special which exhibited maximum infection of this virus.

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LITERATURE CITED

Clark, M.F. and A.N. Adams. 1977. Characteristics of the microplate method of enzyme-linked immunosorbent assay for detection of plant viruses. *J. Gen. Virol.* 34: 475-83.

2. de Bokx, J.A. 1972. Spread of Potato virus S. *Potato Res.* 15: 67-70.

3. de Bokx, J.A. 1972. Graft and mechanical transmission. *In : Viruses of Potatoes and Seed-Potato Production.* (J.A. de Bokx, Ed.) pp 26-35.

4. Khurana, S.M. Paul. 1990. Modern approaches for detection and management of potato virus and viroides. *In : Current Facets in Potato Research* (J.S. Grewal *et al*, Eds.) IPA, CPRI, Shimla, pp. 98-108.

5. Khurana, S.M. Paul. 1992. Potato Viruses and Viral Diseases. *CPRI Tech. Bull No.* 35, 23 pp.

6. Mackinnon, J.P. and R.M. Bagnall. 1972. Use of *Nicotiana debneyi* to detect viruses S, X and Y in potato seed stocks and relative susceptibility of six common varieties to potato virus S. *Potato Res.* 15: 81-85.

7. Moran, J.R., R.G. Garrett and J.V. Fairweather. 1983. Strategy for detecting low levels of potato viruses X and S in crops and its application to the Victoria certified seed potato scheme. *Plant Dis.* 67: 1325-27.

8. Nagaich, B.B., G.S. Shekhawat, S.M. Paul Khurana and S.K. Bhattacharyya. 1974. Pathological problems of the potato cultivation in India. *J. Indian Potato Assoc.* 1: 32-44.

9. Scholz, M. 1962. Die Bedeutung des S-virus fur den Kartoffelbau und probleme der S-Virussanierung. *Nachr Bl. dt. Pflschutzdienst* (Braunschweig) 8: 174-79.

10. Singh, Sarjeet., G.C. Upreti., V.P. Bhardwaj., K.S. Vashisth., A.K. Verma., V.K. Garg and M.K. Dhingra. 1984. Effect of temperature and physiological age of the tubers on detection of potato viruses X and S. *J. Indian Potato Assoc.* 11: 12-19.

11. Tavantzis, S.M. and S.G. Southard. 1983. Incidence of potato virus X in foundation and certified seed of seven cultivars. *Plant Dis.* 67: 959-61.

12. Upreti, G.C., V.P. Bhardwaj, V.K. Garg and Sarjeet Singh. 1979. Natural spread of contagious viruses PVX and PVS in some potato varieties during nucleus seed production. *J. Indian Potato Assoc.* 6: 66-69.

13. Van Slogteren, D.H.M. 1972. Serology. *In : Viruses of Potatoes and Seed-Potato Production* (J.A. de Bokx, Ed.), pp. 87-101.

14. Vashisth, K.S., A.K. Verma, I.P. Chaubey and B.B. Nagaich. 1981. Comparative degenerative effect of viral and MLO-diseases during autumn and spring season on Indian potato varieties in Punjab. *Seeds & Farms* 7(10): 25-28.

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CHANGING SCENARIO OF POTATO DISEASES IN INDIA

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INTRODUCTION

Ever since the introduction of potato in India some time in the end of 18th century (53), it has reached all nook and corner of the country. Druing the course of its introduction and subsequent spread, it has experienced/ acclamatised and adapted to a wide range of agroclimatic conditions in the country (37). This had not only brought about selection of suitable genotypes in different regions but also had immense effect on the pattern of diseases affecting the crop. Besides natural selection and adaptation, the crop had also been subjected to scientific manipulations atleast for the last serveral decades. More than two dozen high yielding varieties have been bred by CPRI replacing old ones (27) and also improved methods of its agronomy like use of optimum rate and size of seed; date and time of planting; chemical fertilizers; fungicides and insecticides have been adopted for replacing the traditional methods. Although, these changes in varietal pattern and crop husbandry were mainly aimed at increasing the over all potato production in the country, they also had a non-targetted effect on the ecology, especially flora and fauna of the soil, thereby bringing about a shift in the population of several pathogens and ultimately the diseases. This article is an effort to summarise the impact of such a diversification, over the recent times, in agriculture on potato diseases.

NEW VARIETIES

Introduction of new high yielding varieties certainly affected the pattern of major potato diseases in the country. To illustrate, pink rot caused by *Phytophthora erythroseptica* (*Syn. P. himalayensis*) was recorded in Shimla hills way back in 1948 (16). However, it remained below detectable limits till 1978 when Rai (38) again observed it.

Since then, it had come to not only manifest in Shimla hills (14, 15) but also in some other areas (32). Roy *et al* (39) tried to explain the reasons for outbreak of pink rot in Shimla hills. In early fifties and sixties, var. Up-to-Date was the most dominant one in the region. Since this cultivar is highly susceptible to late blight, *P. infestans*

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apparently did not allow development of *P. erythroseptica* (58, Table 1). Since the introduction of cv. Kufri Jyoti in early seventies, *P. erythroseptica* might have multiplied on Kufri Jyoti tubers unhindered without much competition from *P. infestans* as the tubers of cv. Kufri Jyoti was then highly resistant to *P. infestans* and has continued so till mid eighties.

Table 1. Varietal pattern in relation to pink rot infection

Year	Variety	% Pink rot
Upto 1970	Up-to-Date, Desiree, etc.	0.0
1971-1976	Kufri Jyoti	0.0
1977	-do-	0-10
1987	-do-	4-6.2
1990	-do-	0.6-10

Replacement of Up-to-Date by cv. Kufri Jyoti had also brought about a change in the severity of late blight (Table 13) and leaf spots. Till 1975, late blight followed by early blight were two major foliar diseases. But cv. Kufri Jyoti, introduced in early seventies, proved highly susceptible to *Phoma* and *Alternaria* spp. Within a period of five years these pathogens led to the out break of a new disease complex, the 'leafspots'. (Table 2; 34). Today, this disease (leafspots) has become important over early blight (11, 12, 47). Similary, appearance and buildup of late blight disease has also been affected by the introduction of cv. Kufri Jyoti. This has happened throughout the country wherever this variety was introduced (4, 9, 10, 13). Prior to cv. Kufri Jyoti, varieties with no R-genes were grown and expectedly only simple races (0, 4, 1) of *P. Infestans* were prevalent (3). Introduction of cv. Kufri Jyoti which possess R_3, R_4, and R_7 resistance genes put selection pressure on late light pathogen to overcome this barrier which led to development of newer races having virulence to resistance genes R_3, R_4 and R_7, and/or their combinations. Later, more complex races also developed during the course of time. As a result, now 9-10 gene complex races are most prevalent in all the hilly regions (5, Table 3). Development of compatible races in *P. infestans* to resistance genes in cv. Kufri Jyoti changed the entire spectrum of late blight disease. Cultivar Kufri Jyoti, which was field immune to late blight upto 1974 turned totally susceptible. The process of break down of resistance in cv. Kufri Jyoti began as early as 1975 in Shimla hills and even earlier, in North-eastern hills

Table 2. Varietal pattern in relation to fungal leaf spots in Himachal Pradesh

Year	Variety	% Leaf spots
1955-1970	Up-to-Date	Nil
1976	Kufri Jyoti	5-75
1980	-do-	10-50
1985	-do-	5-40
1990	-do-	5-745

and by 1985 it was registered highly susceptible. At one time, losses due to late blight in cv. Kufri Jyoti were negligible (1%) in hills but now with break down of its resistance the losses again had gone up and by 1990 they were recorded to the tune of 81% (14, Table 4).

Table 3. Potato varietal pattern in relation to variability in *P. infestans*

Year	Cultivar	Races
1965	Up-to-Date	'0'
1967	-do-	2 gene complex
1970	-do-	3 " "
1975	Kufri Jyoti	4-6 " "
1980	-do-	4-8 " "
1985	-do-	7-8 " "
1990	-do-	9-10 " "

Wart disease of potato was for the first time observed in Darjeeling district of West Bengal in 1953 (18). It was again observed in 1957 (25). Since then, it has spread to most parts of Darjeeling district. The reason for its wide spread had been the cultivation of wart susceptible varieties like DRR, White long, White Round and 'Kala Alu'. Therefore, a scheme "Saturation of wart affected areas with wart immune varieties" was enforced by the West Bengal Govt. However, only during 1960-1961, cv. Pimpernel was adopted on small scale. Cultivar Kufri Jyoti having immunity to wart and also high level of late blight resistance became popular with the farmers alongwith other wart immune cultivars which covered about 80% of the area under potato in 1985 (33). In 1958, the disease incidence ranged between 5-75% in majority of potato growing blocks and the areas infested was 40%. In 1985, the disease incidence was 5.2-44.7% in plants and 12.1-43.5% in tubers and the infested area was 28%. This shows that an increase in the cultivation of wart immune varieties brought down both the disease incidence and the infested area. It is hoped that situation will further improve by introduction of cv. Kufri Kanchan that may replace DRR in near future.

Table 4. Potato late blight in H.P. : Varietal pattern & yield losses

Year	Variety	Losses
1955	Up-to-Date	21
1965	-do-	40
1973	-do-	72
1974	Kufri Jyoti	0.1
1980	-do-	10
1985	-do-*	40
1990	-do-*	85

*Field resistance broken down by complex races ('3,4, 7' gene combinations).

CROP HUSBANDARY METHODS

Crop husbandary methods like crop rotation, green manuring and use of chemical fertilizers have also brought about significant changes in the disease scenario. In late seventies, the common scab incidence went upto serious proportion (24) threatening the seed production in western Uttar Pradesh. Researches have shown that two years rotation of burseem (*Trifolium*)-*bajra* (Pearl millet) brings down the level of scab significantly over fallow and continuous potato cultivation (Table 5). Other crop sequences like wheat-rice and mustard-*mung*-sunhemp (Table 5) also kept the disease in check (45). Several soil and tuber borne diseases are the result of continuous cultivation of potato without following any crop rotation. Lahoul & Spiti is one such area where potato is being grown year after year since late sixties. This has led to spread of serious diseases like common scab and *Verticillium* wilt endangering seed potato industry in the valley (44).

Table 5. Effect of crop rotations on potato common scab

Rotation	Mean scab intensity
Wheat-Rice	6.5
Burseem-*Bajra*	5.5
Mustard-*Mung*-Sunhemp	6.1
Control-Fallow	6.3
Continuous potato cultivation	10.0

Crop rotations have a more telling effect on bacterial wilt (15, 41). If potato crop is grown continuously for 3 years in an infested field, the wilt incidence increases by 92%. Conversely, if finger millet is grown for two years preceding to the potato crop the incidence of wilt is reduced almost by 75-80%. Other crops which reduce the wilt incidence include wheat, maize and paddy (Table 6). Besides crop rotation, other cultural practices also play an important role in bacterial wilt management. Use of healthy seed reduces the wilt over 50% (Table 14), use of bleaching powder + blind earthing up by 70-90%, summer ploughing in hills by 50-80% and 60-75% respectively and early planting in hills by 77-80% (40, 41, 57). Use of above cultural practices has brightened the future of potato cultivation in North-western and North-eastern hills which otherwise looked very bleak.

Table 6. Effect of cropping sequences on wilt incidence and yield loss of potato*

Sequence	Av. wilt incidence		Yield loss
	1987	1990	1990
Potato-potato-potato-potato	26.9	51.7 (+92)	56.9
Potato-beans-beans-potato	26.3	19.7 (-25)	18.3
Potato-paddy-paddy-potato	25.5	12.0 (-53)	29.7
Potato-wheat-wheat-potato	25.3	9.2 (-63)	18.8
Potato-maize-maize-potato	25.7	8.7 (-66)	13.1
Potato-finger millet-finger millet-potato	24.8	44.7 (-81)	07.1

*CPRI Ann. Sci. Rept. 1990-91, and Shekhawat *et al.* 1988, 1992 (41, 42).

Use of FYM was common practice for growing potatoes. FYM favours black scurf pathogen (*Rhizoctonia solani*) and consequently its application led to an over all increase in the incidence of black scurf. However, increasing acreage under potato cultivation put pressure on FYM which fell short of demand. Green manures were advised as a substitute to FYM which farmers, particularly in Punjab, Haryana and western Uttar Pradesh adopted quickly. This fortunately led to the reduction in black scurf incidence (Table 7). Field experiments carried out by Sikka *et al* (43) and Bhattacharyya *et al* (2) proved that green manures like maize and sunhemp suppressed the growth of *R. solani* (Table 7). Sikka *et al* (43) were able to reduce black scurf incidence to negligible level by employing an IPM encompassing green manures, summer ploughing and treatment of seed potatoes with mercurial compounds.

Table 7. Reduction in potato black scurf incidence due to green manuring

Variety	Green manure		
	Maize	Sunhemp	Control (fallow)
Up-to-Date	11.3	14.6	18.0
Kufri Red	8.3	12.1	12.5
Kufri Kuber	17.9	20.6	23.7
Kufri Sindhuri	3.6	8.2	11.9

CHEMICALS

Common scab got introduced in the plains in 1958 (31) but was not a serious problem till early seventies. During this period, black scurf continued to be the most important soil and tuber borne potato disease. Treatment of seed tubers with organo-mercurials (viz. Agallol, Aretan, Emisan etc., @ 0.5% for 10 minutes*), was recommended and used extensively. Though this helped in effectively reducing the black scurf incidence, it could not check common scab. May be the dipping was not enough to kill the scab pathogen. Consequently, common scab continued to buildup unabated in the newly released cultivars which were prone to the disease more than the old ones (8). Therefore, to combat its buildup, the duration of seed treatment of tubers was increased to 30 min (28). Keeping in view the hazards in use of OMC and also the likely ban on their use, search for a safer alternative was initiated. Recently, boric acid (3%) was found as good as organo-mercurial compounds (1, 48, Table 8).

CHEMICAL FERTILIZERS

Introduction of high yielding varieties has brought about substantial increase in the composition of chemical fertilizers including nitrogenous fertilizers. Most of the farmers in Punjab, Haryana and western Uttar Pradesh use nitrogen doses ranging

*Commercially available OMC in market.

between 150-200 kg/ha. Such a practice of applying high doses of N reduced the severity of leaf spots caused by *Phoma* and *Alternaria* spp. to a negligible limit (47. Table 9). In fact, use of recommended doses of N (150 kg/ha) supplemented by one or two sprays of urea (2%) has been recommended for the management of leafspots (40). Application of fertilizers like ammonium sulphate reduces the incidence of common scab mainly by lowering down the soil pH. Its use has been reduced over the years mainly because of cost factor and it has been replaced by fertilizers like urea and CAN. This might be one of the factors responsible for flaring up of common scab infection in the plains.

Table 8. Effect of seed treatment on soil & tuber borne diseases

Chemicals		% Disease incidence Black scurf	Common scab	Dry rot
OMC (0.5%)	30 min. dip	4.2	12.5	3.1
Boric Acid (3%)	-do-	3.8	12.7	2.8
Acetic acid (1%) + Zinc sulphate (0.05%	15 min.	8.4	-	-
Control (infected tubers)		97.0	38 0	-
Control (healthy tubers)		9.5	10.2	8.6

- Data not available.

Table 9. Effect of nitrogen levels on potato leaf spot incidence**

N kg/ha*	% leaf spots
0	28.8
50	20.7
100	14.8
150	11.8
200	10.5

* Normal doses of PK for the crop. **Mainly *Phoma* spp. and *Alternaria* spp.

STORAGE CONDITIONS

Prior to the commissioning of cold stores, storage rots had a lion's share in crop losses caused by diseases. In some of the varieties, losses were to the tune of 49% (26). Mainly, soft rot, wet rot and dry rot were involved. However, advent of cold stores has changed the entire scenario of storage rots. At present, losses in the cold stores do not exceed beyond 2% in cured and healthy potatoes. (46, Table 10.) On the other hand, cold stores have assured the survival of *Phytophthora infestans* in seed potatoes (35) which has resulted in frequent late blight epiphytotics as compared to earlier period when tubers were stored in the country stores.

Table 10. Impact of cc..l stores on potato rottage

Tuber condition	% Rottage	
	Country stores	Cold stores
Cured (healthy)	13	0.2
Uncured (healthy)	22	3
Injured (cut/bruised)	40	5

CULTIVATION PRACTICES

Until early seventies, charcoal rot was a serious disease in eastern India with disease incidence being as high as 100 per cent (30, 36, 52). However, its incidence has since come down to 2-3% at harvest (14). This has mainly happened due to change in the cultivation practices in that region. Earlier, two crops (Oct-Jan., Dec-March) were grown in Bihar. The charcoal rot incidence was usually high in the second crop due to delayed harvesting say in March (Table 11). At present only one crop (Oct/Nov.-Jan/Feb.) is grown which has advanced the harvesting date by several to many weeks. This has resulted in steep decline of charcoal rot in eastern India.

Table 11. Potato* charcoal rot incidence in relation to time of harvest at Patna

Harvest date	% Infection
Feb. 16	11
24	21
March 3	20
11	25
18	36
24	39
31	39
April 7	73
15	78

* Var. Darjeeling Red Round.

Like charcoal rot, formation of *Rhizoctonia solani* sclerotia on tuber surface gets aggravated at high temperature (6, 7). This may be the reason for higher incidence of black scruf infection in spring crop (Table 12). However, with the discontinuation of spring crop in most of the regions, the black scurf incidence has also come down.

NEW TECHNIQUES/CULTIVARS AND VIRAL DISEASES

Virus incidence in the hills and plains of India varied from locality to locality but was extremely high (upto 100%) in most areas in the 40's. It varied from 6 to 93% in Kumaon hills, 11 to 21% in Kangra hills and 12 to 41% in Shimla hills. In the plains

Table 12. Effect of harvest date on black scurf incidence

Variety	Harvest date/infection		
	30th Jan	16th Feb.	5th April
Up-to-Date	0.0	4.4	10.0
Kufri Red	0.7	0.7	-
Kufri Kuber	6.7	2.2	15.0
Kufri Safed	2.6	4.0	-
'Phulwa'	0.1	0.4	5

Table 13. Varietal pattern in relation to potato late blight

Year	Variety	% Losses
1955	Up-to-Date	21
1965	-do-	40
1973	-do-	72
1974	Kufri Jyoti	0.1
1980	-do-	10
1985 a, b	-do-	40
1990 a, b	-do-	85
1991-92*		

a- Kufri Megha for Meghalaya (released by State)
b- Kufri Kanchan for Darjeeling (-do-)
*EB/A-304; QB/A 9-120 for H.P. hills; JH-222 and JI-5857 for N.I. Plains and D79-56 for Ooty are in pipeline.

Table 14. Control of bacterial wilt/brown rot through healthy seed

Treatment	% Reduction		%
	Wilt	Rot	Yield increase
Healthy seed (HS)	50-76	40-46	18-27
HS+SBP* 12 Kg/ha+blind earthing up	70-94	50-85	22-28
HS+summer ploughing (plains)	50-83	50-70	05-25
HS+winter ploughing (hills)	60-75	62-78	35-40
HS+early planting (hills)	77-80	75-85	44-68

* Stable Bleaching powder

the condition was still bad. For example, the total virus incidence varied between 7 to 75% in Bihar, 53 to 72% in UP, 11 to 88% in Punjab and 64 to 94% in West Bengal (56). Recent countrywide surveys revealed that the incidence of mild, severe mosaics and leafroll was lower and varied greatly depending on the location, cultivars as well as the season (20, 55). Present day cultivars possess resistance to several potato viruses to a varying extent (Table 15). This has been due to the advent of seed production system and availability of new virus-tolerant varieties for cultivation in different parts of India. The virus incidence has gone down to negligible level at most locations in UP, Punjab, Rajasthan, Gujarat and Haryana in main seed crop but it may be slightly higher (5-12%) in certain areas with higher vector activity, especially in spring season and still higher (70-90%) in the areas where vector-free periods are

Table 15. Virus resistance in Indian potato cultivars

Virus	Cultivar[c]
PVS	Kufri Jyoti[T], Kufri Megha[R]
PVX	Kufri Jyoti[R], Kufri Sindhuri[T]
	Kufri Megha[R], Kufri Kanchan[R]
PVY	Kufri Jyoti[R]/Kufri Sindhuri[T]
PLRV	Kufri Jyoti[T], Kufri Bahar[E(?)]

[c]Susceptible to PVX, S & Y - Kufri Chandramukhi, Kufri Lauvkar and Kufri Lalima, Kufri Bahar.
T - Tolerant, R - Resistant, E - Escape.

Table 16. Varieties associated with different types of potato mosaics (23)

Symptoms	Cultivar/Hybrid	Potato virus					
		X	S	Y^o	Y^N	A	M
Severe mosaic	Desiree		0	2	5	5	5
	Kufri Jyoti	9	9	4	0	6	-
Severe mosaic with	A-73	5	9	7	0	0	-
green blisters and	D-6	1	2	5	0	0	-
necrotic spots	LT-2	0	3	6	0	0	-
Mosaic	B-15	8	1	4	0	0	-
	EB/A-304	8	1	0	0	0	-
	Kufri Jyoti	3	0	1	0	0	0
Mild mosaic/mottle	B-15	3	9	7	0	0	0
	LT-2	5	2	8	0	0	0
	Kufri Jyoti	8	4	1	0	0	0
	EB/A-304	6	1	0	0	0	0
Yellowing with mild rugosity and necrotic flecks.	Desiree	5	8	4	0	0	0
Stipple streak	Kufri Bahar	1	1	6	0	6	0
Veinal necrosis with blighting of stem and leaves	LT-2	2	8	7	0	0	0
Marginal chlorosis, wavy leaflets	Kufri Jyoti	8	7	2	0	0	6
Highly wavy leaflets	DTO-28	3	8	7	0	0	0

-= not tested; 0 = no virion seen; 1 = 0.2, 2 = 0.4, 3 = 0.8, 4 = 1.6; 5 = 3.2; 6 = 7.4; 8 = 14.8; and 9 = 29.6 virions/screen (5 x 4 cm) at 21,000.

not available, e.g. in western Maharashtra (Rajgurunagar) (19) or where the seed is not frequently changed (17, 20). Lowest incidence was observed in the central and eastern UP, Punjab and J&K while maximum incidence was recorded in *Tarai* (Pantnagar, UP) followed by that of Meghalaya, MP and West Bengal.

In old varieties, like Phulwa, DRR, Gola, Majestic, President and Up-to-Date, higher yield losses to the tune of 70-90% were observed due to rugose/severe mosaics and leafroll and upto 50% due to mild mosaics (56). In present day commercial varieties, like Kufri Chandramukhi, Kufri Jyoti and Kufri Sindhuri, yield losses due to mild/faint mosaics vary from 10 to 50% but their over all incidence normally remains low (21). Similarly, the incidence of PVY and PLRV, usally do not exceed beyond 16% and 3%, respectively, and the yield losses also do not exceed 25% (22, 49, 50).

In the past, farmers used to store their seed potatoes in the country stores in the plains. This led to inactivation of PLRV and the crop raised from this seed was free from PLRV infection (51). Nagaich and Upreti (29) found that six weeks incubation of tubers at 40°C for 2 hours daily inactivated the virus. Later on, inactivation of PLRV became possible with exposing cut-tubers to hot water (55°C) for 15-20 min (54) but affecting germination to some extent.

CONCLUSIONS

Adoption, domestication and subsequent scientific manipulation of the various crop plants has been the hall mark of the modern day agriculture. This has been done world over, including India, with a view to meeting the food requirement of the ever increasing population. In the process of achieving this objective, most of the food and vegetable crops have been subjected to scientific manipulations. Newer varieties with better yield potential, having pest and disease resistance have been bred; age old methods of raising crops have been replaced by new scientific methods including optimum seed rate, size and spacing; planting /harvesting time, use of chemical fertilizers as well as plant protection measures and better storage conditions for safe and long storage. All these changes have affected the ecology, especially flora and fauna of the soils. This change in turn had a far reaching effect on the soil 'health' as well as the crop health. Some changes brought about an adverse effect on certain (specific) diseases whereas others were responsible for their flaring up. An over view of the disease situation in the country vis-a-vis changes that have occurred in the potato cultivation over the years, indicated that the improved methods introduced for boosting the crop production, also had some negative effects. Therefore, it is imperative to conduct followup studies/measures consequent to introduction of the new innovations made for use in crop. The feed back thus received will certainly be helpful in safeguarding against the negative aspects of newer technologies well in time.

LITERATURE CITED

1. AICPIP. 1987. *Sixteenth Progress Report*. All India Coordinated Potato Improvement Project, CPRI, Shimla, pp 69.
2. Bhattacharyya, S.K., V.K. Bahal and B.S. Bist. 1977. Effect of crop rotation on potato black scurf incidence. *J. Indian Potato Assoc.* 4: 1-4.
3. Bhattacharyya, S.K., S.G. Phadtare and R.N. Khanna. 1984. Races of *Phytophthora infestans* recorded in India. In : KK Nambiar (Ed). *Proceedings of Workshop on Phytophthora Diseases of Tropical Cultivated Plants*. CPCRI, Kasargod, Kerala, pp. 148-53.
4. Bhattacharyya, S.K., G.S. Shekhawat and B.P. Singh. 1990a. Potato Late Blight. Tech. Bull. No. 27. CPRI, Shimla HP, 46 pp.
5. Bhattacharyya, S.K., B.P. Singh., V.C. Sharma and O.M. Bombawale. 1990b. Mode of survival and sources of primary inoculum of late blight of potato. *Int J. Tropical Plant Diseases* 8: 79-88.
6. CPRI. 1958-60. *Ann. Sci. Rept.* Central Potato Research Institute, Shimla, pp. 94-101.
7. CPRI. 1963. *Ann. Sci. Rept.* Central Potato Research Institute, Shimla, pp. 65-68.
8. CPRI. 1965. *Ann. Sci. Rept.* Central Potato Research Institute, Shimla, pp 63-64
9. CPRI. 1974. *Ann. Sci. Rept.* Central Potato Research Institute, Shimla, pp 63-64.
10. CPRI. 1981. *Ann. Sci. Rept.* Central Potato Research Institute, Shimla, pp 61-64.
11. CPRI. 1982. *Ann. Sci. Rept.* Central Potato Research Institute, Shimla, pp 89-90.
12. CPRI. 1983. *Ann. Sci. Rept.* Central Potato Research Institute, Shimla, pp 89-90.
13. CPRI. 1986. *Ann. Sci. Rept.* Central Potato Research Institute, Shimla, pp 91-97
14. CPRI. 1989-90. *Ann. Sci. Rept.* Central Potato Research Institute, Shimla, 68 pp.
15. CPRI. 1990-91. *Ann. Sci. Rept.* Central Potato Research Institute, Shimla, 73 pp.
16. Dastur, J.F. 1948. *Phytophthora* spp. of potatoes (*Solanum tuberosum*) in the Shimla hills. *Indian Phytopath.* 1: 19-26.
17. Dube, G.S., R.S. Singh and R.G. Chaudhary. 1982. Effect of systemic insecticides on germination, aphid and virus disease incidence. *In : Potato in Developing Countries* (BB Nagaich *et al.* Eds) IPA & CPRI, Shimla, pp. 284-88.
18. Ganguly, A. and D.N. Paul. 1953. Wart disease of potato in India. *Sci.* and *Cult.* 18: 605-06.
19. Garg, I.D. 1987. Degeneration of potato varieties in western Maharashtra. *J. Indian Potato Assoc.* 14: 127-28.
20. Khurana, SM Paul. 1990. AICPIP experiments on virus diseases of potato. In : *Proc. A decade of Research on Diseases of Hort. Crops under AICRP* (1990-89). IIHR., Bangalore, June, 14-15.
21. Khurana, S.M. Paul. 1992. Potato viruses & viral diseases. *Tech. Bull.* No. 35, 23 pp. CPRI, Shimla.
22. Khurana, S.M. Paul and M.N. Singh. 1988. Yield loss potential of potato viruses X and Y in Indian potatoes. *J Indian Potato Assoc.* 15: 27-29.
23. Khurana, S.M. Paul, I.D. Garg and M.N. Singh. 1991. Virus component analysis of the mosaics of potato hybrids/cultivars. *Proc.* IPS (NZ) meeting. PAU, Ludhiana Nov. 18-19, 1991, pp. 27 (Abstr.)
24. Jeswani, M.D., A.V. Gadewar and B.P. Singh. 1987. Studies on mixed infection of *Streptomyces griseus* and *Fusarium oxysporum* on potato tubers. *J. Soil. Biol. Ecol.* 7: 73-78.
25. Lal, K.B. 1958. Out breaks and new records. *F.A.O. Plant Protection Bull.* 6: 158-59.

26. Mann, H.H. and W.V. Joshi. 1925. Further investigation on potato cultivation in western India. *N. Storage experiments with potatoes*. Deptt. of Agric. Bombay, *Bull. 121*, pp 17-25.

27. Misra, P.C., P.C. Gaur and N.M. Nayar. 1984. Potato cultivars released by the Central Potato Research Institute, *Tech. Bull. No.* 12. CPRI, Shimla. 27 pp.

28. Nagaich, B.B. 1982. Potato in India. *Bulletin No.* 1. Central Potato Research Institute, Shimla, 44 pp.

29. Nagaich, B.B. and G.C. Upreti. 1964. Heat inactivation of potato leafroll virus. *Indian Potato J.* 5: 104-05.

30. Paharia. K.D. 1960. Charcoal rot of potato in India. *Indian Potato* J. 2: 1-11.

31. Paharia K.D. and Pushkarnath. 1963. Occurrence of common scab on potatoes in Bihar. *Indian Potato J.* 5 : 104-05.

32. Phadtare, S.G. 1978. Pink rot of potato-A new report from India. *J. Indian Potato Assoc.* 5:173-74.

33. Phadtare, S.G., P.H. Singh, and G.S. Shekhawat. 1990. Wart disease of potato in Darjeeling hills. Central Potato Research Institute, Shimla. *CPRI Technical Bull. No.* 19, 45 pp.

34. Prasad, B. 1977 New foliar diseases of potatoes due to *Phoma spp. J. Indian Potato Assoc.* 4: 36-39.

35. Pushkarnath and K.D. Paharia. 1963. Survival of *Phytophthora infestans* on infected tubers in cold storage in the plains of India. *Indian Potato J.* 5: 48-51.

36. Pushkarnath, D. Sahai and S.N.S. Srivastava. 1966. The rot and deterioration of potatoes in storage. In.: S.P. Raychaudhuri et al (Ed.) *Plant Disease Problems (Proc. Int. Symp. Pl. Path.* New Delhi, pp. 324-28.

37. Pushkarnath. 1976. *Potato in Sub-Tropics.* Orient Longman Limited, New Delhi, 277 pp.

38. Rai, R.P. 1979. Pink rot of potato in Shimla hills. *J. Indian Potato Assoc.* 6: 36-40.

39. Roy, S., B.P. Singh, S.K. Bhattacharyya, and G.S. Shekhawat. 1992. Distribution and control of pink rot of potato in Shimla hills. *J. Indian Potato Assoc.* 19: 45-49.

40. Shekhawat, G.S. 1990. Fungal and Bacterial Diseases of Potato. In : Decade of Research on *Diseases of Horticultural Crops under* AICPIP. Indian Institute of Horticultural Research, Bangalore, pp 120-38.

41. Shekhawat, G.S., A.V. Gadewar, V.K. Bahal and R.K. Verma. 1988. Cultural practices for managing bacterial wilt of potato. In : *Bacterial Diseases of Potato : Report of the Planning Conference on Bacterial Diseases of Potato,* 1987. CIP, Lima, Peru, pp 65-84.

42. Shekhawat, G.S., S.K. Chakrabarti and A.V. Gadewar. 1992. Potato bacterial wilt in India. *CPRI Tech. Bull.* No. 38, 44 pp.

43. Sikka, L.C., S.N.S. Srivastava, A.K. Singh and V.P. Bhardwaj. 1971. Integrated approach to the control of *Rhizoctonia solani* on potato. *Indian Phytopath.* 24: 544-47.

44. Singh, B.P. and K.P. Sharma. 1985. Disease free seed potato production in Lahoul Valley. *Indian Farming* 1: 24-26.

45. Singh, B.P. and M.D. Jeswani. 1987. Managing common scab of potato through chemical and cultural practices. *J. Indian Potato Assoc.* 14: 26-32.

46. Singh B.P. 1986. Studies on Fusarium wilt and dry rot of potatoes (*Solanum tuberosum* L.). Ph.D. Thesis, A.M.U. Aligarh.

47. Singh, B.P., B. Prasad and M.S. Walia. 1987. Effect of date of planting, crop age and environmental factors on potato leaf spots. *Indian Phytopath.* 40: 70-75.

48. Somani A.K. 1988. Control of black scurf (*Rhizoctonia solani*) and common scab (*Streptomyces scabies*) of potato (*Solanum tuberosum*) with boric acid. *Indian J. agri. Sci.* 58: 693-98.

49. Singh, M.N., S.M. Paul Khurana, B.B. Nagaich and H.O. Agrawal. 1981. Epidemiological studies on potato viruses Y and leafroll in subtropical India. *Proc. Pl. Virus. Epidem. Confr.*, Oxford, July, 1981 (Abstr.) pp. 89-90.

50. Singh, M.N., B.B. Nagaich and H.O. Agrawal. 1982. Potato yield depression due to current *year* infection with viruses Y and leafroll. *J. Indian Potato Assoc.* 9: 128-35.

51. Thirumalachar, M.J. 1954. Inactivation of potato leafroll by high temperature storage of seed tubers in Indian plains. *Phytopath. Z.* 22: 429-36.

52. Thirumalachar, M.J. 1955. Incidence of charcoal rot of potatoes in Bihar (India) in relation to cultural conditions. *Phytopath.* 45: 91-93.

53. Upadhya, M.D. 1974. In : *Evolutionary studies in world crops.* J. Hutchison, (Ed.) Cambridge Univ. Press. pp 139-48.

54. Upreti, G.C. and B.B. Nagaich. 1968. Inactivation of potato leafroll virus in tubers by a hot water treatment. *Am Potato J.* 45: 373-77.

55. Vashisth, K.S., A.K. Verma, I.P. Chaubey and B.B. Nagaich. 1981. Comparative degenerative effects of viral and MLO - diseases during autumn and spring seasons on Indian varieties in Punjab. *Seed & Farms* 7 (10) : 25-28.

56. Vasudeva R.S. and R.N. Azad. 1952. Investigations on virus disease and production of disease free seed potatoes in India. *Emp J. Expt. Agric.* 20: 293-300.

57. Verma, R.K. and G.S. Shekhawat. 1990. Role of healthy seed in abatement of losses due to brown rot of potato in high hills of Uttar Pradesh. *J. Indian Potato Assoc.* 17: 206-08.

58. Waterhouse, G.M. 1963. Key to the species of *Phytophthora* de Bary. *Mycol. papers* 92. CMI, Kew, Surrey, England, 22 pp.

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AGRIBUSINESS POTATO SYSTEM OF THE TYPICAL POTATO GROWER OF FARRUKHABAD DISTRICT

P.K. Singh[1]

ABSTRACT: In Farrukhabad district the potato producers have a relatively big agribusiness commodity system of potato. The problems of the producers centre around the input supply, potato storage and marketing. The inputs distribution channels are to be streamlined. Though markets in the district are regulated by government, still the producers are being exploited by the traders. The district has large cold storage capacity but looking to the level of potato production, it is not adequate. Producers also suffer from wide price fluctuations.

INTRODUCTION

Traditional farm management and / or marketing studies on potatoes have usually concentrated on a particular aspect of the problem investigated. Such an approach fails to take into account the many related aspects of the commodity since all the aspects from farm supplies to farming, aseembling, storing and distribution and coordinating institutional arrangements are integrated. Hence, before taking policy decisions about the modernization of the system the agribusiness system of potatoes has to be understood. Major parts or sub-systems of this system are input supply, production, storage, marketing and consumption. These sub-systems are inter-depenent in a number of ways and an understanding of these interrelations and that of problems is also necessary. This problematic situation calls for a thorough investigation into the potato system as a whole. The present study was undertaken in the most important potato producing area of Uttar Pradesh with the specific objective to study the existing agribusiness system of potato crop.

MATERIALS AND METHODS

The study was conducted in Farrukhabad district of Uttar Pradesh. The data used cover two blocks of Kamalganj and Barhpur having maximum per cent of total cropped area under the crop. From the selected blocks, a total of 24 villages were chosen. From the sampled villages farmers were pooled and then a sample of 100 farmers was drawn at random. The required data on production pattern, crop operations, pattern of storage and sales, marketing costs, farm purchases and input acquiring costs, availability of resources, etc., were collected from the sample farmers through personal interviews on a well structured pre-tested schedule questionnaire. Some information were also gathered from the offices of the Potato Development Officer, District

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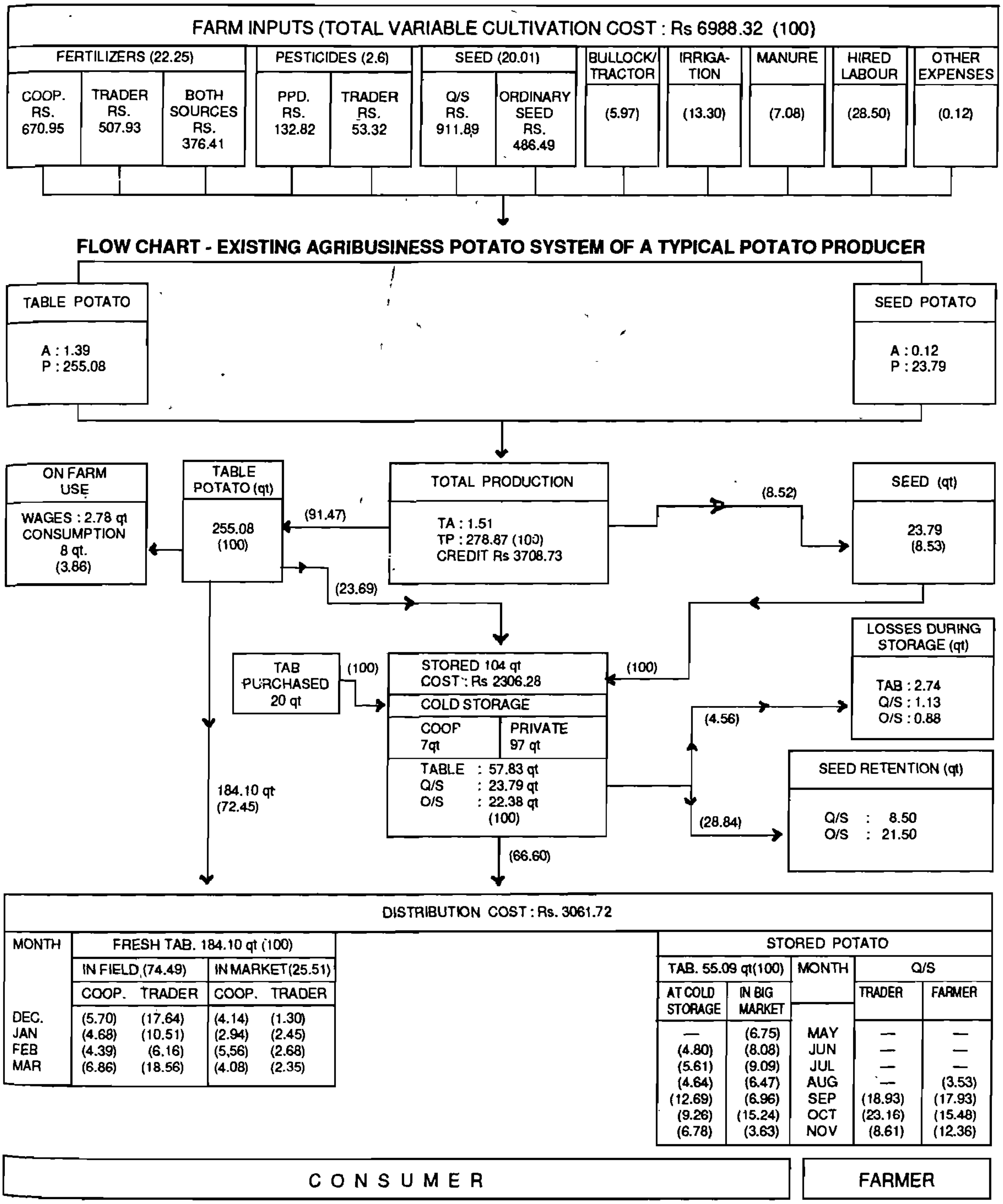
To fulfill the objective of the study the agribusiness system approach was used. For the purpose, the whole agribusiness potato system was partitioned into four important sub-systems: (i) input supply, (ii) production, (iii) potato storage and (iv) potato marketing. To analyse the existing system, simple tabular analysis was done.

RESULTS AND DISCUSSION

An average potato producers of the study area owned 2.98 h of cultivated land of which 2.77 h were irrigated. Human labour and tractor/draught power were not the constraints in the area. However, the important constraint recognised was the availability of funds. The typical farm-firm had several alternatives for the use of its resources. It could choose from a number of different potato crops (crop produced in different months and for the table and seed purposes are different in respect of input-output mix) and crops other than potato, different input supplying agencies (co-operative societies, private traders, government departments) to buy different inputs (seed, fertilizers, pesticides), different marketing alternatives (place, agency and time alternatives for the sale of fresh and stored table and seed tubers) and storage alternatives (including maintaining inventory of table and seed potato tubers through different months and under private and co-operative cold storage alternatives). The existing agribusiness potato system of the typical potato producers is shown in Flow Chart. The typical producer allocated about 1.5 h of land (50.60 per cent of total operated area) to potato cultivation and this crop alone contributed about 62 per cent towards the gross cash revenue. The total potato production on the farm was about 279 q of which table potato accounted for about 91.5 per cent and remaining being for seed potato.

The per farm total variable cash expenses on potato cultivation amounted to Rs. 6988. The dominant inputs were hired labour, fertilizer and seed. These inputs together accounted for about 70 per cent of the total variable cash expenses. Of the total potato production 2.87 per cent was used in domestic consumption, 1 per cent paid to labourers as wages and about 14.6 per cent was retained as seed.

A complex system for handling, marketing and distribution of fresh and stored table potatoes and for seed potato has evolved in the area. The system is characterised by the diffused decision making process of the producers based on highly imperfect marketing information. Thus, the marketing costs borne by the producers accounted for quite a big share of total cost of production. On an average farm, the total cash cost of Rs. 12,356.37 was incurred in potato production of which the share of marketing cost was about 25 per cent i.e., Rs. 3062. Similarly, the per farm average



Figures in parentheses are percentage to total.

*Note :

A : AREA (HECT.)
TAB : TABLE POTATO
TA : TOTAL AREA (HECT.)
TP : TOTAL PRODUCTION (qt)
P : PRODUCTION (qt)
PPD : PLANT PROTECTION DEPARTMENT
Q/S : QUALITY SEEDS
O/S : ORDINARY SEEDS

cost of storing the produce amounted to Rs. 2306 which was 18.60 per cent of the total production cost. This clearly shows that the marketing and storing functions together accounted for 43.40 per cent of total cost.

Of the total marketable surplus of table potato on a farm about 75 per cent i.e., about 184q was sold as fresh and remaining about 58q 25 per cent was stored in cold stores and sold later in lean months to reap the benefits of price rise. Approximately 74.5 per cent of the fresh table potato was marketed in fields itself through co-operative marketing societies and private traders during December through March. During the same period the remaining 25.5 per cent of the fresh produce was disposed off in the nearby markets. A major share (53.72 per cent) of the stored table potato was sold in the big consuming markets. Potato is inherently a capital intensive crop, and requires capital at production, storing and even at marketing stages. On an average a producer borrowed about Rs. 3709 from different institutions and money lenders to meet the cultivation and storing costs. It was observed that the traders exploited the producers by taking extra potatoes in lieu of the presence of dirt and soil in the produce; charging for weighting the produce and for paying the gratuity to labourers, taking brokerage and *arhat*, making deferred payments, etc. There is scope to reduce the marketing costs by effectively implementing *Mandi Adhiniyam.*[1] The cost of storage may also be brought down by minimising the losses on account of piliferage and sprouting of potatoes in stores.

The studied blocks had the cold storage capacity of over 13 lakh quintals but looking to the level of potato production even this was not sufficient and there was need to increase the cold storage capacity. The district being surplus in potato the produce is being exported to the distinct consuming markets of Gujarat, Assam, etc. Among other factors prices of potato in the district are governed by the availability of transport i.e., railway wagons and trucks and the prices in the consuming markets. Hence, ways and means are to be explored to promote export of the crop to other deficit areas. Availability of rail wagons, particularly during the peak months of December through April should also be increased. Shortage of wagons even for few days created periodical gluts causing wide price functuations. To minimise the losses in the transit there is also need to provide special aircooled and ventilated wagons.

[1]The fresh produce was marketed in different months in markets and/or plot itself to the private traders and/or co-operative marketing society. When produce was sold through traders the producer incurred 16 per cent to 108 per cent more marketing expenses in market and plot respectively in comparison to the co-operative marketing society.

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INTEGRATED NUTRIENT MANAGEMENT WITH SULPHUR BEARING FERTILIZER, FYM AND CROP RESIDUES IN RELATION TO GROWTH AND YIELD OF POTATO

S.S. Mondal, M. Chettri, S. Sarkar and T.K. Mondal[1]

ABSTRACT: A field experiment was conducted to evaluate the growth and productivity of potato under different fertilizer management with particular reference to 'S' bearing fertilizer, FYM and crop residues. Maximum dry matter production (855 g/m^2), tuber bulking rate (16 g/m^2/day) and tuber yield (266 q/ha) were recorded at 100% of the recommended doses (N : P_2O_5 : K_2O = 100 : 100 : 100 kg/ha) of N, P_2O_5 (through SSP) and K_2O in conjunction with 10 t FYM per hectare. Application of 'S' bearing fertilizer (SSP) improved the growth and tuber yield (9%) of potato as compared with the application of DAP. The maximum total uptake of nutrients (115.02 kg N, 25.31 kg P_2O_5, 249.11 kg K_2O and 16.67 kg S/ha) were recorded where the potato crop was fertilized with 100% of the recommended doses of N, P_2O_5 (through SSP) and K_2O. Any reduction in their recommended doses without application of FYM/crop residues depleted the soil fertility status. Better net production values (2.16 and 2.12) were recorded at 75% of the recommended doses of N, P_2O_5 (through SSP) and K_2O along with 10 t FYM/ha as well as in the treatment receiving 100% of the recommended doses of N, P_2O_5 (through SSP) and K_2O.

INTRODUCTION

In the Gangetic plains of West Bengal, particularly in the district of Nadia, the average intensity of cropping is more than 200%. The rainfall being high (1500 mm) and the relatively upland soils being light in texture, there is a good amount of leaching loss and crop removal of nutrients. Application of FYM and crop residues can to a certain extent, compensate for these losses particularly in respect of S and K. This has been amply demonstrated by the studies of Widdowson *et al* (8) and Chatterjee *et al.* (2) 'S' deficiency can also be met out by using 'S' bearing fertilizers like Super Phosphate (1, 6). In this paper an attempt has been made to study the effect of sulphur bearing fertilizer, FYM, crop residues and different quantum of recommended doses of fertilizers on the growth and tuber yield of potato.

MATERIALS AND METHODS

The experiment was conducted during the short winter seasons of 1989-90 to 1990-91 at Bidhan Chandra Krishi Vishwavidyalaya farm Kalyani on sandy loam soils having the total N (0.067%), available P (15.4 kg/ha), available K (229 kg/ha), available

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sulphur (18.7 ppm) and pH of 7.6. The experiment was laid out in randomised block design with three replications and eight treatment combinations (Table 1).

Paddy straw @ 30 q/ha was chopped and incorporated in soil 15 days before planting of potato. The contribution of N, P_2O_5 and K_2O from crop residues were 14 kg N, 5 kg P_2O_5 and 54 kg K_2O/ha. The plant samples (5 plants at 60, 80 and 90 days after planting) were cut at ground level randomly. After drying, haulms and tubers were kept separately in oven and the samples were ground in grinder for chemical analysis. Soil samples were collected treatment wise from a depth of 15 cm and processed for chemical analysis after harvest of the crop.

To evaluate the effect of 'S' on growth and development of potato, S-bearing fertilizer (SSP) and S - free phosphatic fertilizer (DAP) were applied according to the treatments. The source of 'N' was urea and K was muriate of potash. Application of FYM @ 10 t/ha at the time of final land preparation contributes 44 kg N, 19 kg P_2O_5 and 42 kg K_2O/ha. The potato variety Kufri Badshah (110 days maturity) was planted in 2nd week of November and harvested in the 1st week of March.

RESULTS AND DISCUSSION

Dry matter accumulation: The dry matter production (g/m^2) varied significantly with different treatments at all growth stages (Table 1). At 60, 80 and 100 days after planting (DAP), the maximum dry matter (383.50, 579.33 and 855.17 g/m^2) were produced by the treatments receiving 100% of the recommended doses of N, P (through SSP) and K followed by 75% doses of N, P (through SSP) and K+10 t FYM/ha. Both the treatments are rich in 'S' nutrition suggesting that the 'S' nutrition supplemented

Table 1. Total dry matter production in potato (g/m^2)

Fertilizer dose in Kg/ha as N, P_2O_5 and K_2O		Dry weight (g/m^2) at DAP		
		60	80	100
T_1	: 100% recommended doses (100-100-100) of N, P (SSP) & K	383.5	579.3	855.1
T_2	: 100% N, P (DAP & K	290.0	419.9	716.3
T_3	: 75% N, P (SSP) & K	300.6	482.3	699.2
T_4	: 75% N, P (DAP) & K	254.1	398.6	653.9
T_5	: as T_3 + FYM @ 10 t/ha	342.0	507.3	745.9
T_6	: as T_4 + FYM @ 10 t/ha	303.7	426.7	679.0
T_7	: as T_3 + crop residue incorporation (rice straw)	298.5	458.0	679.1
T_8	: as T_4 + crop residue incorporation (rice straw)	293.1	458.0	653.9
SEm ±		16.3	14.3	14.0
C.D. at 5%		49.6	43.7	42.7

by FYM or 'S' bearing fertilizers is gold for dry matter production. Similar results were obtained by Chatterjee *et al* (2) and Jayaram *et al* (4).

Tuber bulking rate: The tuber bulking rate was improved significantly with the application of sulphur bearing fertilizers like SSP and FYM or incorporation of crop residues (Table 2). At 80 days after planting, highest TBR (9.24 $g/m^2/day$) was recorded under the treatment receiving 75% of the recommended doses of N, P (through SSP) and K in conjunction with 10 t FYM/ha (14.07 $g/m^2/day$) or incorporation of crop residues (13.37 $g/m^2/day$).

Tuber yield: The tuber yield differed significantly with different fertilizer managements (Table 2). Highest tuber yield (265.83 q/ha) was obtained under the treatment where 100% of the recommended doses of N, P (through SSP) and K was applied. The lowest tuber yield (210.00 q/ha) was recorded under the treatment receiving 75% of the recommended doses of N, P (through DAP) and K. It is clearly implied that sulphur bearing fertilizers *i.e.* SSP (12% S) or FYM (1.5 kg S/t) has a marked effect on tuber yield. This finding corroborates with the results observed by Anspok (1) Rammurthy (5) and Singh (6).

Table 2. Tuber bulking rate ($g/m^2/day$) DAP and tuber yield (q/ha)

Fertilizer dose in Kg/ha as N, P_2O_5 and K_2O_5 and K_2O	Tuber bulking rate ($g/m^2/day$) at 80 days	100 days	Tuber yield
T_1 : 100% recommended doses (100-100-100) of N, P (SSP) & K	6.2	15.5	265.8
T_2 : 100% N, P (DAP & K	4.4	13.1	242.0
T_3 : 75% N, P (SSP) & K	6.2	13.0	225.0
T_4 : 75% N, P (DAP) & K	2.7	10.5	210.0
T_5 : as T_3 + FYM @ 10 t/ha	5.1	14.0	253.1
T_6 : as T_4 + FYM @ 10 t/ha	3.3	11.4	230.0
T_7 : as T_3 + crop residue incorporation (rice straw)	9.2	13.3	229.6
T_8 : as T_4 + crop residue incorporation (rice-straw)	5.6	6.5	225.3
SEm ±	0.6	1.3	8.9
C.D. at 5%	1.8	4.2	26.9

Application of FYM 10 t/ha along with N, P through SSP (12% S) and K fertilizers, improved the tuber yield of potato. Similar results were obtained by othe workers (3, 4).

Nutrient uptake by potato plant at harvest: The uptake of N, P, K and S by potato plant ranged from 62.51 to 115.02 Kg N/ha, 15.76 to 25.31 kg P_2O_5/ha, 137.65 to 249.11 kg K_2O/ha and 10.39 to 16.67 kg S/ha respectively (Table 3). Highest N,

Table 3. Nitrogen, phosphorous, potassium and sulphur uptake by potato at lowest (on dry weight basis)

Fertilizer dose in kg/ha as N, P_2O_5 & K_2O	Nutrient uptake (kg/ha)			
	N	P	K	S
T_1 : 100% recommended doses (100-N, P (SSP) & K	115.0	25.3	249.1	16.6
T_2 : 100% N, P (DAP & K	93.4	20.7	195.9	11.9
T_3 : 75% N, P (SSP) & K	81.6	18.9	197.9	12.0
T_4 : 75% N, P (DAP) & K	69.3	18.1	177.0	10.8
T_5 : as T_3 + FYM @ 10 t/ha	86.4	19.6	203.1	12.9
T_6 : as T_4 + FYM @ 10 t/ha	67.0	17.5	176.4	10.7
T_7 : as T_3 + crop residue incorporation (rice straw)	78.9	18.7	172.3	12.4
T_8 : as T_4 + crop residue incorporation (rice straw)	62.5	15.7	137.6	10.3

P, K and S uptake were recorded under the treatment receiving 100% of the recommended doses of N, P (through SSP) and K. Lowest N, P, K and S uptake were recorded under the treatment receiving 75% of the recommended doses of N, P (through DAP) and K along with incorporation of crop residue (rice straw) @ 30 q/ha.

Table 4. Net production values (NPV) under different fertilizer management practices in potato cultivation

Fertilizer in kg/ha^{-1} as N, P_2O_5 and K_2O	Yield ha^{-1}	Cost of fertilizers, manures h^{-1} = X (Rs)	Total cost of cultivation ha^{-1} A = (X + Y) Rs.	Value of produce B Rs.	Net profit ha^{-1}= c (B-A)	NPV = C/A
T_1 : 100% N, P (SSP) & K	266	3635.85	10635.85	33250	22614.15	2.12
T_2 : 100% N, P (DAP) & K	242	3470.9	10470.9	30250	19779.10	1.88
T_3 : 75% N, P (SSP) & K	225	27260.90	9726.90	28125	18398.10	1.89
T_4 : 75% N, P (DAP) & K	210	2603.79	9603.79	26250	16646.21	1.73
T_5 : as T_3 + FYM @ 10 t/ha	253	2976.90	9976.90	31625	21648.10	2.16
T_6 : as T_4 + FYM @ 10 t/ha	230	2853.79	9853.79	28750	18896.21	1.91
T_7 : as T_3 + crop residue incorporation	229	5726.90	12726.90	28625	15898.10	1.24
T_8 : as T_4 + crop residue incorporation	225	5603.79	12603.79	28125.21	15521.21	1.23

Price of fertilizers/manures/rice straw
Urea = Rs. 350/q MOP = Rs. 600/q
DAP = Rs. 850/q FYM = Rs. 25/ton
SSP = Rs. 300/q Rice Straw = Rs. 100/ton

Price of produce
Potato = Rs. 125/q

Cost of cultivation excluding fertilizers
Rs. 7000/ha

Higher doses of nutrient application enhances the uptake of nutrients by potato plant which is ultimately reflected in the tuber yield of ptato. SSP in conjunction with FYM produced much better results even at lower dose (75% of the recommended dose). FYM increases the fertilizer use efficiency of the aded nutrient to a considerable extent. This results corroborates with finding of Jayaram *et al.* (4) and Sanyal *et al.* (7).

Net production values (NPV): The aim of commercial farming is to fetch more money per unit investment. From the table 4, it is revealed that the maximum net production value (2.16) was given by 75% recommended doses of N, P (through SSP) and K in conjunction with FYM (10 t/ha) which was closely followed by the NPV (2.12) in the treatment receiving 100% of the recommended doses of N, P (through SSP) and K. These findings also suggest that use of FYM and 'S' bearing fertilizers is superior over other treatments.

LITERATURE CITED

1. Anspok, P.I. 1987. A comparative efficiency of different forms of K, mg and S containing fertilizers in the Latvian USSR. *Agrokhimiya* 1 : 23-28.
2. Chatterjee, B.N., N.C. Banerjee, D.C. Ghosh and P.K. Debnath. 1979. Response to P, K and FYM in multiple cropping with potato. *J. Indian Potato Assoc.* 5: 7-12.
3. Grewal, J.S. and R.C. Sharma. 1984. Response of potatoes and other crop grows in rotation to P and K fartilizers and FYM in India. *Potash Rev.* Sub. II. Suite 28: 1-5.
4. Jayram, D., B.N. Chatterjee and S.S. Mondal. 1990. Effect of FYM, crop Residues and fertilizer management in sustaining productivity under intensive cropping. *J. Potassium Research* 6: 172-79.
5. Rammurthy, N. 1979. Effect of different sources and levels of S on the yield and quality of potato. *Mysore J. Agri. Sci.* 14: 275.
6. Singh, K. 1988. Relative efficiency of straight and complex fertilizers on potato yield. *Indian J. Agron.* 33: 197-99.
7. Sanyal, S., S.S. Mondal and B.N. Chatterjee. 1990. Integrated nutrient management in rice based cropping system. *Proc. Int. Symp. in Rice Research. New Frontiers.* Nov. 15-18, 1990. Directorate & Rice Research, Hyderabad. pp. 303-04.
8. Widdowson, F.V., A. Penny and R.C. Flint. 1979. Results from experiments measuring the effects of large amount of fertilizer and of FYM on main crop potatoes grown in sandy soil at Woburn. *Potash Rev.* 1: 13.

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COMBINING ABILITY STUDY IN THE DEVELOPMENT OF POTATO HYBRIDS SUITABLE FOR PROCESSING*

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ABSTRACT: Forty crosses involving 14 parents crossed in line x tester design were studied for tuber yield, number of tubers per plant, average tuber weight and per cent tuber drymatter in F_1 generation. The additive gene action was found to be more important for tuber yield and average tuber weight, whereas, the non-additive gene action was more important for tuber number and per cent tuber drymatter. The good combiners for various characters were identified. The superior crosses for selecting recombinants with high yield, average tuber weight and per cent tuber drymatter involved parents with good or average combining-ability only. The crosses involving poor combiners always showed low mean values of these characters in the crosses.

INTRODUCTION

The potato is a highly heterozygous crop wherein non-additive gene action is known to be important for most of the economic characters. This makes it necessary to assess the combining ability of the parents before they are involved in crosses in a breeding programme. For a programme on breeding improved potato varieties for processing purposes, parents were selected from the germplasm collection and assessed for their combining ability for tuber yield, number of tubers, average tuber weight and tuber drymatter. The crosses producing recombinants suitable for processing purposes, were identified.

MATERIALS AND METHODS

In all 14 accessions mostly having high tuber drymatter were selected from the germplasm collection. Some of the parents were known good combiners for yield. Four of these genotypes viz. EX/A 680-16, QB/B 92-4, MS/78-79 and PH/F-1545 were used as male (testers) and the remaining ten were used as female parents (lines). Forty crosses were made in line x tester design at Kufri (2370 m above MSL). The seedlings of all the corsses were grown in field at CPRS, Modipuram in randomized block design in three replications, using normal cultural and manurial practices. Each replication consisted of 30 seedlings. At harvest, the data on average tuber yield (g)/plant and number of tubers/plant were recorded for all the crosses. The average tuber weight was calculated by dividing tuber yield by number of tubers. For estimation of tuber

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drymatter duplicate samples, each comprising of 30 tubers representing 30 seedlings of a replication in a cross, were drawn. These were cut into thin slices, mixed and duplicate 200 g subsamples were oven dried to a constant weight at 80°C. The data were analysed according to line x tester method suggested by Kempthorne (8).

RESULTS AND DISCUSSION

The analysis of variance (Table 1) revealed that the differences between male parents were highly significant for tuber yield, number of tubers and average tuber weight. The differences due to female parents were significant only for yield and average tuber weight. The female x male interaction variance was significant for all the four characters indicating inter-allelic action for these traits. The variances due to replications for all the characters were non-significant indicating a low environmental variation.

Table 1. Analysis of variance for line x tester analysis

Source	df	Yield g/plant	Tubers per plant	Av. tuber weight	% Dry matter
Females	9	12652.78**	17.50	130.63**	14.86
Males	3	19316.92**	70.47**	98.11**	23.44
Females x Males	27	2311.40**	10.35**	18.79**	9.40**
Error	78	905.83	3.75	9.30	0.51
6^2 gca		714.48	1.30	5.98	0.46
6^2 sca		468.52	2.20	3.16	2.96

* P = 0.05, ** P = 0.01

The estimates of 6^2 gca and 6^2 sca (Table 1) revealed that both additive and non-additive types of gene actions were important for tuber yield, number of tubers per plant and average tuber weight. The proportion of 6^2 gca was, however, more for tuber yield and tuber weight and 6^2 sca for number of tubers. Only non-additive type of gene action was found to be important for tuber drymatter. Our estimates of variances for yield confirmed the findings of Golmirazaie and Mendoza (6) and Pandey (10) who also indicated a higher proportion of additive genetic variance for this character. Nearly equal proportion of gca and sca variances for this character have also been reported by several workers (1, 3, 4, 9, 11, 12, 13). Our estimates, however, differed from those of Thompson *et al.* (14) who reported sca variance to be more important for yield. The low proportion of gca in the population studied by them could be due to reduced variance among parents resulting from several generations of recurrent selection cycles. Our estimates of gca variance for average tuber weight were higher than the sca variance thus confirming the observations of Killick (9) and Gaur *et al.* (4). These, however, differed from those of Gaur *et al.* (3) and Sanford (12). This could be due to differences in the populations studied by them. Whereas, Gaur *et al.* (3) studied the dihaploids which involved *Solanum phureja* in its pedigree. Sanford (12) studied neo-tuberosum population selected for good tuberization for 7 generations of recurrent selection cycles. For number of tubers the sca variance was relatively higher indicating the importance of non-additive gene action. This was in confirmation of previous findings of Tai (13) and Gaur *et al.* (3). Our estimate of sca variance for tuber drymatter was about 7 times than that of gca variance and was similar to that observed by Gaur *et al.* (5). The low gca variance was, however, expected in the paresent study as the parents were selected for high values of tuber drymatter.

Table 2. Estimated general combining ability of parents

Parents	Yield g/plant	Tubers per plant	Av. tuber weight	% Dry matter
Male (M)				
EX/A-680-16	- 2.357	- 0.235	- 0.106	+ 0.210
MS/78-79	- 26.435**	- 0.127	- 2.430**	+ 0.274**
PH/F-1545	- 5.764	- 1.677**	+ 1.851**	- 1.269**
QB/B-92-4	+ 34.556**	+ 2.039**	+ 0.685	+ 0.785**
Females (F)				
CP-2334	+ 47.015**	- 1.247*	+ 7.160*	- 0.025
CP-2346	+ 23.777**	+ 0.974	+ 1.160	+ 0.551**
CP-2351	- 28.955**	- 0.135	- 2.521**	- 1.249**
CP-2370	+ 26.873**	+ 0.772	+ 1.029	+ 0.828**
CP-2378	+ 44.740**	+ 1.876**	+ 1.405	+ 0.611**
CP-2401	- 27.839**	+ 0.067	- 2.846**	- 2.642**
CP-2407	- 5.271	-1.355*	+ 1.287	+ 0.131
CP-2413	- 25.116**	+ 1.377*	- 4.915**	+ 0.316
CP-2416	- 29.547**	- 1.289*	- 1.500	+ 0.862**
CP-2417	- 15.677	- 1.044	- 0.159	+ 0.617**
SE ± (M)	5.495	0.353	0.557	0.131
SE ± (F)	8.688	0.559	0.880	0.207

* P = 0.05, ** P = 0.01

The estimates of general combining ability effects (Table 2) showed that the good combiners for yield were QB/B 92-4, CP 2334, CP 2346, CP 2370 and CP 2378; for number of tubers QB/B-92-4, CP 2378 and CP 2413; for average tuber weight PH/F-1545 and CP 2334 and for per cent tuber drymatter MS/78-79, QB/B-92-4, CP 2346, CP 2370, CP 2378, CP 2416 and 2417. The gca effects for yield and average tuber weight appeared to be positively correlated which confirmed the observations of Gaur *et al.* (4).

Out of 40 crosses studied, only two viz. CP 2370 x PH/F 1545 and CP 2413 x QB/B 92-4 showed significant positive sca effects for yield. For number of tubers the crosses CP 2413 x MS/78-79, CP 2370 x PH/F 1545 and CP 2417 x QB/B 92-4 and for tuber weight crosses CP 2417 x MS/78-79, CP 2334 x PH/F 1545 and CP 2346 x QB/B 92-4 showed positive sca effects. There did not appear to be any relationship between the combining ability of the parents and the sca effects observed in the crosses for above three characters. This indicated that selection of parents on the basis of combining ability will not limit the exploitation of sca effects for the improvement of these characters. The poor combiners, however, invariably showed absence of sca effects in the crosses.

Table 3. Estimated specific combining ability of the crosses

Presents	CP-2334	CP-2346	CP-2351	CP-2370	CP-2378	CP-2401	CP-2407	CP-2413	CP-2416	CP-2417
EX/A-680-16	Y - 27.85	- 19.65	+ 24.38	- 34.31*	+ 19.61	+ 24.77	+ 14.98	- 33.45	+ 20.06	+ 11.46
	T - 0.74	+ 2.06	+ 0.32	- 0.01	+ 1.01	+ 0.86	- 9.92**	- 2.37*	+ 0.41	- 1.53
	W - 1.53	- 4.22*	+ 1.62	- 2.41	+ 0.33	+ 2.54	+ 2.05	- 1.11	- 1.71	+ 1.02
	D - 0.42	+ 0.69	+ 0.29	+ 0.21	+ 0.63	- 0.12	- 2.29**	+ 0.99*	+ 0.51	- 0.49
MS/78-79	Y + 8.79	+ 30.82	- 19.50	-34.74*	- 11.76	-10.34	+ 18.81	- 0.95	+ 4.64	+ 14.23
	T + 1.70	+ 1.79	- 0.39	- 2.90**	- 1.03	- 1.64	+ 1.05	+ 2.83*	- 0.24	- 2.17
	W - 2.82	+ 0.33	- 2.10	+ 0.67	+ 0.35	- 0.68	+ 0.10	- 1.30	+ 0.54	+ 4.89**
	D + 1.20**	- 0.17	- 0.17	- 0.80	- 0.57	+ 2.82**	- 0.15	- 0.74	-0.58	- 1.98**
PH/F-1545	Y + 6.35	- 23.10	- 10.66	+ 81.04**	- 2.35	+ 0.03	- 6.43	- 7.65	- 11.67	- 25.57
	T - 0.26	- 0.10	- 1.27	+ 3.31**	- 0.64	+ 0.75	+ 0.79	- 1.23	- 0.21	- 0.24
	W + 3.54*	- 0.97	+ 1.43	+ 2.39	+ 1.05	- 1.61	- 1.71	- 0.40	- 1.25	- 2.47
	D - 1.60**	+ 0.37	+ 0.57	+ 1.90**	+ 1.17	- 5.47**	+ 1.45**	- 0.80	+ 0.52	+ 1.90**
QB/B-92-4	Y + 12.71	+ 11.93	+ 5.77	- 12.00	- 5.51	-14.45	- 27.36	+ 42.05*	13.02	- 0.12
	T -0.70	- 2.86*	+ 1.35	- 0.39	- 0.66	- 0.97	- 1.84	+ 0.77	+ 0.04	+ 3.95**
	W - 0.81	+ 4.86**	- 0.95	- 0.65	- 1.73	- 0.25	- 0.44	- 2.81	- 1.01	- 3.45*
	D + 0.81*	- 0.88*	- 0.69	- 1.30*	- 1.23**	+ 2.77**	+ 1.00**	+ 0.55	- 1.60**	+ 0.60

SE ± (Y) = 17.3765; (T) = 1.1174; (W) = 1.7609; (D) = 0.4136

Where (Y) = yield (g/plant) (T) = Tubers/plant (W) = Average tuber weight (g). (D) = % Tuber drymatter

* P = 0.05, ** P = 0.01

For tuber drymatter, 10 crosses showed positive sca effects, the highest being in CP 2401 x MS/78-79 followed by CP 2401 x QB/B 92-4 and CP 2417 x PH/F 1545. In general, the crosses involving one good combiner and the other average or poor combiner showed significantly positive sca effect (Table 3). The crosses, CP 2370 x QB/B 92-4, CP 2378 x QB/B 92-4 and CP 2417 x MS 78-79 involving only good combiners for drymatter generally showed a significant negative sca effect indicating that both the good combiners for tuber drymatter should not be involved in a cross.

The crosses with high average yield in general involved either only the good combining parents or atleast one good combiner and an average combiner. These results confirmed the findings of Gaur *et al.* (4). Similarly, the crosses with high average tuber weight or number of tubers or high tuber drymatter also generally involved a good combiner for that character. The crosses showing low values of the above four characters invariably involved only poor and average combining parents.

For processing purposes, tuber drymatter of variety is an important character as it determines the quantity and quality of the processed product. The varieties with low drymatter absorb more fat during frying (7), and are therefore undesirable. An increase in tuber drymatter, however, should not be accompanied with a decrease in yield, as will be expected due to a negative correlation between these two characters (2). A negative correlation between average tuber weight and tuber drymatter is also reported (2). A combination of all the three characters viz. high yield, average tuber weight and tuber drymatter in the crosses, though difficult, is desirable for selecting a recombinant genotype suitable for processing. In the present study the crosses CP 2334 x QB/B 92-4, CP 2346 x QB/B 92-4, CP 2370 x PH/F 1545 and CP 2378 x PH/F 1545 showed high mean values for all the above three characters indicating possibilities of selecting such a desirable recombinant.

The combining abilities of parents involved in the above four crosses showed that these had atleast one parent with good combining ability for two characters and an average combining ability for the third character, whereas, the other parent had good combining ability for the third character and good or average combining ability for the other two characters. Further, when both the parents involved in a cross had poor combining ability for a particular character, the mean performance of the cross fo the character was also poor. Thus the selection of parents should be restricted to good or average combiners and those with complimentary characters should be involved in a cross.

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LITERATURE CITED

1. Dayal, T.R. 1981. *Heterosis in potato (Solanum tuberosum L.) and the use of some induced tetraploi for its exploitation.* Ph.D. Thesis, Agra Univ., Agra.

2. Gaur, P.C., H. Kishore and P.K. Gupta. 1978a. Studies on character association in potato. *J. agr Sci.* (UK), 90: 215-19.

3. Gaur, P.C., P.K. Gupta, and H. Kishore. 1978b. Genetic components of tuber yield and quality characters in potato. *J. Indian Potato Assoc.* 5: 32-37.

4. Gaur, P.C., J. Gopal and M.S. Rana. 1983. Combining ability for yield, its components and tuber dry matter in potato. *Indian J. agri. Sci.* 53: 876-79.

5. Gaur, P.C., J. Gopal and M.S. Rana. 1985. Combining ability performance of some recently developed hybrids. *J. Indian Potato Assoc.* 12: 195-98.

6. Golmirzaie, A.M. and H.A. Mendoza. 1985. Identification of parental lines for development of true potato seed (TPS) populations. *Am. Potato J.* 62: 427-28 (Abst.)

7. Grewal, S.S. and D.S. Uppal. 1989. Effect of drymatter and specific gravity on yield, colour and oil content of potato chips. *Indian Food Packer* 43: 17-20.

8. Kempthorne, O. 1957. *An Introduction to Genetical Statistics.* John Wiley and Sons, Inc., New York.

9. Killick, R.J. 1977. Genetic analysis of several traits in potatoes by means of diallele cross. *Ann. appl. Biol.* 86: 279-89.

10. Pandey, S.K. 1993. *Genetic divergence and combining ability studies on true potato seed (TPS) in potato (Solanum tuberosum* L.). Ph. D. Thesis, Meerut Univ., Meerut.

11. Plaisted, R.L., L.L. Sanford, W.T. Federer, A.E. Kehr and L.C. Peterson. 1962. Specific and general combining ability for yield in potatoes. *Am. Potato J.* 39: 185-97.

12. Sanford, L.L. 1979. Effect of random mating on yield and specific gravity in *Solanum tuberosum* populations. *Am. Potato J.* 56: 597-607.

13. Tai, G.C.C. 1976. Estimation of general and specific combining ability abilities in potato. *Can. J. Genet. Cytol.* 18: 463-70.

14. Thompson, P.G., H.A. Mendoza and R.L. Plaisted. 1983. Estimation of genetic parameters for characters related to potato propagation by true seed (TPS) in an *andigena* population. *Am. Potato J.* 60: 393-401.

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CHANGES IN PROCESSING CHARACTERISTICS AND PROTEIN CONTENT OF POTATO TUBERS WITH CROP MATURITY*

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ABSTRACT: Five released and three pre-release cultivars of potato were grown at the CPRS, Modipuram farm for three seasons. The crop was harvested 60 and 75 days after sowing; and at full maturity 90 days after sowing. At each stage, the tuber yield was recorded and the tubers were analysed for their dry matter, true protein, free amino acids, reducing sugars and phenolic contents. The results indicated that it was advantageous to harvest the crop at full maturity, because, at this stage the tubers have the highest dry matter and protein contents and the lowest reducing sugars and free amino acid contents.

INTRODUCTION

With the ever increasing productivity and production, there are occasional slumps in potato prices due to temporary gluts which occur during the harvesting season.

Many a time the farmers prefer to harvest their crop much before it is fully mature and thus they do not realise the full yield potential of the cultivars. The loss in yield, however, is compensated for by the high prices that prevail in the market just before the main harvesting season. Systematic information on the effects of early harvest on the processing attributes of potato tubers is, however, not available. With a view to generating information on this aspects, experiments were conducted at the Central Potato Research Station, Modipuram, Meerut (U.P.) during three crop seasons and the results obtained are discussed in this paper.

MATERIALS AND METHODS

Five varieties viz. Kufri Bahar, Kurfi Chandramukhi, Kufri Jyoti, Kufri Lauvkar and Kufri Lalima and three pre-release cultivars viz. JE 808, MS77/x-15 and MS77/x-1 were grown at the Central Potato Research Station, Modipuram, farm in randomised block design with three-replications. The experiments were conducted in three successive crop seasons commencing 1982-83. The standard package of cultural practices recommended for the region was followed. The sowing was done during 15-18 October every year. The N:P:K were applied @ 120:80:80 kg/ha. The nitrogen was applied in split dose, half at the time of sowing and the remaining half at the time of

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earthing up. The crop was harvested premature at 60 and 75 days after sowing and at full maturity, 90 days after sowing. The tuber yield was recorded at each date of harvest. The tubers were allowed to cure in dark for 100 h. Ten tubers, 4-6 cm in diameter, were selected from each replication for chemical analysis.

The tubers were first cut into halves from heel to rose end. One set of halves was used for determination of dry matter while portions of the other set were used for the determination of true proteins and for extracting reducing sugars, free amino acids and phenolics. The tuber halves were cut into small dices (0.5 cm) and dices from a set of halves were pooled to obtain a composite sample, referred to as "sample" hereinafter.

Dry matter was determined by oven-drying 100 g of sample at 105°C for 18 h. The true protein content was determined by the method of Swaminathan *et al* (7). Reducing sugar, free amino acids and phenolics were extracted twice from 10 g of sample by refluxing for 1 h with isopropanol and then making the volume 100 ml. The phenolics in the extract were determined by the Folin Denis reagent (3). The reducing sugars and free amino acids were first obtained in aqueous solution after evaporating isopropanol and then estimated by arsenomolybate (8) and ninhydrin (2) reagents, respectively.

RESULTS AND DISCUSSION

The genotypes differed significantly in their dry matter, true protein, free amino acids, reducing sugars and phenolic contents of tubers. The mean-squares due to seasons were highly significant for all the characters studied, thus indicating a significant variation in the characters due to crop seasons. The mean squares due to stages of crop maturity were also highly significant for dry matter, true protein, free amino acids and reducing sugars showing that these constituents of tubers were highly influenced by the stages of crop maturity (Table 1).

In general, the dry matter and protein contents of potato tubers were the lowest when harvested early at 60 DAS and increased significantly upto 90 DAS (Table 2). The increase during 60 to 75 DAS was much more than that registered during 75 to 90 DAS. The amino acids exhibited a drastic increase during 60 to 75 DAS, followed by a sharp decrease afterwards. The reducing sugars were highest at 60 DAS, followed by a steep decline during 60 to 75 DAS to reach half the initial value. The reducing sugars further declined during 75 to 90 DAS, and at 90 DAS remained almost one-third of its content at 60 DAS. There was no significant change in the phenolic content of potato tubers during 60 to 90 DAS.

Table 1. ANOVA of 8 genotypes of potato grown over 3 seasons and harvested at three stages of crop maturity of for five tuber characteristics

Sources of variation	d.f.	Mean sum of squares				
		Dry matter g	True protein mg	Free amino acids mg	Reducing sugars mg	Phenolics mg
Genotypes	7	12.5**	34420**	35443**	155460**	684.8*
Seasons	2	46.4**	1451506**	86806**	1516032**	10436**
Replications	2	1.6	11871	3267	3664	28.9
Error (a)	14	0.8	3742	4059	14384	68.9
Total	25					
Stages	2	53.8**	576496**	1001792**	5245942**	182.5
Genotype x stages	14	0.7	8549	6388	28295	95.6
Genotype x season	14	1.0	8729	3649	35970	98.1
Error (b)	160	0.8	5991	5460	27383	79.6
Total	215					

Table 2. Effect of stages of crop maturity on tuber yield and composition (averaged over three crop seasons and eight genotypes)

Stages of crop maturity DAS	Tuber yield q/ha	Content per 100 g fresh weight				
		Dry matter g	True protein mg	Free amino acids mg	Reducing sugars mg	Phenolics mg
60	160	18.16	707	174	748	59
75	230	19.48	817	380	334	57
90	298	19.78	885	177	242	55
Mean	229	19.14	803	244	441	57
CD (p=0.05)	19	0.29	25	24	54	NS

A comparison of yield and chemical composition of genotypes is shown in table 3. The tuber yield of genotypes ranged from 199 to 246 q/ha and the tuber dry matter 17.81 to 19.78%. The tubers of Kufri Lalima while being at par with with Kufri Lauvkar, Kufri Chandramukhi, Kufri Bahar and MS/77/x-1 contained significantly more dry matter than the mean and the remaining three genotypes. The true protein content of tubers ranged from 749 to 846mg/100g. Tubers of variety Kufri Jyoti while being at par with Kufri Bahar, Kufri Lauvkar, MS/77/x-1 contained significantly higher protein than the mean and the remaining four genotypes. The free amino acid content of tubers of genotypes ranged from 203 to 296 mg/100g. The tubers of MS/771x-15 while being at par with Kufri Lalima, JE 808 and Kufri Bahar contained significantly less free amino acids than the mean.and MS/77/x-1, Kufri Chandramukhi, Kufri

Table 3. Yield and chemical composition of tubers of eight genotypes (averaged over three crop seasons and three stages of crop maturity)

Genotype	Tuber yield q/ha	Content per 100g fresh weight				
		Dry matter %	True protein mg	Free amino acids mg	Reducing sugar mg	Phenolics mg
Kufri Bahar	245	19.4	834	223	475	50
Kufri Chandramukhi	214	19.5	775	277	477	55
Kufri Jyoti	241	17.8	846	296	337	62
Kufri Lauvkar	235	19.6	832	278	313	56
Kufri Lalima	246	19.8	749	211	458	66
JE 808	226	18.4	804	212	527	58
MS/77/x-15	228	19.3	767	203	496	58
MS/77/x-1	199	19.3	818	250	445	53
Mean	229	19.1	803	244	441	57
CD (p=0.05)	36	0.5	36	37	70	5

Lauvkar and Kufri Jyoti. The reducing sugar content of tubers ranged from 313 to 527 mg/100g. Tubers of Kufri Lauvkar while being at par with Kufri Jyoti contained significantly less reducing sugars than the mean and the remaining six genotypes. The phenolic contents ranged from 50 to 60 mg/100g. The tubers of Kufri Bahar while being at par with Kufri Chandramukhi and MS/77/x-1 contained less phenolics than the mean and the other five genotypes.

Potatoes with more dry matter and less reducing sugars are preferred for chip making (1). Accordingly, among the eight genotypes evaluated, from processing point of view, Kufri Lauvkar was adjudged to be the best while Kufri Lalima with a high dry matter content and a medium reducing sugar level was considered the second best.

The levels of dry matter, true protein, free amino acids and phenolic contents obtained in the present investigations are in conformity with those reported earlier for Indian varieties (4, 6). It is now a well established fact that early harvesting of crop results in lower tuber yield. It has also been shown that early harvested tubers have a lower protein content (9) and a lower dry matter content (5). The results of the present experiements support these obervations.

It could thus be concluded that though the varieties differed in their processing attributes and protein content, it would be desirable to harvest the potato crop at full maturity irrespective of the variety. For, only at full crop maturity, besides maximum tuber yield, tubers with highest dry matter and protein contents and lowest reducing sugars content are realised.

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LITERATURE CITED

1. Habib, A.T. and H.D. Brown. 1957. Role of reducing sugars and amino acids in browning of potato chips. *Food Technol.* 11: 85-89.
2. Lee, Y.P. and T. Takahashi. 1966. An improved colorimetric determination of amino acids with ninhydrin. *Analytical Biochem.* 14: 71-77
3. Johnson, G. and L.A. Schaal. 1957. Accumulation of phenolic substances and ascorbic acid in potato tuber upon injury and their possible role in disease resistance. *Am. Potato J.* 200-9.
4. Marwaha, R.S. 1987. Evaluation of some potato cultivars for processing on the basis of their chemical composition. *J. Indian Potato Assoc.* 14: 9-16.
5. Singh, J., M.P. Singh, R.P. Rajput and D.B. Singh. 1983. Effect of method of planting, nitrogen application and time of harvesting on potato crop in Central India. *J. Indian Potato Assoc.* 10: 10-15.
6. Swaminathan, K. and Pushkarnath. 1962. Nutritive value of Indian potato varieties. *Indian Potato J.* 4: 76-83.
7. Swaminathan, K., K.C. Sud and H. Kishore. 1973. Rapid photometric method for the determination of true protein content of potato based on non-selective dye binding capacity. *Indian J. Expl. Biol.* 11: 63-64.
8. Somogyi, M. 1945. A new reagent for determination of sugars. *J. Biol. Chem.* 160: 61-68
9. Varis, E. 1970. Variation in the quality of table potato and the factors influencing it in Finland. *Acta Agr. Fenn.* 11: 1-99.

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ECONOMIC ANALYSIS OF PRODUCTION OF RIVERBED AND FIELD POTATO IN DEESA TALUKA, GUJARAT

P.K. Singh[1], B.H. Kakadia[2] and V.M. Patel[3]

ABSTRACT: Productivity of potato crop under riverbed cultivation is about 330 q per hectare which is about 50 per cent higher than under field situation. Cultivation of potato both under riverbed and fields is a profitable proposition but it requries heavy investment too. Farmers faced many constraints in the availability of inputs. Area has potential to produce even high yields of potato which may be achieved by relaxing the constraints in farm supplies.

INTRODUCTION

Potato is not only an important cash crop but also a rich and cheap source of nutrients. Not only its cultivation is labour intensive but it has potential for providing off farm employment too. Gujarat with 2.39 per cent of total potato production ranks only seventh in the country but productivity-wise the State stands first. In the State, the crop is being raised under irrigated conditions in the fields as well as on riverbeds. The productivity of crop in riverbed in general is much more than that in fields. Most of the studies in the past have concentrated mainly on the production of potato in fields under irrigated situation and little is known about its riverbed cultivation. It is in this perspective that the present study was initiated in Deesa Taluka of Gujarat to study the pattern of input use in potato cultivation, and to estimate the cost of cultivation and returns from the potato cultivation.

MATERIALS AND METHODS

All potato growing villages of the Deesa Taluka were arranged in ascending order according to area under the crop. From the list, a sample of 10 per cent villages i.e., four in number, was taken based on potato area. Next, all potato growers of the chosen villages were categorised according to holding size into marginal (possessing upto one ha land), small (owning one h to two h of land), medium (two to four h of land) and large (operating more than four h land) size group. For the selection of growers in riverbed the allottees were grouped into two categories i.e., small, cultivating upto 1 ha land and large, cultivating one ha and above. Of the farmers growing potato in field a sample of 10 per cent growers with a minimum of 10 growers was taken at random for each size group. Thus, a sample of 10 marginal, 17 small, 29 medium and 21 large farmers was taken. Likewise from riverbed 11 small and 15 large farmers were chosen.

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The total sample consisted of 104 potato growers of which 78 cultivated the crop in field and remaining 26 in riverbed. The required data on production pattern, crop operations, input availability, etc. were collected from the sample farmers through personal interview in two rounds on a well-structured schedule questionnaire. The data pertained to the agricultural year 1984-85. For achieving the objectives, simple tabular analysis was done. For the comparison of cost of cultivation of field and riverbed potato on different farm sizes different cost concepts viz. Cost A (i.e., out of pocket expenses which included cost of seed, manure, fertilizers, hired labour, bullocks, tractor, pesticides, irrigation, depreciation on farm assets, interest on working capital, land revenue, etc.), Cost B (Cost A plus rental value of owned land) and Cost C which is the total cost and included cost B plus computed value of family labour were used.

RESULTS AND DISCUSSION

Of the 118 thousand ha of the total operated area of the taluka about 39 per cent was irrigated. During 1984-85 the taluka had 2287 ha and 972 ha under field and riverbed potato crop respectively.

Table 1. Operationwise human labour use in potato cultivation (percentage of total labour use)

Farm Operations	Field Potato					Riverbed Potato		
	Farm					Size		
	Marginal	Small	Medium	Large	Average	Small	Large	Average
1. Primary tillage/Seedbed preparation	7.3	7.4	6.2	5.8	6.2	7.3	8.4	8.2
2. Application of F.Y.M., cakes & fertilizers	8.9	8.6	10.0	9.6	9.6	8.7	8.1	8.2
3. Sowing, etc.	25.3	25.8	26.5	27.8	26.9	40.1	38.9	39.2
4. Irrigation	8.7	8.1	8.8	7.6	8.23	-	-	-
5. Interculture, earthing, etc.	15.9	16.5	12.3	13.7	13.5	-	-	-
6. Plant-protection	0.9	0.7	00.5	0.5	0.6	1.1	0.6	0.7
7. Watch and ward	-	-	-	-	-	3.3	2.8	2.9
8. Harvesting	32.6	32.7	35.4	34.7	34.6	39.2	40.8	40.6
Total labour use	100 (216)	100 (221)	100 (200)	100 (193)	100 (199)	100 (255)	100 (249)	100 (250)

Figures in parentheses indicate the use of total labour days per hectare.

The operated area of the field potato growers ranged from 0.72 to 5.94 ha with the overall average being 2.74 ha. Their cropped area varied from 1.67 h to 9.67 ha. The area under field potatoes as a percentage of total cropped area was 15 per cent and minimum on large size group and maximum on medium group (i.e., 21.12 per cent). On marginal and small categories of growers it was 21 per cent and 17 per cent respectively. The average farm of riverbed potato grower ranged from 0.85 ha on small group to 5.12 ha on large group. The allotted riverbed area on the two categories was 0.85 ha and 4.31 ha, respectively. The respective cropped area was 1.81 ha and 7.09 ha. The riverbed cultivators put about 11 and 30 per cent respectively of their cropped area under potato crop.

Input use pattern: The use pattern of human labour, bullock labour and fertilizers in potato cultivation is discussed below.

(a) Human labour use: Farm operationwise use pattern of human labour is given in Table 1. In case of field potato the use of labour ranged from 193 days per ha on large farms to 221 days per ha on small size farms with marginal and medium size farms using 216 and 200 man days respectively. Of all the farm operations harvesting accounted for the maximum labour use on all groups. This operation accounted for 32.7 per cent of total labour use on both marginal and small, 34.7 per cent on large farms and 35.4 per cent on medium farms. Other important operations from the view point of labour use were sowing and interculture and earthing. Share of sowing in total labour use ranged from 25.36 to 27.89 per cent on different sizes of farms and that of interculture and earthing from 12.34 per cent to 16.51 per cent. Irrigation, application of farm yard manure, etc. and field preparation were other important operations where labour need was substantial.

The riverbed cultivation require on an average 250 labour days per hectare. Thus, the use of human labur was more in riverbed cultivation than in field cultivation. In riverbed the lion's share of labour use went to sowing and harvesting operations. The share of sowing on small and large farms was 40 and 39 per cent, respectively. Similarly the share of harvesting was found to be 39 per cent on small and 41 per cent on large farms. Among other imporatnt farm operations the levelling of riverbed for

Table 2. Farm sizewise use pattern of bullock labour and fertilizer nutrients in potato crop

Farm size	Bullock labour (days)	Nutrients (kg/ha) N	P	K
Field Potato				
1. Marginal	18.5	101.3	85.0	90.0
2. Small	15.0	121.0	89.5	85.9
3. Medium	13.0	117.2	92.0	82.0
4. Large	11.2	109.2	84.6	92.1
All farms	14.0	113.1	88.0	87.3
Riverbed Potato				
1. Small	31.0	180.0	138.0	150.3
2. Large	28.0	187.1	145.9	123.0
All farms	29.0	185.8	144.4	127.9

the preparation of seedbed and the application of F.Y.M. and fertilizers accounted for about 7.33 and 8.78 per cent of the total labour utilization on small farms and 8.46 and 8.14 per cent on large farms, respectively.

(b) Bullock labour use: As is seen in table 2 the riverbed potato required more bullock labour than the field potato. The per hectare requirement of bullock labour input for the former was about 31 days and 28 days on small and large farms respectively. For field cultivation the requirement ranged from 11 days on large farm, to 18.5 days on marginal size farm. It was observed that the use of bullocks declined with the increase in farm size.

(c) Fertilizer use: in addition to the application of farm yard manure and oilseed cakes in potato crop the growers also used chemical fertilizers. Farm sizewise per hectare use of nitrogen (N), phosphorus (P) and potash (K) through fertilizers is given in table 2. As is evident from the table the use of nutrients was more in riverbed than in field crop. In riverbed, the per hectare use of N, P and K was in the range of 180 to 187 kg., 138 to about 146 kg. and 123 to 150 kg. respectively. At the average level the growers used about 186 kg. N, 144.5 kg. P and about 128 kg. K per ha in riverbed crop. In field, the per ha application of nutrients on different size farms was in the range of 101 to 121 kg., 85 to 92 kg. and 82 to 92 kg., respectively.

Table 3. Farm size and itemwise cost of cultivation of potato (percentage to total cost)

Items of Cost		FIELD POTATO					RIVERBED POTATO		
		Marginal farms	Small farms	Medium farms	Large farms	All farms	Small farms	Large farms	All farms
1.	Hired human labour	8.0	9.7	9.7	10.3	9.8	12.2	12.4	12.3
2.	Bullock labour	3.6	2 9	2.5	2.3	2.5	5.1	4.4	4.5
3.	Tractor	2.2	3.5	4.6	5.0	4.5	14.0	12.5	12.8
4.	Seed	27.6	26.7	27.8	26.6	27.1	28.2	25.6	26.0
5.	Manure & Cakes	5.9	5.8	5.6	5.4	5.6	7.7	8.2	8.1
6.	Fertilizers	7.8	8.5	9.1	8.5	8.7	13 8	13.4	13.4
7.	Pesticides	0.6	0.3	0.5	0.5	0.5	0.6	0.5	0.5
8	Irrigation	10.2	9.8	9.0	10.0	9.6	-	-	-
9.	Depreciation on farm assets	6.1	4.7	4.5	5.0	4.8	0.8	1.1	1.1
10.	Interst on working capital	2 7	2.7	2.7	2.7	2.7	3.3	3.1	3.2
11.	Land revenue & taxes	0.1	0 1	0 1	0.1	0.1	7 9	13.8	12.7
12.	Miscellaneous costs	0 3	0.5	0.0	07	0.6	1.9	1.9	1.6
	Cost-A	75.2	75.3	77.2	77.5	77.0	96.0	97.3	97.1
13.	Rental value of owned land	19.3	26.3	19.1	19.2	19.3	-	-	-
	Cost-B	94 5	95 6	96.4	96.7	96.3	96.0	97 3	97.1
14.	Value of family labour	5.5	4 4	3.5	3.2	3.6	3.9	2.6	2.8
	Total Cost (Rs. per hectare)	15580.1	15637 0	15107 6	14376.5	14855.2	15905.4	16843.1	16673.5

Cost of cultivation: Itemwise, cost of cultivation of potato crop is given in table 3. The average per ha cost of cultivation in field was Rs. 14, 855 of which out of pocket expenses accounted for about 77 per cent. Among the items of cost, seed, irrigation, hired human labour and fertilizer were most important and accounted for about 27, 9.6, 10 and 8.7 per cent of the total cost, respectively. Other important items together with their share in total cost were farm yard manures and oilseed cakes (5.6%), tractor power (4.5%) and bullock labour (2.5%). The share of imputed value of owned inputs such as rental value of land and family labour was 19.3 and 3.6 per cent, respectively. The maximum per h cost of cultivation of Rs. 15,637 was incurred by small farmers followed by marginal farmers with Rs. 15,580, medium farmers with Rs. 15,107 and large farmers with Rs. 14,376.

The average per hectare cost of cultivation of riverbed potato was about Rs. 16,673 of which cost-A accounted for about 97 per cent and the remaining about 3 per cent was shared by the imputed value of family labour. Amongst the cost items seed with about 26 per cent of the total cost was the single most important input. It was followed by fertilizer with about 13.5 per cent, tractor charges and revenue of the allotted land each with 12.8 per cent, hired human labour with about 12.4 per cent, manure and cakes with about 8 per cent and bullock power with about 4.5 per cent of the total cost. There was significant variation in the amount of revenue paid for the allotted riverbed land by the small and large farmers. It was because of the reason that some small allotees sub-let their parcels of riverbed to large farmers at higher rates. The table also revealed that the riverbed cultivators spent more on hiring the tractor, bullock and human labour and also on fertilizer, FYM and cakes in comparison to the field growers of potato.

Table 4. Farm sizewise productivity and returns from potato (per hectare)

Farm	Productivity (q)	Gross return (Rs)	Net returns over		
			Cost A (Rs.)	Cost B (Rs.)	Cost C (Rs.)
Field Potato					
Marginal	228.7	18759.1	7044.9	4043.4	3179.0
Small	225.8	19878.3	8110 7	4930.2	4241.3
Medium	229.0	18091.7	6416.1	3521.4	2984.1
Large	215.8	17269.6	6120.4	3357.3	2893.0
Average	222.7	17931.44	8482.8	3613.8	3076.2
Riverbed Potato					
Small	335.0	31828.8	16545.5	16545.5	15923.3
Large	329.8	29359.3	12964.4	12964.4	12516.2
Average	330.8	29805.8	13612.0	13612.0	13132.3

Returns from potato cultivation: As given in table 4 the per hectare average productivity of field grown potato was about 222 q. The productivity varied from about 216 q on large farms to 226 q on small farms, about 229 q on marginal and medium size farms. The per hectare gross returns were Rs. 17,931. Average net returns over Cost A, Cost B and Cost C were about Rs. 8483, Rs. 3614 and Rs. 3076 per ha respectively.

Average productivity of riverbed potato was about 331 q per ha. The productivity of riverbed crop was about 48 per cent higher than the field crop. The per hectare average gross returns of the former were Rs. 29,806. The average net returns over Cost A, Cost B and Cost C concept were Rs. 13,612, Rs. 13,612 and Rs. 13,132 respectively. Thus, the cultivation of crop both in field and riverbed was a profitable proposition.

CONCLUSIONS

The study revealed that the cultivation of potato in riverbed relative to field required more human and bullock labour. The average per ha labour employment in the former crop for operations like seedbed preparation, application of FYM, fertilizers, etc., sowing and harvesting was 20.62, 20.65, 98 and 101.52 days, respectively, as against this the labour use in field crop for these operations was 12.65, 15.86, 53.69 and 69 days per ha, respectively. It was also found that the use of fertlizer nutrients was also more in riverbed. The average per hectare cost of cultivation was Rs. 14,855 in field and Rs. 16,673 in riverbed. The average productivity was 222 q, and 331 q, respectively. The per hectare net returns from the former were about Rs. 3076 and Rs. 13,132 from the later. The average price of field and riverbed potato was about Rs. 80.50 and Rs. 90 per quintal, respectively. The tubers produced in riverbed fetched higher price due to their large size. Difference in the month of sale, i.e. 83.5 per cent of field potato was sold in March-April and 85 per cent of riverbed crop was disposed of in April-May, also caused the price differnce. In the area there is problem of inadequate and untimately availability of quality seed tubers. Farmers also faced the problem in the availability of fertilizer, diesel and electricity. Potato cultivation in riverbed is highly profitable but the preparation of seedbed in riverbed is labour intensive. It also requires huge investment on tractor charges which small farmers find difficult to meet. The taluka/zilla Panchayats may therefore make some provision for levelling the rivered while allotting it to the growers of weaker sections.

During the survey it was found that many growers were not aware of the improved varieties and recommended practices of potato cultivation particularly under riverbed sitaution. In certain cases farmers applied nutrients in excess of recommended levels. Therefore, there is need to bridge the gap in the technical know how of potato growers.

Potato harvesting is labour intensive. Harvesting cost may be lowered if potato digger suitable to the local needs is made available.

LITERATURE CITED

1. Anonymous. 1984. Economics of potato production in Kheda District, Gujarat. Department of Agric. Econ., B.A. College of Agric., GAU., Anand Campus, Anand.

2. George, P.S. and S.N. Chokshi. 1973. The Sabarmati Riverbed Potato System, C.M.A., Indian Institute of Management, Ahmedabad

3. Singh, P.K. 1987. Economic analysis of potato production under riverbed & field conditions of Deesa Taluka, Dist. Banaskantha. *Ag. Econ. Publication No.* 4, Dept. of Agric. Econ., GAU., Sardar Krishi Nagar.

4. Tripathi, R.S. 1991. Economics of potato cultivation in high hills of U.P. *J. Indian Potato Assoc.* 18: 142-46.

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SHORT NOTE

EFFECT OF IRRIGATION SCHEDULES AND FERTILIZER LEVELS ON TUBER YIELD OF POTATO*

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

Potato crop is grown during *rabi* season in eastern dry zone (Zone-5) of Karnataka with well or lift irrigation, where irrigation water is limited/scarce and costly input. The sandy loam soils (Alfisols) of this region are generally poor in nutrients (low in N and medium in P_2O_5 and K_2O). The available moisture storage capacity is also low. Hence, a proper irrigation schedule coupled with an appropriate fertilizer level assumes prime importance to utilize this scarce resource in order to increase the tuber yield of potato. Increase in frequency of irrigation increases the tuber yields by increasing the tuber size (1, 6). Marked responses of potato crop to higher fertilizer levels have also been reported by earlier workers (5, 7). The present investigation reports on a suitable irrigation schedule with suitable fertilizer level for potato crop.

Two trials were carried out at Main Research Station, University of Agricultural Sciences, Bangalore, during *rabi* seasons of 1985-86 and 1986-87 on red sandy loam soil (Alfisol). The pH of surface soil was 6.7 with low organic carbon (0.56%), total N (0.049 %) and medium available P_2O_5 (30.7 kg/ha) and K_2O (212.5 kg/ha). Six treatment combinations involving two depths of irrigation (20 and 40 mm) at 0.75 IW/CPE ratio 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) were tried in a split-plot design with four replications. Two depths of irrigation at 0.75 IW/CPE were tried in the main plot, while three fertilizer levels were included in the sub-plots. The net plot size was 6.8 m x 3.2 m. Cut seed pieces of cv. Kufri Jyoti weighing approximately 35 to 40 g were planted in furrows with a spacing of 40 cm x 20 cm. As per treatments, 50 per cent N and entire dose of P_2O_5, K_2O and FYM were applied in furrows at planting, 10 cm below the tubers. The crop was top dressed with the rest of N, four weeks after planting.

The evaporation was recorded from USWB Class 'A' Open Pan Evaporimeter. Irrigation was commonly given to the crop upto four weeks and subsequent irrigations were given as per the treatments. Irrigation water was measured and conveyed through polythene lined irrigation channels. Girth of tubers of all the five randomly selected and labelled plants was recorded. The average of all the tubers from five plants was

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considered as the average girth of tuber. Maximum circumference (measurement around the tuber) of each tuber was considered as girth and was recorded with a thread stretched on the scale. Tuber yield and its attributes were analysed for each year and also by pooling the data. The results have been discussed using pooled data.

Table 1. Effect of irrigation schedules and fertilizer levels on tuber yield and its attributes in potato

Treatments	Tuber girth (cm)			Tuber yield (q/ha)		
	1985-86	1986-87	Pooled	1985-86	1986-87	Pooled
Irrigation schedules						
D_1 : 20 mm at 0.75 IW/CPE	11.1	11.2	11.1	173.7	195.0	184.4
D_2 : 40 mm at 0.75 IW/CPE	10.3	10.5	10.4	121.9	146.6	134.2
C.D. (0.05)	NS	NS	NS	21.8	25.4	12.9
Fertilizer levels						
N - P_2O_2-K_2O (kg/ha)						
F_1 : 50 - 50 - 50	10.4	10.4	10.4	141.3	143.9	142.6
F_2 : 100-100-100	10.8	10.6	10.7	149.7	170.5	160.1
F_3 : 150-150-150	10.9	11.5	11.2	152.4	197.9	175.2
C.D. (0.05)	NS	0.9	NS	NS	12.5	12.7

NS : Not significant

When two depths were compared at 0.75 IW/CPE ratio, 20 mm gave significantly higher yields (184.4 q/ha) than 40 mm (134.2 q/ha). This might be related to the increase in the number of tubers per plant from 5.0 to 5.3 and tuber girth from 10.4 cm to 11.1 cm. Similar results were obtained by Bradley and Pratt (1). Further, this might probably be attributed to the high availability of moisture and increase in uptake of nutrients from surface layers which in turn might have appreciably enhanced the yield components, ultimately resulting in higher yields in high frequency of irrigation (Tables 1 and 2).

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

Fertilizer levels (F)	Irrigation schedules (D)	
	D_1	D_2
N - P_2O_2 - K_2O (kg/ha)		
F_1 : 50 - 50 - 50	163.6	124.3
F_2 : 100 - 100 - 100	184.6	156.4
F_2 : 150 - 150 - 150	236.7	159.2
C.D. (0.05)		
Comparison of F within the same level of D	17.6	
Comparison of D within the same level of F	28.7	

D_1 = 20 mm at 0.75 IW/CPE
D_2 = 40 mm at 0.75 IW/CPE

As reported by Grewal and Sharma (4), potato crop being shallow and sparse rooted, takes up moisture from a maximum depth of 30 to 45 cm. Since the available moisture storage capacity of sandy loam soil (Alfisols) 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. According to Singh and Singh (6), increase in frequency of irrigation also increased the tuber yields.

The tuber yields also increased significantly with increase in the fertilizer levels in both the years (Table 2). Tuber yield obtained was significantly higher (175.2 q/ha) with higher fertilizer level of 150:150:150 kg N, P_2O_5 and K_2O per ha as compared to medium and lower fertilizer levels. These results are in accordance with the findings of several earlier workers (5, 7). Tuber yields increased due to increase in the number of tubers per plant and tuber girth with higher level of fertilizers. These results are in agreement with the findings of Singh *et al.* (2) and Govindakrishnan and Sahota (3). Viets (8) reported that fertilization permits deeper penetration of roots facilitating greater extraction of water. Finally, nutrients and soil moisture interact, leading to higher yields due to increase in the fertilizer levels.

Thus in the present study, higher fertilizer level (150 : 150 : 150) has increased the yield of potato with high frequency irrigation given at lower depth as compared to lower fertilizer levels.

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LITERATURE CITED

1. Bradley, G.A. and A.J. Pratt. 1955. *Amer. Potato J.* 32: 254-58.
2. Singh, D., Mukhtar Singh and H.S. Sandhu. 1979. *Indian J. Agric. Sci.* 49: 641-48.
3. Govinda Krishnan, P.M. and T.S. Sahota. 1984. *J. Indian Potato Assoc.* 11: 26-30.
4. Grewal, J.S. and R.C. Sharma. 1984. *Potash Rev.* 11: 1-5.
5. Kailash, CH Dal and S. Nayak. 1980. *Orissa J. Hort.* 8: 13-20.
6. Nirmaljit Singh, and Harnam Singh. 1981. *J. Indian Potato Assoc.* 8: 35-36.
7. Roy, R.K. and R.S. Tripathi. 1986. *Annals agric. Res.* 7: 114-23.
8. Viets, F.G. Jr. 1962. *Adv. Agron.* 14: 223-64.

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SHORT NOTE

THE INTRINSIC RATE OF NATURAL INCREASE OF THE POTATO TUBER MOTH ON STORED POTATOES

Usha Chauhan[1], K.C. Sharma[1] and L.R. Verma[2]

The potato tuber moth, *Phthorimaea operculella* Zeller (Lepidoptera: Gelechiidae) is one of the most serious pests of potato throughout the country and causes heavy loss in field and storage (6). Larvae mine the foliage, stem and tuber in the field as well as under storage. Recently this pest has been found to infest stored potato seriously from various parts of Himachal Pradesh. Studies were, therefore, undertaken during May-June, 1992 on developing life table of *P. opercullella* so as to determine its true intrinsic rate of increase. The information thus gathered would be utilized in pinpointing the stage in the life cycle contributing most toward mortality and would provide base for future study on factors regulating populations in the field.

To initiate stock cultures, adults and larvae of *P. operculella* were collected from the field and were kept in plastic jars (9 cm dia), tops of which were covered with black muslin cloth, which acts as an ideal ovipositional substrate (5). Potato tubers and a cotton soaked in 5% sugar solution were also kept inside jars as food for adults. Adults which emerged on a particular day were kept in pairs in glass chimney (20 x 15 cm). Single pair was kept in one glass chimney and these were further reared as per method described earlier for adults. Fifteen such pairs were thus maintained. The observations were started as soon as the females started ovipositing and ended with the death of last female. The mean number of eggs laid per day was worked out and average fecundity was calculated. Sex ratio 1:1.1 (♀:♂) was used to determine the number of female eggs. Observations were also recorded on age-specific mortality in the egg, larval, pupal and adult stages. The life table was prepared as per method outlined by Birch (3). The true intrinsic rate of increase was calculated through graphical method as suggested by Andrewartha and Birch (2) and Southwood (7). The true generation time (T) and finite rate of increase and time taken to double the population was calculated. The whole experiment was conducted at temperature ranging from 22-28°C.

The data on the reproductive potential of *P. operculella* are presented in Table 1. The maximum longevity of ovipositing female was 14 days and the maximum

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Table 1. Life-table (for females) of *Phthorimaea operculella* on stored potato

Pivotal age (days) x	Survival of females at diferent intervals		No. of females female		Trial rm	
	lx	mx	lxmx	x lxmx	0.14 e^{7-rmx} lxmx	0.16 e^{7-rmx} lxmx
0-23	Immature stage, pre-oviposition period					
24	0.60	3.429	2.057	49.368	78.355	48.485
25	0.60	23.238	13.943	348.575	461.729	280.053
26	0.60	17.333	10.400	270.400	299.408	178.004
27	0.60	13.426	8.056	217.512	201.627	117.498
28	0.60	13.524	8.114	227.192	176.548	100.846
29	0.60	11.429	6.857	198.853	129.706	72.622
30	0.60	4.574	2.744	82.320	45.124	24.765
31	0.60	4.762	2.857	88.567	40.844	21.972
32	0.50	4.190	2.095	67.040	26.038	13.730
33	0.40	1.619	0.648	21.384	7.002	3.619
34	0.30	0.857	0.257	8.738	2.414	1.223
35	0.20	0.286	0.057	1.995	0.465	2.231
36	0.20	0.286	0.057	2.052	0.405	0.197
37	0.20	0.00				
38	0.00					
Total		98.953	58.142	1583.996	1469.665	863.245

reproductive period was 13 days. There was 60 per cent survival at the time female started laying eggs and the survival rate decreased after eighth day of oviposition, thereafter, a negative trend in the oviposition was observed. The mean progeny during the entire reproductive period was 98.953 while the net reproductive rate (Ro) was 58.142. The value of net reporductive rate (Ro) represanting the ratio of total female birth was lower than the gross reproductive rate. The variation could be due to decrease in survival value (lx) for the parent females, most of which, died earlier than the maximum life span of 37 days. The species had the capacity for natural increase (rc) of 0.149. The true instrinsic rate of increase (rm) which was determined graphically was found to be 0.153 (Figure 1), which is higher than 0.09, as reported by Abdel Wahab *et al* (1) for summer generation from Egypt. This difference may be attributed to the effect of fluctuating temperatures which is known to stimulate the rate of development (4). The finite rate of increase was found to be 1.165, thus the species would multiply 1.165 times a day and would be able to multiply 2.918 times every week (Table 2). The time taken for completing a generation was 26.55 days, and the doubling time of population was 4.54 days.

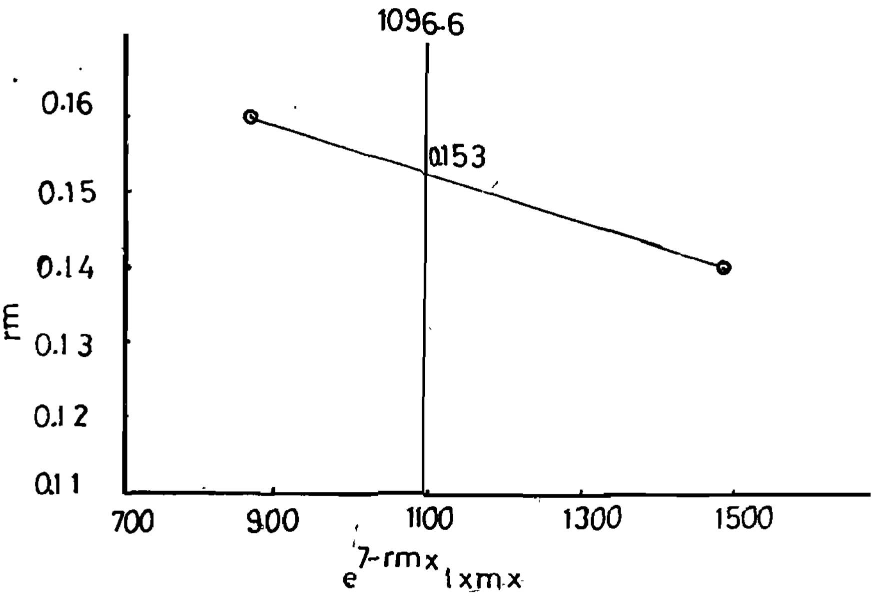

Figure 1. Determination of the true intrinsic rate of increase of *P. operculella* on potato

Table 2. Population growth statistics of *P. operculella*

Gross reproductive rate (GRR)	$= \Sigma$ mx = 98.953 female eggs/female
Net reproductive rate (Ro)	$= \Sigma$ 1 xmx = 58.142 female eggs/female
Mean length of generation (Tc)	$= \Sigma \frac{xlxmx}{Ro}$ = 27.24 days
Innate capacity for increase in number (rc)	$= \frac{\log_e Ro}{Tc}$ = 0.149
The intrinsic rate of increase (rm)	$= e^{7-rm}$ lxmx (at 1096.6) = 0.153
Corrected generation time (T)	$= \frac{\log_e R_o}{rm}$ = 26.55 days
Finite rate of increase in number (λ)	= anti $\log_e rm$ = 1.165 females/day
Weekly multiplication of population	$= (e^{rm})^7$ = 2.918
Doubling time (DT)	$= \frac{\log_e^2}{rm}$ = 4.54 days

LITERATURE CITED

1. Abdel-Wahab, M.A., F.A., Addel-Galil, F.M. Khalil and N.M. Soliman. 1987. *J. Agric. Sci.* 18: 255-61.
2. Andrewarth, H.G. and L.C. Birch. 1954. *The Distribution and Abundance of Animals*. Univ. Chicago Press, Chicago, 782 pp.

3. Birch, L.C. 1948. *J. Anim. Ecol.* 17: 15-26.

4. Cloudseley-Thompson, J.L. 1953. *Entomologist* 86: 183-89.

5. Fenemore, P.G. 1978. *N.Z.J. Zool.* 5: 591-99.

6. Saxena, A.P. and S.M.A. Rizvi. 1974. *J. Indian Potato Assoc.* 1: 45-50.

7. Southwood, T.R.E. 1976. *Ecological Methods with particular reference to the study of Insect Population.* Mathuen and Company Ltd., London, 391 pp.

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SHORT NOTE

EFFECT OF NITROGEN LEVELS AND HAULMS CUTTING DATES ON NUTRIENT CONCENTRATIONS AND UPTAKE IN DIFFERENT PLANT PARTS OF POTATO*

S.N.S. Chaurasia[1] and K.P. Singh[2]

Among major nutrient elements, nitrogen play a very important role in propagating vegetative growth and hence yield of potato crop. As accumulation of nitrogen in the soil is generally low and at the same time its requirements to the plants is rather high particularly where growing season has to be arbitrarily shortened by harvesting the crop at immature stage for early marketing. In such circumstances the nitrogen play an important role in nutrient concentration and uptake in potato and also enhancing quick bulking of potatoes. Therefore, the present studies were conducted to evaluate the effect of various nitrogen levels and haulms cutting dates on N, P, K concentrations and their uptake in different plant parts of potato.

An experiment with four levels of nitrogen (0, 50, 100 and 150 kg/ha) and five haulms cutting treatments, (80, 90, 100, 110 and 120 days after planting (DAP) was conducted at Vegetable Research Farm of Banaras Hindu University, Varanasi during 1986-88 with 3 replications using a randomized block design.

The soils of experimental plots were sandy loam in texture with pH 7.65, available nitrogen 128 ppm, P_2O_5 8.20 ppm and K_2O 6.40 ppm during 1986-87 and pH 7.68, available nitrogen 130 ppm, P_2O_5 8.10 ppm and K_2O 6.60 ppm during 1987-88. Well sprouted tubers of cultivar Kufri Lalima were planted at 20 cm x 60 cm in plots measuring 3 x 3 m on 23rd October 1986 and 1st Nov. 1987. Full dose of phosphorus (50 kg P_2O_5/ha) from single super phosphate and potash (80 kg K_2O/ha) through muriate of potash to all the plots and half dose of nitrogen from urea as per treatments were applied as basal dressing in band placement. Remaining half dose of nitrogen was top dressed as per treatments at the time of earthing. The crop was grown under irrigated condition. Tubers were harvested 7 days after haulms cutting.

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The samples of leaves, stems and tubers were taken from each plot, washed and oven dried. The dry material was grounded and passed through 40 mesh sieve. N, P and K contents were determined by the method as suggested by Jackson (2). The total nutrients uptake was calculated by multiplying N, P and K contents in the leaves, stems and tubers, with the total dry matter yield and presented as pooled data of two years.

The N and P concentrations in the leaves, stems and tubers increased significantly with increasing levels of nitrogen (Table 1). The increase in N and P concentrations in the leaves, stems and tubers was due to more absorption of the nutrients (3). Contrary to N and P concentration in leaves, stems and tubers, K decreased significantly with increasing levels of nitrogen. The low concentrations of potassium in the leaves, stems and tubers at 150 kg N/ha was due to dilution effect (6, 9)

Table 1. Effect of nitrogen levels and haulms cutting on nutrients concentration (%) in the leaves, stems and tubers (pooled of two years)

Nitrogen level (kg/ha)	Nitrogen			Phosphorus			Potassium		
	Leaves	Stems	Tubers	Leaves	Stems	Tubers	Leaves	Stems	Tubers
Control	3.80	1.81	1.41	0.238	0.101	0.187	3.69	4.68	2.08
50 kg	3.96	2.43	1.61	0.270	0.140	0.224	3.44	4.46	1.93
100 kg	4.50	2.58	1.80	0.313	0.184	0.229	3.03	4.27	1.85
150 kg	4.66	2.81	1.86	0.327	0.190	0.325	3.24	4.03	1.78
C.D. at 5%	0.09	0.06	0.04	0.200	0.016	0.014	0.08	0.08	0.04
Haulms cutting (days after planting)									
80	4.35	2.56	1.77	0.345	0.197	1.286	3.39	5.01	2.07
90	4.26	4.52	1.73	0.324	0.174	0.266	3.38	4.80	2.00
100	4.16	2.49	1.69	0.303	0.155	0.250	3.25	4.44	1.90
110	44.10	2.45	1.61	0.266	0.133	0.233	3.13	3.92	1.83
120	4.04	2.40	1.55	0.204	0.111	0.203	2.98	3.64	1.76
C.D. at 5%	0.10	0.07	0.05	0.023	0.018	0.015	0.09	0.09	0.04

N, P and K concentration in the leaves, stems and tubers decreased with delay in haulms cutting and was significantly higher at 80 days after planting in both the years. The results are in conformity with the findings of Sharma and Verma (4).

The increase in the levels of nitrogen from 0-150 kg/ha increased the uptake of N, P and K in the leaves, stems and tubers, uptake was noted maximum at 150 kg N/ha (Table 2) and it was at par with 100 kg N/ha in respect to N uptake by tubers. Increasing levels of nitrogen increased the uptake of N and the increase in uptake of P and K was due to the fact that nitrogen govern the utilization of P and K elements. Further the increase in these nutrients was due to the higher yields and higher nutrients concentration in different parts of the plants (6, 8).

Table 2. Effect of nitrogen levels and haulms cutting on nutrients uptake (Kg/ha) in the leaves, stems and tubers (pooled of two years)

Nitrogen levels (Kg/ha)	Nitrogen			Phosphorus			Potassium		
	Leaves	Stems	Tubers	Leaves	Stems	Tubers	Leaves	Stems	Tubers
Control (N_0)	12.54	1.99	33.74	0.83	0.14	5.36	12.08	5.41	49.59
50	25.88	4.43	68.69	1.88	0.29	9.41	22.59	8.15	83.82
100	25.13	6.48	93.33	1.94	0.41	12.95	16.47	9.79	96.15
150	35.05	7.27	97.63	2.52	0.49	16.71	20.90	10.73	93.31
C.D. at 5%	4.49	1.39	7.42	0.38	0.12	1.25	3.56	2.39	7.72
Haulms cutting (days after planting)									
80 (H_1)	32.48	5.50	58.83	2.58	0.42	9.64	24.55	10.35	66.29
90 (H_2)	35.03	6.53	67.46	2.68	0.45	10.38	26.64	11.69	24.72
100 (H_3)	27.57	5.99	77.30	1.85	0.37	11.50	20.59	9.89	83.44
110 (H_4)	17.47	4.38	81.44	1.10	0.27	11.86	12.56	6.50	88.91
120 (H_5)	10.73	2.83	81.71	0.55	0.17	10.92	8.07	4.25	90.56
C.D. at 5%	5.01	1.56	8.29	0.43	0.14	0.62	3.98	2.37	8.63

The uptake of N, P and K in the leaves and stems increased upto 90 days after planting and decreased lateron till 120 DAP. Whereas in the tubers the uptake of nutrients increased significantly except uptake of P which decreased after 110 DAP. The increase in uptake of nitrogen by the tubers and decrease in nutrients uptake by leaves and stems was due to the translocation of nitrogen from aerial parts to the tubers at tuber bulking stage (4).

LITERATURE CITED

1. Ezeta, F.N. and L.E. Mc Collum. *Am Potato J.* 49: 151-63.
2. Jackson, M.L. 1967. *Soil Chemical Analysis, edn.* I. Prentice Hall of India Pvt. Ltd., New Delhi, pp. 148-55.
3. Sagar, T.S. and R.P. Singh. 1973. *Indian J. Agric. Sci.* 43: 579-81.
4. Sharma, I.P. and U.K. Verma. 1988. *J. Indian Potato Assoc.* 15: 74-79.
5. Sharma, R.C., J.S. Grewal and A.K. Sharma. 1978. *J. Indian Potato Assoc.* 5: 56-69.
6. Sharma, U.C. 1989. *J. Indian Potato Assoc.* 16: 91-95.
7. Singh, K., U.C. Pandey and O.P. Srivastava. 1975. *J. Indian Potato Assoc.* 2: 10-14.
8. Singh, S.N. and J.S. Grewal. 1979. *J. Indian Potato Assoc.* 6: 78-86.
9. Sud, K.C., J.S. Grewal and R.C. Sharma. 1982. *J. Indian Potato Assoc.* 9: 1-9.

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SHORT NOTE

EFFICACY OF AGRO-PRACTICES TO CONTROL BACTERIAL WILT OF POTATOES IN CENTRAL INDIA

R.B.S. Sangar[1]

Bacterial wilt caused by *Pseudomonas solanacearum* E.F. Smith is an important disease of potato (2). It is prevalent in most of the hilly, plateau and Deccan parts of India (4). In Madhya Pradesh, bacterial wilt of potato is one of the important disease particularly, in plateau area (3). Some of cultural practices have been found to control this disease effectively but, their effectiveness varied from region to region (5). The present experiment was, therefore, carried out to find out appropriate agro-practices to manage the disease under plateau area of Madhya Pradesh.

Experiements were conducted during 1987-88 and 1988-89 on sandy loam soil on farmer's field of Chandangaon, Chhindwara under All India Co-ordinated Potato Improvement Project. Treatments were arranged in a randomised block design and replicated four times (Table 1). The cultivation were followed as per recommendation for the region. The crop was irrigated. The observations on plant emergence, wilt incidence and tuber yield were noted and statistically analysed.

Table 1. Efficacy of different agro-practices for control of bacterial wilt of potatoes

Treatment	Disease incidence (%)			Total yield (q/ha)		
	1987-88	1988-89	Average	1987-88	1988-89	Average
T_1 = Seed from bacterial wilt free area	0.0	0.0	0.0	309	295	302.0
T_2 = T_1 + full earthing up at planting + Grammaxone	0.4	0.0	0.2	304	295	299.5
T_3 = T_1 + Bleaching powder @ 12 kg/ha in furrows	0.0	0.0	0.0	329	343	336.0
T_4 = T_1 + Full earthing up + Bleaching powder @ 12 kg/ha	0.0	0.0	0.0	316	306	311.0
T6 = T1 + Gramaxone				309	288	298.5
T_5 = T_1 + Ploughing after harvesting	0.6	0.0	0.3	278	260	269.0
T_7 = Apparently healthy local seed tubers from diseased crops	6.2	6.0	6.1	267	241	254.0
C.D. (0.05)	2	2		44	43	-

The results showed that there was no significant difference in plant emergence among the treatments in both years (Table 1). All treatments were found to reduce

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wilt incidence significantly over control. Average highest incidence of wilt (6.1%) was recorded in the crop raised from apparently healthy tubers obtained from diseased crop. There was no wilt in plots in which seed from disease free area was used (T_1, T_3, T_4). Significant increase in tuber yield was obtained in plots where bleaching powder was added besides using healthy seed (T_3). Other treatments also increased tuber yield but the increase was not satistically significant. The findings of present study corroborate the previous report (1, 4, 5).

It can be concluded from the above study that bacterial wilt of potato may be controlled effectively by using disease free seed alone, combined with soil application of bleaching powder @ 12 kg/ha or practicing full earthing up at planting.

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LITERATURE CITED

1. De, B.K. and P.C. Sengupta. 1992. *J. Indian Potato Assoc.* 19: 90-92.
2. Dutt, B.L. 1979. *Bacterial and Fungal Diseases of Potato* I.C.A.R., New Delhi, 1979, 199 pp.
3. Sangar, R.B.S. 1985. *Ann. Progress Rept. AICPIP.* JNKVV, Chhindwara, 43 pp.
4. Shkhawat, G.S., A.V. Gadewar, V.K. Bahal and R.K. Verma. 1988. In : *Bacterial Diseases of Potato*, C.I.P., Lima, Peru, pp. 65-84.
5. Shekhawat, G.S., V.K. Bahal, V. Kishore, R.B.S. Sangar, R.L. Patel, B.K. Dev. S.K. Sinha and A.K. Pani. 1990. *J. Indian Potato Assoc.* 17: 52-60.

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SHORT NOTE

ON-FARM STUDIES TO EVALUATE THE RESPONSE OF POTATO TO K IN RELATION TO FARM YARD MANURE

Harsharn Singh Grewal and J.S. Kolar[1]

Potassium is known for its important role in synthesis of simple sugars and starch and, in translocation of carbohydrates (3). It also helps in maintaining the tone, vigour and efficiency of the potato plant. Removal of potassium (K) by potato can be as high as 193 kg/ha in hills and 148 kg/ha in the plains of India(2). Application of K fertilizers is, therefore, essential for attaining higher yield of potato.

Response of potato to K fertilizer may be variable in the presence or absence of FYM. It was, therefore, considered imperative to study the response of potato to K fertilizer in relation to FYM.

On-farm experiments were conducted during 1989 and 1990 at village Kadiana in Jalandhar District of Punjab to study the response of potato to K nutrition in relation to farm yard manure (FYM) use. The experiment was laid out in a randomised complete block design having 5 levels of K (0, 50, 75, 100 and 125 K/ha) and two levels of FYM (0 and 10 tonnes/ha). The number of replications were three. FYM having 0.6% N, 0.2% P and 0.7% K, was applied two days before potato planting. Phosphorus (60 kg P_2O_5/ha) was applied to all the plots irrespective of treatments at planting. Nitrogen (120 kg/ha) was applied in two equal splits i.e. 60 kg/ha at planting and remaining 60 kg/ha after one month of planting. The source of N, P and K were urea (46% N), single superphosphate (16% P_2O_5) and muriate of potash (60% K_2O), respectively. Potato variety Kufri Sindhuri was planted on September 28 in 1989 and September 25 in 1990 by potato planter at a spacing of 60 cm x 20 cm. The crop was harvested 115 days after planting. The soil of the experimental field was loamy sand (Typic ustochrept) in texture, with pH 8.5, organic carbon 0.23 per cent, 0.5 N $NaHCO_3$ extractable P of 13.5 kg/ha and 144 kg/ha of 1N neutral ammonium acetate extractable K.

Tuber yield and yield attributes: Potato responded significantly to K application upto 100 kg K/ha (Table 1). The average response was 58 kg tubers/kg of applied K. Application of K significantly improved the number of tubers per plant which was favourably reflected in tuber yield. FYM at 10 tonnes/ha also significantly improved tuber number and potato yield. The average response was 760 kg tubers per tonne of

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Table 1. Response of potato to K and FYM (mean of 2 years)

Level of K (Kg/ha)	Tuber yield (q/ha) FYM tonnes/ha 0	10	Mean	Number of tubers per plant FYM Tonnes/ha 0	10	Mean
0	180	270	225	8.8	9.5	9.2
50	215	295	255	9.1	9.7	9.4
75	235	310	272	9.2	9.7	9.5
100	249	318	283	9.2	9.8	9.5
125	254	320	287	9.3	9.9	9.6
Mean	227	303		9.1	9.7	
L.S.D. (0.05) for	K levels	= 9				0.2
	FYM	= 7				0.2
	K x FYM	= 14				0.4

applied FYM. Sahota and Govindkrishnan (1) also reported a considerable improvement in tuber yield with FYM use at Shillong.

The interaction effect between K and FYM on tuber yield was significant. The significant response to K application was upto 100 kg K/ha when FYM was not applied at planting time, whereas with FYM use, the response was upto only 75 kg K/ha. Further the tuber yield with only FYM use (without K) was 270 q/ha which was significantly more than the yield (254 q/ha) obtained at 125 kg K/ha in the absence of FYM use. FYM, being rich source of K, partially met the K requirement of potato and hence the response was only 75 kg K/ha.

LITERATURE CITED

1. Sahota, T.S. and P.M. Govindkrishnan. 1984. *J. Indian Potato Assoc.* 11: 73-77.
2. Sahota, T.S., Harsharn Singh and S.S. Cheema. 1990. *Better Crops International.* June 1990, pp. 22-23.
3. Smith, Ora. 1977. *Potatoes : Production, Storing* and *Processing.* Ind. Edn. AVI Publishing Co. Westport, CT.

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SHORT NOTE

EFFECT OF APPLICATION OF LIME AND DOLOMITE ON SOIL pH, EXCHANGEABLE CALCIUM AND POTATO TUBER YIELD

R. Shanmugasundaram[1] and K. Nanjan[2]

Potato is grown extensively in the acidic soils of Nilgiris where considerable amount of bases are removed from the soil during every rainy season. (RF : 1300-2200 mm). Soil acidity not only affects the nutrient availability to plants but also suppresses the yield of potato. Liming of acidic soils is known to improve the crop yield. In this paper attempt has been made to see the effect of lime and dolomite on soil pH, exchangeable calcium and potato yield.

Acid soil amendments viz. lime ($CaCO_3$) and dolomite (Ca Mg) CO_3 were applied each at four levels (5, 10, 15 and 20 t/ha) before planting of potato. Seed tubers of cv. Kufri Jyoti were planted with a spacing of 50 x 20 cm in $20m^2$ plot size. N, P_2O_5 and K_2O @ 120:240:120 kg/ha were applied to all the treatments. The trial was carried out in randomised block design with nine treatments replicated three times during autumn season (Aug.-Nov.) of 1989 and main season (March-June) of 1991.

The experimental soil was sandyloam in texture with a initial pH of 3.8, 3.9, OC of 3.0, 3.1 and available N 400, 440 kg/ha, Bray's P 8, 85 ppm and K 200, 260 kg/ha. *Soil samples were collected periodically on 60th, 90th and 120th day after* planting for soil pH measurements. Tuber yields were recorded at harvest. Soil chemical analysis were done as per the procedure given by Jackson(2).

Potato tuber yield: Addition of liming materials increased the tuber yield significantly over unlimed control (Table 1). Application of lime 5t/ha significantly increased the tuber yield to 11.25 and 11.3 t/ha from 7.08 and 7.5 t/ha with no lime in 1989 and 1991 respectively. This is in line with the work of Sahota (5) who reported that liming of potato with 2.5 t/ha of $CaCO_3$ increased the yield of potato tubers in acidic soils. No further significant increase in tuber yield was observed when the level of lime was increased beyond 5t/ha. Application of dolomite @ 5t/ha and above significantly increased the tuber yield over control.

Soil pH: The significant changes in soil pH values were effected due to application of lime and dolomite (Table 1). There was marked increase in soil pH upto 90 days

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Table 1. Effect of application of lime and dolomite on soil pH, exchangeable Ca and potato tuber yield

Treatments	Soil pH values 1989			1991			Soil ex. Ca meq/100g		Tuber yield (t/ha)	
	60	90	120	60	90	120	1989	1991	1989	1991
	(Days after planting)									
1. Lime 5 t/ha	4.63	4.87	4.17	3.9	3.8	4.4	5.47	7.5	11.25	11.3
2. Lime 10t/ha	4.77	4.87	4.33	4.0	3.9	4.5	6.87	8.2	11.67	12
3. Lime 15t/ha	4.87	5.0	4.56	4.0	4.0	4.6	9.17	8.9	11.67	13
4. Lime 20t/ha	5.17	5.67	4.70	4.0	4.1	4.6	9.37	9.9	13.75	14
5. Dolomite 5t/ha	4.47	4.6	4.16	3.9	3.9	4.3	4.83	7.2	10	10.8
6. Dolomite 10t/ha	4.63	4.80	4.30	4.0	4.1	4.4	6.27	7.8	10.42	10.9
7. Dolomite 15t/ha	4.77	5.03	4.30	4.1	4.1	4.6	6.60	8.4	10.42	12
8. Dolomite 20t/ha	4.80	5.17	4.40	4.2	4.2	4.7	8.13	9.2	11.67	13.1
9. Control	4.17	4.10	4.03	3.7	3.6	3.9	2.73	3.8	7.08	7.5
CD at 0.5 level	0.34	0.54	NS	0.04	NS	NS	1.39	2.05	3.22	3.2

after planting but thereafter it declined in 1989. On the other hand, increase in soil pH was observed throughout the season in 1991. Application of lime and dolomite registered high pH value of 4.4 and 4.3 as compared to 3.9 in control in 1991. Mandal and Mukherjee (3) have also reported increase in soil pH due to liming.

Soil exchangeable calcium: Application of lime and dolomite had significant effect in improving soil exchangeable content in both the years. (Table 1). Lime applied @ 5t/ha increased the soil exchangeable content from 2.74, to 5.47 and 3.7 to 7.5 meq/100g soil as against control (2.73 and 3.8 meq./100 g soil) in 1989 and 1991 respectively. Similarly, increase in soil exchangeable Ca content was observed in the dolomite applied plots. It is confirmed by Kothandaraman and Mariakulandai (4) that exchangeable Ca of Nilgiris soil in TN(PH 4.5) increased from 4.3 to 7.3 meq/100 g soil when treated with 3,920 kg/ha of lime.

LITERATURE CITED

1. Barnes. W.C. 1944. *Proc. Amer. Soc. Hort. Sci.* 44: 379-80.
2. Jackson. M.L. 1973. *Soil Chemical Analysis.* Prentice Hall of India Private Ltd., New Delhi.
3. Mandal, S.C. and H.N. Mukherjee. 1952. *Proc. Indian Sci Congr.* Pt. III (Abstract).
4. Kothandaraman, G.V. and Mariakulandai. 1965. *Madras agric. J.* 52: 183.
5. Sahota, T.S. 1985. *J. Indian Potato Assoc.* 12: 192-194.

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SHORT NOTE

BIOEFFICACY OF INSECTICIDES AGAINST POTATO TUBER MOTH

N.P. Kashyap, D.C. Sharma, R.M. Bhagat and S.M. Suri[1]

Potato tuber moth (PTM), *Phthorimaea operculella* (Zeller) is a serious pest of potato both in fields and in storage especially, in foot hills of Kangra district (1). A large number of insecticides have been tried in various regions of our country for managing this pest (4, 2, 5). However, attempts have not been made on these lines for controlling this pest in Himachal Pradesh, where this pest has come in epidemic form since 1988. So keeping in view the gravity of problem certain pyrethroids alongwith some synthetic insecticides have been evaluated against PTM to manage its menace in fields. Eight insecticides (Table 1) were evaluated in the field (1989-91).

Each insecticide was mixed with water @ 750 l/ha containing the respective dosages of insecticides as mentioned (Table 1). First spray was applied, during 3rd week of March followed by second spray at an interval of 15 days. Plot size was 12 M^2. Pheromone trap as per method described by Trivedi and Rajagopal (5) was used to assess the population of tuber moth/plot. Data on per cent plant damaged/plot, yield per plot and per cent tuber damage/plot was also recorded.

Pooled analysis of data for two seasons (Table 1) revealed that all the insecticidal treatments were superior in checking the PTM attack in field on potato foliage as compared to control except tamaron. The best control of PTM was achieved with spray of decamethrin. But no significant difference between monocrotophos and cypermethrin treatment was observed with respect to yield. Application of decamethrin significantly gave much higher yield i.e. 200.5 quintal/h and low moth population and per cent plant damage (Table 1). Interstingly, no tuber damage was recorded at harvest both in treated and untreated check. The yield differences obtained in the present studies could be due to the reduced size and less number of tubers/plant.

Lal and Prasad have recommended the spray of carbaryl @ 2.5 kg a.i./h to control PTM attack (3) but in the present findings carbaryl did not prove to be effective in controlling the PTM attack. Contrary to this, spray of monocrotophos or decamethrin or cypermethrine @ 0.6 kg., 0.05 kg and 0.15 kg a.i./ha, respectively gave effective control of tuber moth on the foliage and also increased the yield of potato crop significantly.

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Table 1. Efficacy of insecticides against potato tuber moth during 1989-91 season*

Treatments	Dosages kg a.i. ha	Pre spray		Days after spray										Yield (q/ha)
		M**	P**	1 day		7 day		14 day		21 day		28 day		
		M	P	M	P	M	P	M	P	M	P	M	P	
Carbaryl (Sevin 50 WP)	2.0	12.3 (3.53)[a]	0.3 (2.53)[b]	0.0 (0.71)	0.3 (2.53)	0.5 (0.97)	0.3 (2.53)	0.97 (1.20)	0.96 (5.57)	1.48 (1.40)	1.16 (6.19)	2.64 (1.76)	2.33 (8.72)	150.83
Cypermethrin (Cyperkill 25EC)	0.15	13.66 (3.76)	0.0 (0.00)	0.0 (0.71)	0.0 (0.00)	0.0 (0.81)	0.0 (0.00)	0.16 (0.71)	0.0 (0.81)	0.5 (0.97)	0.0 (0.00)	1.33 (1.35)	0.0 (0.00)	179.88
Decamethrin (Decis 2.8EC)	0.05	13.66 (3.76)	0.16 (1.9)	0.0 (0.71)	0.15 (1.9)	0.0 (0.71)	0.15 (1.9)	0.0 (0.71)	0.15 (1.9)	0.0 (0.71)	0.15 (1.9)	1.0 (1.22)	0.15 (1.9)	200.50
Fenitrothion (Folithion 50 EC)	0.5	12.6 (3.62)	0.17 (1.9)	0.0 (0.71)	0.17 (1.9)	0.15 (0.80)	0.17 (1.9)	1.0 (1.22)	0.66 (3.78)	2.3 (1.67)	1.3 (6.37)	3.33 (1.96)	2.0 (8.12)	146.08
Methyl demeton (Metasystox 25EC)	0.25	14.26 (3.84)	0.0 (0.00)	0.0 (0.71)	0.0 (0.00)	0.0 (1.05)	0.0 (3.30)	0.60 (1.22)	0.33 (3.30)	1.0 (1.61)	0.33 (4.68)	2.1	0.66	156.38
Monocrotophos (Monocil 36SL)	0.6	10.92 (3.38)	0.15 (1.9)	0.0 (0.71)	0.15 (1.9)	0.0 (0.71)	0.15 (1.9)	0.15 (0.80)	0.31 (3.14)	0.50 (0.97)	0.31 (3.14)	1.5 (1.40)	0.66 (4.62)	172.83
Tamaron (Tamaron 40 SL)	0.5	10.6 (3.33)	0.6 (4.4)	0.0 (0.71)	0.6 (4.4)	0.6 (1.05)	0.6 (4.43)	1.6 (1.45)	0.6 (4.4)	2.6 (1.76)	1.6 (7.26)	- -	- -	123.00
Tamaron (Tamaron 40 SL)	0.75	10.0 (3.24)	0.0 (0.00)	0.0 (0.71)	0.0 (0.00)	0.30 (0.89)	0.0 (0.00)	1.3 (1.34)	0.0 (0.00)	2.0 (1.58)	1.0 (5.72)	-	-	142.05
Control	-	14.6 (3.89)	0.15 (1.9)	8.3 (3.22)	0.15 (5.65)	9.8 (3.22)	1.5 (5.65)	11.15 (3.41)	4.4 (12.2)	12.32 (3.66)	7.16 (15.41)	13.50 (3.74)	6.66 (14.79)	112.08
(C.D. 5%)		(N.S.)	(N.S.)	(0.19)	(0.56)	(0.17)	(0.45)	(0.13)	(0.72)	(0.37)	(0.98)	(0.39)	(0.88)	14.48.

P = Per cent plant damaged
M = Moths attracted/min.
Values in parenthesis = $\sqrt{n + 0.5}$

* Pooled analysis of two seasons.
** Mean of six replications.
Value in parenthesis b = Angular transformation value of per cent damage.

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LITERATURE CITED

1. Kashyap, N.P., R.M. Bhagat., D.C. Sharma and S.M. Suri. 1992. *J. Ent. Res.* 16: 223-27
2. Lal, L. and B.S. Barua. 1984 *Proc. National Symp. Soil Pest* and *Soil Organism, BHU.* Abst. No. 87, pp. 59.
3. Lal, L. and.K.S.K. Prasad. 1989. *Pesticides* Z. 7: 53-57.
4. Raj, B.T. and A.P. Saxena. 1980. *J. Indian Potato Assoc.* 7: 12-20.
5. Trivedi, T.P. and D. Rajagopal. 1988. Proceedings *National Symposium* on *Integrated Pest Control-Progress and Prospective*, October 15-17, 1987-88, pp. 58-64.

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SHORT NOTE

EFFECT OF DIFFERENT SEED RATE AND SEED SIZE ON GROWTH, YIELD AND SEED SIZE TUBER PRODUCTION IN POTATO UNDER COASTAL PLAIN OF ORISSA

D.N. Singh, A. Nandi and P. Tripathy[1]

Potato variety Kufri Badshah produces large sized tubers. In addition to seed size, optimum seed rate is indispensable for deriving optimum as well as high yields of the potato crop. Though increase in seed rate and eventually plant population can increase yields, there is a certain limit to it (2). The present experiment was, therefore, conducted to discern the optimum seed size and seed rate for deriving high tuber yields of the variety Kufri Badshah.

The experiment was conducted under the All India Coordinated Potato Improvement Project, Bhubaneswar, during the *rabi* season of 1987-88. It was laid out in the randomised block design with 12 treatments (Table 1) replicated 4 times. Plot size was 12 sqm. Row to row spacing was 60 cm. Potato variety Kufri Badshah was planted on 30 November 1987. Fertilizers were applied @ 120 kg N, 80 kg P_2O_5 and 100 kg K_2O/ha. Haulms were cut on 22 February 1988.

Plant height did not differ significantly. Seed size of 50g resulted in highest and 15g in lowest number of stems/hill. The highest number of compound leaves/main stem were recorded in the combination of 15g seed size and 8q/ha seed rate (Table 1). It was at par with most of the treatment combinations except the combinations of 15g seed size and 22.5 q/ha seed rate, 25g seed size and 30 or 37.5 q/ha seed rate, 50g seed size and 37.5 q/ha seed rate.

Significant differences were recorded among treatments with respect to total tuber yield. The highest yield of 123.9 q/ha was derived with the combination of 50g seed size and 30 q/ha seed rate. Bannerjee *et al.* (2) also recorded higher total yield using large seed tubers. At constant seed rate, tuber yield increased with increase in seed size because large seed tubers being physiologically more advanced, emerge early, produce better vegetative growth, more large size tubers (3, 4) and consequently higher yield. The optimum and economic seed rate for 50g seed size was 30 q/ha in plains(1). The lowest yields of 82.9 q/ha was the outcome of 15g seed size and 15 q/ha seed

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Table 1. Effect of different rate and seed size on growth, yield and seed size tuber production in potato

	Seed size (g)	Seed rate (q/ha)	Plant height (cm)	Stems/ hill	Number of compound leaves/ mainstem	Total tuber yield (q/ha)	Tuber yield (q/ha) in seed size 25-75g
T_1	15	8.0	65.0	3.5	11.1	97.9	48.1
T_2	15	15.0	58.5	3.3	10.0	82.9	42.5
T_3	15	22.5	57.1	3.0	9.7	93.7	50.4
T_4	15	30.0	59.0	3.8	10.5	109.3	52.5
T_5	25	15.0	58.5	3.8	10.1	90.8	43.5
T_6	25	22.5	5.94	4.1	9.8	108.5	52.0
T_7	25	30.0	57.1	3.6	9.4	120.1	56.8
T_8	25	37.5	55.6	4.3	8.8	112.6	58.7
T_9	50	22.5	62.3	4.3	11.0	99.3	44.9
T_{10}	50	30.0	60.7	3.9	10.0	123.9	58.1
T_{11}	50	37.5	55.8	4.5	9.0	111.4	54.3
T_{12}	50	45.0	58.1	4.1	10.9	95.4	46.4
CD (P = 0.05)			NS	0.7	1.3	2.8	NS

NS = Non-significant

rate. Potato yield in general increased with an increase in seed rate (1). Statistical parity was revealed amongst the treatments on comparing the tuber yield in 25-75g range.

LITERATURE CITED

1. Anonymous. 1988. *Annual Scientific Report*, Central Potato Research Institute, Shimla.
2. Bannerjee, M.K., R.S. Honda, J.S. Samdyan and D.S. Tonk. 1986. *Seeds and Farms* 12(12): 21-24.
3. Pandey, J. and V.B. Ghai. 1975. *Indian J. Agron.* 20: 167-70.
4. Singh, Kamla, A.K. Bhattacharjee, A.K. Singh and Dhani Ram. 1980. *J. Indian Potato Assoc.* 7: 145-49.

Book Review

"STRATEGIES FOR POTATO PRODUCTION, MARKETING, STORAGE & PROCESSING", Eds. J.S. Grewal, G.S. Shekhawat and others; Published by Indian Potato Association (1993)

Potato will continue to occupy a dominant position in the Indian diet despite self-sufficiency achieved in foodgrains. Its importance world over as a food item is an acknowledged fact. However, in India the demand is mostly for the vegetable purposes. Significant trends are visible in the country in favour of potato processing, involving even multinational companies, and use of potato products by the average Indian household. The day is not far off when potato would become indespensable part of the primary diet of Indian masses. That itself is going to increase the pressures of demand, and consequently need for improving productivity, overall production, quality and nutritive value would be felt more and more. As such, any effort to bring together right thinking people, potato scientists, technologists, marketing and processing experts, planners etc. of the country for developing future strategies for this crop is a step in right direction. This is what has been done jointly by the Indian Potato Association and the Central Potato Research Institute, Shimla by organising the National Symposium at IARI during Dec. 21-23, 1990.

The book under review is an edited compilation of the papers presented in the above symposium covering four sessions namely, i) Potato production : New technology; ii) Seed production including innovation; iii) Marketing, storage and processing; and iv) Improving production and protection in major producing states. The deliberations have rightly laid stress on improving production, marketing, storage etc. in different states. These issues have been debated earlier also. However, not much stress had been laid on marketing, storage and processing. These aspects have direct bearing on improving productivity per unit area and availability to the consumers at a reasonable price.

Surprisingly, there has been only one paper on processing relating to drying potatoes. As such, the Seminar has not yielded the required information on this subject. Similarly, there is no mention about the research work being done on these aspects. A paper on village level processing of potato would have been very useful input before giving a specific recommendation on this aspect as given on page 134. The Seminar has also not laid any emphasis on breeding of varieties meant exclusively for processing, which is now assuming importance and forcing processing companies to try hard for importing varieties.

The Seminar also did not make much attempt on developing long term projections of demand of potato for different uses, and suggesting a broad strategy for the same. The figures quoted for 2000 A.D. (are merely repetition of the National Commission on Agriculture's recommendations of 1975) do not seem to be fully relevant now because of diversified uses of potato presently seen and the rising population. Despite these few shortcomings, the papers in the book provide a good reference material and information.

(G.L. Kaul)

New Delhi, August 27, 1993 — Horticulture Commissioner

POTATO

PRESENT & FUTURE

Edited by Drs. GS Shekhawat, SM Paul Khurana, SK Pandey & VK Chandla

No doubt potato is a nutritional gold mine which can supply nutritious food to substitute staple food (cereals) to meet growing world hunger and might lead to a second agricultural revolution for meeting the food needs of ever growing world population. The Indian Potato Association organised the symposium entitled **"Potato: Present & Future"** during March 1-3, 1993, to provide a platform to the research workers for presentation of latest research data and representatives of the industries and growers for their interaction on new technologies and refinements being worked out. The symposium, held at a very appropriate time was having comprehensive programme with a wide range of aspects. Majority of the papers of the symposium were compiled and edited to be presented in this volume which covers all aspects of potato mainly research on **Potato Varieties & True Potato Seed; Storage; Marketing & Transfer of Technology; Potato-based Cropping Systems; Plant Protection, Physiology & Boichemistry and Biotechnology & Seed Production. The Inaugural Address, the Key Note, five lead papers on Session themes by eminent scientists and Recommendations.**

The papers and recommendations in the volume may be equally useful to the students, teachers, research and extension workers as well as progressive growers and agricultural planners. It is also hoped to serve as a reference book on potatoes in India.

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