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COMPARISON OF INORGANIC FERTILIZERS AND CATTLE SLURRY FOR MEETING NITROGEN NEEDS OF MAIZE AND POTATOES

S.P. Trehan[1]

ABSTRACT: Application of cattle slurry to maize and potatoes was compared with inorganic N fertilizers in greenhouse and field experiments. Application of equivalent amount of inorganic N through cattle slurry gave significantly more dry matter yield of maize than ammonium sulphate. The recovery of labelled nitrogen in plants plus soil by the end of the experiment at 40 days was 92% with ammonium sulphate alone and 78% with cattle slurry. During the first 20 days with cattle slurry almost one third of the labelled nitrogen became immobilized in organic matter. In the same period there was mineralization but the overall reaction was net immobilization. In later period there was mineralization which was more than that with ammonium sulphate. *In a field experiment, response to NH_4NO_3 was significant only with 70 kg N ha^{-1}* and was less than cattle slurry (containing 170 kg organic N and 108 kg inorganic N ha^{-1}). produced a total dry matter yield that was higher, though not significantly so, than ammonium nitrate (70 to 750 kg N ha^{-1}.) Incorporation of wheat straw (5 t ha^{-1}) into slurry did not influence the yield.

INTRODUCTION

Recently, many reports have pointed to the important place which organic waste materials take in soil fertility improvement. The value of the organic materials derives from their low cost and from environmental benefits related to the disposal of organic waste. Increases or sometimes no effect on plant yields with cattle slurry have been reported (1, 2). There are reports that applications of cattle slurry to rye and potatoes in the field either had no effect or reduced their yield (2,3,4). We compared cattle slurry and inorganic fertilizers with respect to their effects on mineralization and immobilization of N and response of maize and potatoes in greenhouse and field experiments.

MATERIALS AND METHODS

Greenhouse experiment: Samples (0-15 cm) of the sandy loam soil which has been under a mainly arable rotation for more than 20 years were collected from an experimental site at the University of Reading Farm, Sonning (UK). A subsample (< 2 mm) had a pH of 5.8 in 0.01 M $CaCl_2$ and contained 15% clay, 1.2% C and 0.112% N on a dry weight basis. At the time of application, cattle slurry had 12.9% dry weight, and on a dry weight basis, contained 3.13% total N, 0.202% NH_4^+ - N; it also contained a trace of NO_3^- - N.

Samples of moist soil equivalent to 1 kg oven dry soil were thoroughly mixed in a rotary mixer with either (i) a solution of ammonium sulphate (140 μg N g^{-1} soil) or (ii) cattle

[1] Central Potato Research Station, Jalandhar - 144003 (Punjab).

slurry (280 μg NH_4^+-N g^{-1} soil). In the ammonium sulphate treatment the ^{15}N was labelled to give 13.791% atom excess. In the cattle slurry treatment, labelled ammonium sulphate was added to give the same (13.791%) atom excess in the water soluble ammonium of the slurry. At the same time as these additions were made, water and solutions of KH_2PO_4 and KCl were added to the pots of the control (which received no added nitrogen but were otherwise treated similarly) and the ammonium sulphate treatment in amounts equal to those of the water soluble nutrients in the cattle slurry. The treated soils were potted up and the pots were placed in saucers in a greenhouse (mean minimum and maximum temperatures during the course of the experiment were 16°C and 35°C, respectively). For each treatment there were 15 pots planted with three germinated maize plants in each pot. Six of the planted pots were used for root measurements only. The water content was maintained at 40% WHC for first eight days and later at 60% WHC. The plants were harvested, and the soil and plants were analysed, on the day of planting and after 20 and 40 days. Plants shoots were cut at soil level, dried at 80°C, weighed, and analysed for total nitrogen and ^{15}N using Micromass 602 E Mass spectrometer. Large roots were removed from the soil, finely chopped and returned to the soil. The soil containing chopped roots was sampled for analysis. On each sampling occasion, the roots from two of the extra replicates were separated by thorough washing, dried and analysed.

On the same day that plants were harvested, the soil in each pot was thoroughly mixed and a 50 g sample from each pot was shaken mechanically for 2 h with 125 cm^3 2 M KCl and centrifuged. After pouring off the supernatent, the extraction was repeated three more times. The combined extracts were stored frozen before being analysed for ammonium and nitrate.

The wet soil from the KCl extraction was dried at 70°C for 48 h and crushed less than 2 mm. Total nitrogen, which included soil organic nitrogen, clay-fixed NH_4^+-N and nitrogen in plants roots, was determined by the Kjeldahl method. A separate soil sample was treated with alkaline potassium hypobromite followed by Kjeldahl digestion and distillation to give non-exchangeable (clay-fixed) NH_4^+-N. The clay fixed and root nitrogen were substracted from total nitrogen to give soil organic nitrogen. Standard errors (SE) of each type of measurement were calculated using a completely randomised design.

Gross mineralization was calculated by allowing for the losses as follows:

Gross mineralization of total nitrogen =

$$(N_1 - N_0) + I' \frac{(A^* + B^*)}{B^*} + U + L' \frac{(A+B)}{B^*} + C' \frac{(A^* + B^*)}{B^*} \quad (1)\ (2)$$

and gross immobilization of total nitrogen = $I' \frac{(A^* + B^*)}{B^*}$ (2)

where N_1 and N_0 are total (labelled + unlabelled) N (NH_4 + NO_3) in KCl extracts at t_1 and t_0, U is uptake of total N during t_1 and t_0. I, `L' and C' are, respectively, labelled nitrogen immobilized, lost in gaseous form and fixed by clay between t_0 and t_1, A and B are the amounts of unlabelled and labelled nitrogen respectively in KCl extracts at 0.5 Δ t, and A* and B* are the amounts of un-labelled and labelled ammonium nitrogen respectively in the KCl extracts at 0.5 Δ t.

Field experiment : The experiment was done in 1986 on an experimental area of the University Farm at Sonning, Berkshire on Rowland soil in a randomized block design. The soil had a pH of 6.4 in 0.01 M $CaCl_2$ and contained 0.95% C and 9.7 $\mu g^{-1} g^{-1}$ mineral N on a dry weight basis. Cattle slurry had 12.6% dry weight and on a dry weight basis contained 3.68% total N, 1.429% NH^+_4-N and a trace of NO_3^--N. Straw contained 40.3% C and 0.531% total N on dry weight basis. There were sixteen field plots, each 3 x 3 m giving two replicates of the eight treatments. The potato crop (cv. Cara, a late variety) was planted in April at an inter-row spacing of 75 cm and a within-row spacing of 30 cm. Two weeks before planting all plots received a basal application of fertilizer (89 kg P ha^{-1} as superphosphate, 232 kg K ha^{-1} as potassium chloride, and 113 kg Mg ha^{-1} as kieserite).

Harvesting of potato tubers was done in October when most of the plant tops were dried except in plots receiving high doses of N. Tubers were washed, air dried, counted and weighed for their fresh weight. Sub-sample of tubers of each grade was chopped, dried to constant weight at 80°C, weighed and ground for total N analysis on 1 LeCo nitrogen analyser.

RESULTS AND DISCUSSION

GREEN HOUSE EXPERIMENT

Dry matter yield and uptake of N : Ammonium sulphate and cattle slurry significantly increased dry matter yield of maize at 40 days (Fig. 1). Application of ammonium sulphate (140 μg N^{-1} g soil) significantly increased the dry matter yield from 1.87 g pot^{-1} to 6.29g pot^{-1} which was significantly lower than 7.08 g pot^{-1} produced by the application of cattle slurry containing the same amount of inorganic N. The uptake of N followed similar trends as that of yield. Table 1 shows that at 40 days the cattle slurry significantly enhanced the uptake of N from 18 mg N pot^{-1} to 98 mg N pot^{1} which was significantly higher than the uptake of 79 mg N pot^{-1} with the application of ammonium sulphate. The results suggest that the presence of organic fraction of cattle slurry increased the dry matter yield and uptake of N significantly.

Transformation of labelled N: Labelled N in KCl extracts decreased significantly with time in ammonium sulphate and cattle slurry treatments (Table 1). The decrease was significantly more in the cattle slurry than in the ammonium sulphate treatment. Immobilization of labelled N was significantly rapid with the slurry treatment as compared to ammonium sulphate and at 40 days organic ^{15}N was 21 μg^{-1} g soil with ammonium sulphate and 50 μg g^{-1} soil with cattle slurry (Table 1). The recovery of 15_N in all forms fell to 92% and 78% in the ammonium sulphate and cattle slurry treatments, respectively. An incubation experiment with unplanted soil also indicated immobilization of large amount of NH_4^+ by cattle slurry decomposing in soil (6).

Table 1. Distribution of [15]N from ammonium sulphate and cattle slurry 0, 20 and 40 days after application as mineral-N, organic-N, clay fixed-N and plant-N in pot experiment. Expressed as μg^{-1} oven dry soil

Treatment	Days	Mineral N						Organic-N	Clay-N	Plant N			Recovery	
		Unlabelled			Labelled			Labelled	Labelled	Labelled	Unlabelled	Total	Total	%
		NH_4-N	NO_3-4	NH_4 + NO_3-N	NH_4 -N	NO_3 N	NH_4+ NO_3-N							
Control	0	2	12	14	-	-	-	-	-	-	(8)	(8)	-	
	20	3	2	5	-	-	-	-	-	-	13	13	-	-
	40	4	10	14	-	-	-	-	-	-	18	18	-	-
Ammonium	0	3	10	13	126	0	126	4	9	0	(8)	(8)	139	99
Sulphate	20	8	7	15	12	54	66	12	13	36	15	51	127	90
	40	5	9	14	5	43	48	21	7	53	26	79	129	92
Cattle	0	5	13	18	127	0	127	2	7	0	(8)	(8)	136	97
Slurry	20	11	15	26	6	23	29	46	13	22	29	51	110	79
	40	6	9	15	2	11	13	50	7	39	59	98	109	78
C.D. (0.05)		2.1	5.1	6.5	4.5	5.9	7.1	2.7	1.2	5.9	4.8	8.6		

Table 2. Gross mineralization and immobilization of total (Labelled + unlabelled) N in pot experiment expressed as $\mu g\ g^{-1}$ oven dry soil

Treatment	Period (days)	Gross Min.	Gross Imm.	Net Min.
Ammonium Sulphate	0-20	11.7	8.6	3.1
	20-40	18.4	15.9	2.5
Cattle Slurry	0-20	42.3	49.3	-7.0
	20-40	27.8	12.5	15.3
C.D. (0.05)		10.23	9.77	10.16

Gross transformation of labelled plus unlabelled N : Table 2 shows that gross mineralization and immobilization of N in cattle slurry amended soil were significantly higher than those ammonium sulphate treated soil particularly during first 20 days. Rate of mineralization and immobilization decreased with time in slurry treated soil. Net mineralization of N started about one month after the addition of cattle slurry.

FIELD EXPERIMENT

Tuber yield : All the treatments increased the number of tubers (Table 3) but the maximum increase was with 70 kg N ha^{-1} as NH_4NO_3. Application of NH_4NO_3 (70 kg N ha^{-1}) significantly increased the fresh as well as dry matter yield of tubers. Further increase of N dose did not have any significant effect. Cattle slurry gave a total dry matter yield that was higher, though not significantly so, than ammonium nitrate. Incorporation of wheat straw into slurry did not influence the yield. However, it has been observed that incorporation of straw into slurry reduced loss of N by about 10% (5). NH_4NO_3 (70 kg N ha^{-1}), slurry and slurry + straw significantly increased the dry matter yield of tubers from 8.8 tonnes ha^{-1} to 12.9 tonnes ha^{-1}, 14.6 tonnes ha^{-1} and 13.7 tonnes ha^{-1}, respectively.

Uptake of N : Uptake of N increased significantly and progressively with increasing doses of N from 92 kg ha^{-1} to 218 kg ha^{-1} with 410 kg ha^{-1} as NH_4NO_3 (Table 3). Uptake of N from cattle slurry and cattle slurry + straw treated plots was 178 kg N ha^{-1} and 163 kg N ha^{-1}, respectively.

Cattle slurry produced a total dry matter yield that was higher though not significantly, than ammonium nitrate (Table 3). A pot experiment also showed that application of equivalent amount of inorganic N through slurry gave significantly more dry matter yield of maize than ammonium nitrate (Fig. 1) and that net mineralization of N started about one month after the addition of cattle slurry (Table 2). Trehan (5) showed that *after taking loss of N into account, almost no organic N of slurry was utilized* by plants in the first three months. Equivalent amounts of P and K in slurry were applied to ammonium sulphate treated pots and sufficient amount of P, K and Mg were applied to NH_4NO_3 treated field plots. These observations suggested that cattle slurry also increased the yield by factors other than N, P, K and Mg. The possibilities are that slurry

Table 3. Effect of application of ammonium nitrate and cattle slurry on tuber yield of potato and uptake of N by potato tubers in the field experiment

Fertilizer/ manure	Treatment Dose (kg N ha^{-1})	No. of tubers (thousand ha^{-1})	Tuber yield (tonnes ha^{-1}) Fresh	Dry	Uptake of N (kg ha^{-1}) Total	Apparent[2] recovery
Ammonium nitrate	0	387	46.2	8.8	92	
	70	550	65.3	12.9	154	62
	125	450	63.7	12.5	165	73
	225	496	59.3	11.9	185	93
	410	461	58.8	10.5	218	126
	750	474	58.3	10.2	207	115
Cattle slurry	60 tonnes[1] ha^{-1}	419	73.9	14.6	178	86
Cattle slurry + Straw	60 tonnes[1] ha^{-1} 5 tonnes ha^{-1}	498	72.2	13.7	163	71
C.D. (0.05)		181	16.4	3.0	47	

1. Containing 170 kg organic N + 108 kg inorganic N ha^{-1}
2. Apparent recovery = (uptake of N in treatment) - (uptake of N in control)

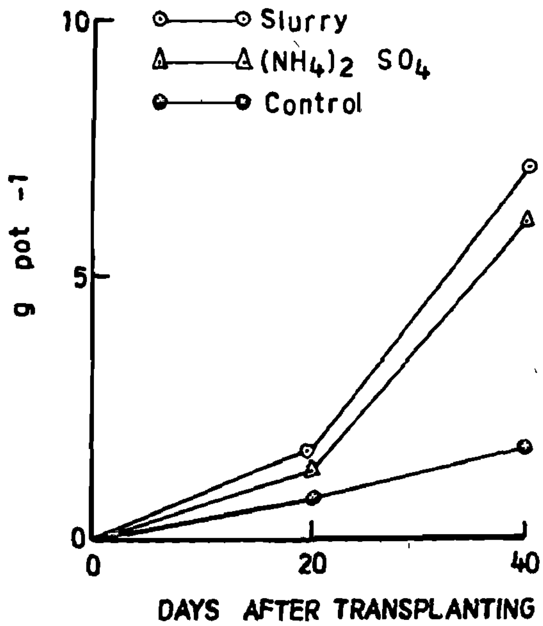

Fig. 1. Effect of ammonium sulphate and cattle slurry on total (top + root) dry matter yield (C.D. (0.05) = 0.71 g pot^{-1})

supplies micronutrients and/or improves physical conditions of soil. It has been reported that bulk density of soil is negatively related to organic matter content of soil and that reduction in bulk density and increase in soil organic matter content have significant positive influence on potato yield (7).

The results show that cattle slurry significantly increased the yield of potatoes and maize. The reduction in plant yields with slurry recorded by some workers (2,3,4) might be due to the high dose (for example, 150 tonnes ha^{-1} used by Debicki and Rejman (2) and the method of its application which perhaps caused injury to emerging sprouts or plants.

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EFFECT OF N, P AND K APPLICATION ON LEVELS OF ENDOGENOUS GIBBERELLIN-LIKE AND ABSCISIC ACID-LIKE ACTIVITY IN POTATO*

Rakesh Bhargava, G.J. Randhawa and V.N. Banerjee[1]

ABSTRACT: Endogenous levels of GA and ABA-like substances in the root and shoot of potato plant (cv. Kufri Chandramukhi) were determined under different levels of mineral nutrition. It was observed that gibberellic acid (GA) like activity of the roots increased with the increase in applied macronutrient. However, abscisic acid (ABA) like activity increased both in the roots and shoots under the same conditions.

INTRODUCTION

The endogenous levels of growth regulators which control various phases of plant growth and development, are known to vary with the changes in external factors such as temperature, day length, water, salinity, etc. However, little is known regarding their behaviour under different levels of mineral nutrition. Mizrahi and Richmond (5) showed that when tobacco plants were transferred to distilled water, the abscisic acid (ABA) content of the plant rose steadily. Similarly, Goldbach *et al.* (4) observed that the ABA content of leaves increased considerably with N deficiency. In both these studies, the emphasis was on the effect of N deficiency; the effect of higher doses of nutrients was not studied. In the present study, an attempt has been made to evaluate the behaviour of two plant growth regulators, viz., gibberellic acid (GA) and ABA like activities, in roots and shoots, under different doses of three major plant macronutrients, i.e., nitrogen phosphorus and potassium.

MATERIALS AND METHODS

The study was conducted with cv. Kufri Chandramukhi. Tubers were planted in pots (20 cm inner dia.) using soil and sand in the ratio of 1 : 3. The basal levels of N, P and K in the soil mixture were 74, 44 and 106 ppm respectively. Only one macro-nutrient was varied at a time keeping the other two constant at the optimum levels (120 ppm N, 44 ppm P and 120 ppm K) of application. The four levels of N and K used were 0, 60, 120 and 180 ppm, and those of P were 0, 22, 44 and 66 ppm. Half strength Hoagland's solution (devoid of N, P & K) was added twice during the experiment and plants were irrigated regularly. The plants were harvested at 50 days after planting and the shoot and root samples were fixed separately in cold methanol and stored in dark. For

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[1]Division of Crop Physiology and Biochemistry, Central Potato Research Institute, Shimla-171001 (H.P.)

extraction and purification of GA and ABA, the method described by Wurr *et al.* (11) was adopted. ABA like activity was quantified by mustard seed germination method as described by Sukumaran *et al.* (9) and for GA the lettuce hypocotyl bioassay, as described by Frankland and Wareing (3) was followed. The two activities were expressed in terms of GA and ABA equivalents and are hereinafter referred to simply as GA and ABA.

RESULTS AND DISCUSSION

GA and ABA levels under different doses of nitrogen : The endogenous levels of GA in roots increased with the increase in the level of added N. This increase was very sharp from 0 to 60 ppm of added N (Fig. 1). For instance, the GA levels were 2.7 µg/100 g fr. wt. of roots when no nitrogen was added. This rose to 8.5, 9.3 and 10.6 µg/100 g fr. wt. with 60, 120 and 180 ppm added N respectively. However, the picture was quite different with shoot. The lowest value was recorded with the highest dose of added N, i.e., 1.7 µg/100 g fr. wt. and highest value was recorded with 60 ppm added N, i.e., 5.8 µg/100 g fr. wt. (Fig. 1).

The ABA content of the shoots was minimum (1.01 µg/g fr. wt.) when the recommended dose of N (120 ppm) was added. However, at 0, 60 and 180 ppm added

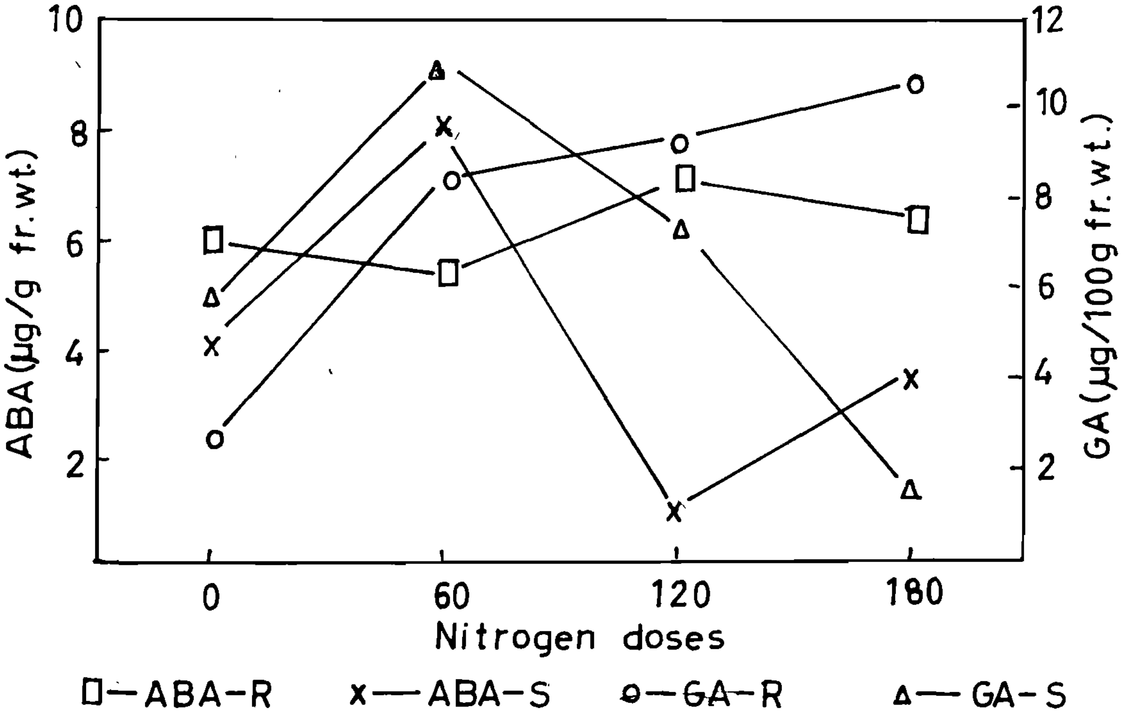

Fig. 1. ABA and GA content in root and shoot of potato under the influence of N nutrition (R-root, S-Shoot).

N, the ABA levels were 4, 8 and 3.5 times more than that recorded at 120 ppm added N (Fig. 1). The roots showed lowest value of ABA at 60 ppm added nitrogen which increased by about 35% and 18.5% when 120 ppm and 180 ppm nitrogen was added, respectively.

GA and ABA levels under different doses of phosphorus : As in the case of N, addition of P also resulted in the accumulation of GA in the roots. This is illustrated by the fact that when P dose was increased, keeping other two components constant, there was an increase in the GA content of roots. This increase was marked at the highest dose (Fig. 2). When no P was added to the soil, the GA content of the roots was only 1.3 μg/ 100 g fr. wt. This increased to 44.1 μg/100 g fr. wt. at 22 ppm and 35.1 μg/100 g fr. wt. at 66 ppm added P. There was an increase in the GA content at 22 ppm added P but at higher doses it declined. For instance, the GA content at 0 ppm added P was 1.0 μg/ 100 g fr. wt. which rose to 12.4 μg/100 g. fr. wt. at 22 ppm P but declined to 5.2 and 3.7 μg/100 g fr. wt at 44 and 66 ppm of added P.

The endogenous levels of ABA in the shoot behaved exactly like that of nitrogen. The lowest concentration of ABA was observed at 44 ppm added P which increased on reducing as well as on increasing the levels of added P. The increase in endogenous level of ABA was more when the P levels were reduced (Fig. 2). In roots, the lowest level of ABA (2.37 μg/g fr. wt.) was encountered at 22 ppm of added P. This rose to 4.0 μg/g fr. wt. when no P was added and to 3.86 and 3.46 μg/g fr. wt. when 44 and 66 ppm were added to the soil showing thereby that the endogenous levels of ABA in root and shoot varies with the depletion or addition of P.

GA and ABA levels under varying doses of potassium : The response of the endogenous levels of growth regulators to varying doses of K is illustrated in Fig. 3. The pattern observed under this macro-nutrient was different from that encountered with the other two macro-nutrients. The endogenous levels of GA in roots increased only upto 120 ppm added K. At higher dose, there was a decrease. For instance, the GA levels in roots were 2.18, 4.0, 34.8 and 23 μg/100 g fr. wt. at 0, 60, 120 and 180 ppm added K (Fig. 3.). However, in shoot the GA content did not show any large variation.

The ABA level in the shoot also did not show much variation with change in added K. The ABA content of the root was highest at 180 ppm added K but otherwise did not show any consistent trend (Fig. 3).

It has been demonstrated that the endogenous levels of GA decreased in leaves of tomato plants grown under sand culture, supplemented with Hoagland's solution devoid of nitrogen (6, 7). In the present study also it was observed that the maximum level of GA was present in plants grown with 60 ppm N, 22 ppm P and 120 ppm K, whereas the quantity of GA was less at the lowest and highest doses. Our results also reveal that both the higher as well as lower doses of macronutrients upsets the hormonal balance of the shoots in the direction of reduction in quantity of GA. In order to explain the reduction in GA content under higher doses of N it has been suggested that with sufficient N nutrition, metabolism of acetyl Co-A occurs via the formation of tryptophan and auxins, which simultaneously decreases gibberellin formation (1).

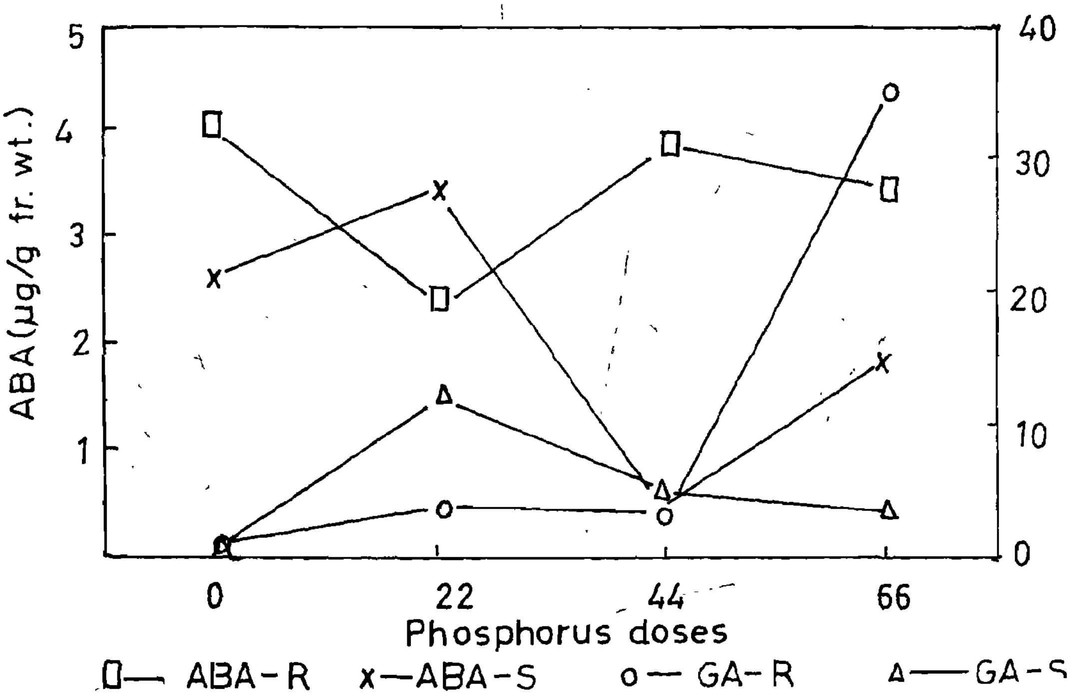

Fig. 2. ABA and GA content in root and shoot of potato under the influence of P nutrition.

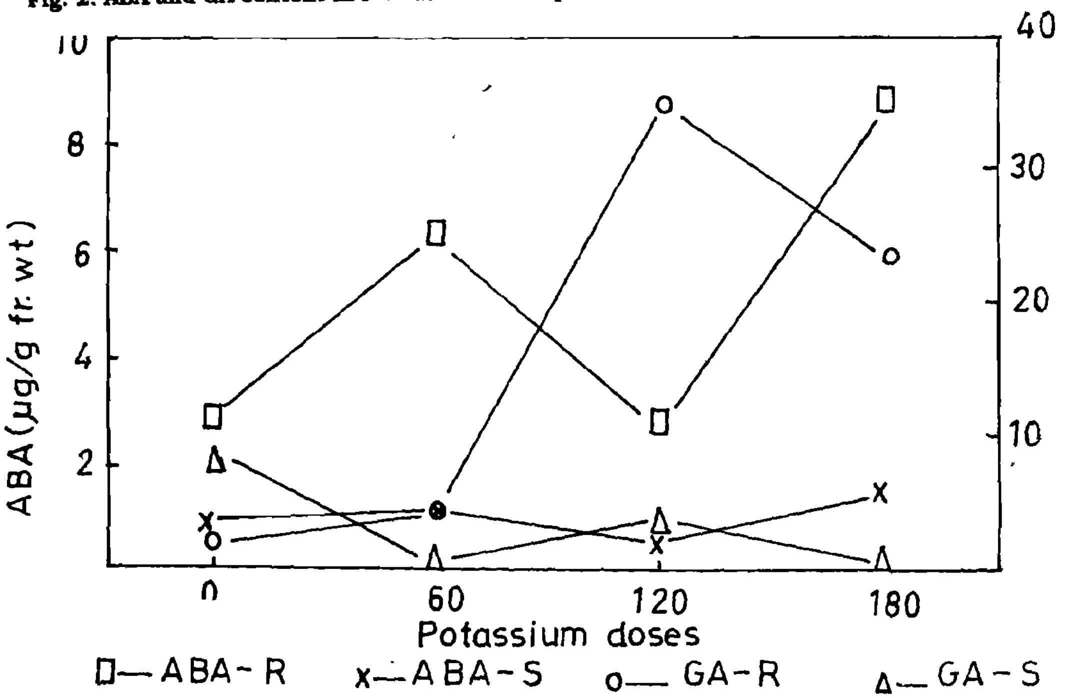

Fig. 3. ABA and GA content in root and shoot of potato under the influence of K nutrition.

Van Steveninck (10), and Cram and Pitman (2) and Shaner *et al.* (8) demonstrated that exogenously applied ABA inhibits K uptake in roots. Fig. 3 shows that ABA content increased sharply in roots, with the application of higher dose of K (180 kg/ha). Thus, it may be concluded that increase in ABA content of roots may be a mechanism by which plants regulate the endogenous levels of K. The response of ABA to doses of N have been investigated in past by few workers (4, 5). Goldbach *et al.* (4) recorded that N deficiency leads to accumulation of ABA in older leaves. They were not able to detect any activity in the roots. In the present study too, accumulation of this growth inhibitor was observed in the shoot under N deficiency.

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YIELD POTENTIAL OF POTATO HYBRIDS IN MADHYA PRADESH

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

ABSTRACT: Nine advanced generation promising potato hybrids alongwith Kufri Chandramukhi and Kufri Badshah as control were evaluated for tuber yield at 75 and 90 days harvest during 1990-91 and 1991-92 crop season in Satpura region of Madhya Pradesh. Wide variability was observed among cultures for tuber yield at 90 days. The hybrids MS/79-10, JN 1758 and JI-5857 showed promise over Kufri Chandramukhi at 75 days but JI-5857 was found promising over high yielding check Kufri Badshah at 90 days and hence can be utilized in potato improvement programme for the region.

INTRODUCTION

Potato is grown in about 31,400 ha in Madhya Pradesh (1). The average yield of potato in the state is around 12.5 t/ha. which is much lower than other states of the country. One of the main reason for low productivity is the low potential of the available cultivars. Therefore, enhancement of tuber yield by improving yield of hybrids/cultures through breeding is vital for increasing production and productivity. Central Madhya Pradesh is one of the important potato growing areas of the country for production of ware potato. Development of high yielding cultivars is a continuous process and this investigation is an attempt to identify high yielding hybrids of potato for Satpura region of Madhya Pradesh.

MATERIALS AND METHODS

Three unreplicated field trials were conducted at Zonal Agricultural Research Station farm and farmer's fields at Kundalikala and Ranikamat in Chhindwara district during *rabi* season of 1990-91 and 1991-92. The trials involved seven new hybrids of potato and two high yielding checks, Kufri Chandramukhi (for early maturity) and Kufri Badshah (for medium maturity). At each location, seed size tubers were planted at 20 cm intra row and 60 cm inter row distances. The plot size was kept at 86.4 sqm. Basal dose consisting of 80 kg N/h as urea, 100 kg P_2O_5/ha. as single super phosphate and 100 kg. K_2O as muriate of potash was applied at planting time. In addition a supplimentary dose of 40 kg N/ha was applied at earthing up at 30 days after planting. The data were recorded for plant height, number of branches, total tuber yield and yield in different grades of tubers at 75 and 90 days after planting. The statistical analysis was done as for randomized block design (2) using location as replication. The analysis was done separately for 75 days and 90 days harvest.

[1]JKNKVV, Zonal Agricultural Research Station, Chandangaon, Chhindwara-480001 (M.P.).

RESULTS AND DISCUSSION

Growth response to cultivars : Cultures showed significant differences with regard to growth characters such as height and numbers of branches per plant (Table 1). Highest average plant height and numbers of branches were recorded in cultures/ hybrids JI-5857 followed by MS/79-10, JI-1857 and MS/78-46 which were significantly superior over early maturiing check i.e. Kufri Chandramukhi.

Grade wise yield : Percentage and yield of tuber size below 20 g produced by QB/ A-9-120, MS/78-46 and Kufri Chandramukhi were more or less similar (Table 1). The fraction 20-100 g were higher in JN-1758 and PJ-37/MS/79-10 while lowest in JI-5857. In case of above 100 g tubers the highest yield were recorded in JI-1857 and JI-5857 whereas remaining cultures were found more or less similar to the check.

It is evident from Table 1, that below 20 g tubers yield decreased from 75 to 90 days in all medium to late maturing cultures, while increasing in small size tubers in early maturing cultures. It is because the early cultures have completed life in short period in comparison to medium to late maturing cultures. It is observed that more yield and percentage of 20-100 g size tuber were observed with early maturing cultures while the bigger size (above 100 g) tubers increased in crop at 90 days after planting.

Yield at 75 days harvest : The cultures differed significantly over check Kufri Chandramukhi, but non significant differences were observed amongst cultures except MS/79-10 which recorded highest yield of 285 g/ha. Second best culture was JN-1758 (273 q/ha) which is early and fast bulking followed by JI-5857 and MS/78-46.

Yield at 90 days harvest : Out of seven cultures only four cultures were found yielding significantly superior over medium maturity check i.e. Kufri Badshah. Culture JI-5857 recorded highest yield of 325 q/ha followed by MS/79-10, JI 1857 and JN-1758, and yield also increased 40%, 35% 26% and 20% over Kufri Badshah. Kang and Birhaman (3) also observed that JI-5857 is a promising culture and can be utilized for potato production.

In case of yield increase from 75 to 90 days the cultures/hybrids JI-5857 and MS/ 79-10 were found best.

It can be concluded that cultures MS/79-10, JN-1758 and JI-5857 are good at 75 days and JI-5857 and MS/79-10 at 90 days. It is suggested that above promising high yielding cultures may be used in breeding to increase the yield of potato crop.

Table 1. Average yield potential of potato hybrids at 75 and 90 days

Hybrids Culture	Avg. growth character at 75 days		Grade wise yield at 75 days			Avg. yield q/ha at 75 days	Grade wise yield at 90 days			Avg. yield q/ha at 90 days	Incr. yield from 75 to 90 days
	Plant. height (cm)	No of Br. per plant	< 20 g	20-100g	>100 g		< 20 g	20-100g	>100g		
JI-1857	78	11	20.5 (8.4)*	117.6 (48.2)*	106.8 (43.6)*	245	18.2 (6.2)*	123.1 (42.0)*	151.8 (51.8)*	293	48 (19.6)
JI-5857	85	13	26.2 (9.7)*	129.3 (47.9)*	114.5 (42.4)*	270	21.1 (6.5)*	140.1 (43.2)*	163.8 (50.3)*	325	55 (20.4)
PJ-376	71	9	19.3 (8.2)*	114.5 (61.5)*	70.9 (30.2)*	235	25.7 (10.6)*	148.7 (61.2)*	68.5 (28.2)*	243	8 (3.4)
QB/A-9-120	64	6	15.9 (6.9)*	141.9 (61.7)*	72.2 (31.4)*	230	32.3 (13.6)*	104.2 (43.8)*	101.4 (42.6)*	238	8 (3.4)
MS/78-46	75	8	13.0 (5.2)*	142.7 (57.1)*	94.3 (37.7)*	250	33.0 (13.0)*	118.6 (46.7)*	102.4 (40.3)*	254	4 (1.6)
MS/79-10	81	12	14.5 (5.11)*	184.4 (64.7)*	86.1 (30.2)*	285	25.1 (8.0)*	174.3 (55.5)*	114.6 (36.5)*	314	29 (10.2)
JN-1758	60	6	19.9 (7.3)*	188.6 (69.1)*	64.7 (23.7)*	273	33.6 (12.0)*	157.1 (56.5)*	87.6 (31.5)*	278	5 (1.8)
K. Chandramukhi (check)	65	7	14.6 (7.7)*	150.3 (79.1)*	25.1 (13.2)*	190	32.0 (16.0)*	124.2 (62.1)*	43.8 (21.9)*	200	10 (5.3)
K. Eadshah (check)	75	8	22.4 (10.6)*	118.4 (61.5)*	84.6 (23.9)*	225	19.4 (8.4)*	121.9 (52.8)*	89.6 (38.8)*	231	
SEm ±	2.8	1.3	3.74	14.6	14.2	16.5	4.5	12.9	12.6	13.9	
C.D. at 5%	8.3	3.4	NS	45.5	43.3	49.0	12.8	39.6	38.5	42.0	

* Figures in parentheses indicate percentage of total yield

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THE EFFECTS OF SHIFTING PLANTING DATES AND IRRIGATION LEVELS ON TUBER SIZE AND YIELD OF POTATO CV. KUFRI BADSHAH UNDER MIDDLE AGROCLIMATIC ZONE OF GUJARAT*

Abker Nooruddin[1] and A.N. Mehta[2]

ABSTRACT: Field experiments were conducted during the *rabi* seasons of 1991-92 and 1992-93 to study the performance of potato crop in relation to dates of planting and irrigation regimes and to test the efficiency of infra-red (IR) thermometry in scheduling irrigation. The relative performance of the various treatments was such that early planting (3rd Nov.) increased percentage of small grade tubers and decreased the percentage of large grade tubers while the second date of planting (16th November) produced highest percentage large grade tubers. Late planting (30th Nov.) produced significantly higher number of tubers as well as higher percentage of medium grade tubers and gave significantly higher tuber yield than 3rd November and 16th November planting in both the years. Scheduling of irrigation with infra-red (IR) thermometry with (T_c-T_a) ranging between ± 1°C could save about 33 to 44% of irrigation water without appreciable reduction in yields.

INTRODUCTION

Potato is a weather sensitive crop. Plant growth and tuber production are markedly influenced by environmental conditions. The main factors which affect the rapid establishment of the crop canopy are genotype, planting date, planting density, pest and diseases, temperature and the availability of water and nutrients in the soil (1). In the state of Gujarat in India, potato crop is planted in mid November to mid December and harvested in mid February to mid-March. In either case, part of the growing season encounters unfavourable weather conditions. The objectives of the experiments described in this study were to determine the best time to plant the potato crop (cv. Kufri Badshah) in order to minimize the adverse effect of temperatures during emergence and tuber bulking stages and to study the effect of different irrigation levels on tuber yield as well as to test the efficiency of infra-red (IR) thermometry in scheduling irrigation.

MATERIALS AND METHODS

The field experiments were carried out in the *rabi* seasons of the years 1991-92 and 1992-93 on loamy sand soil of the College Agronomy Farm, B.A. College of Agriculture, Gujarat Agricultural University, Anand Campus, Anand. The seed tubers of cv. Kufri Badshah weighing 25-35 g were planted in plots measuring 2.7 x 3.9 m. There were three planting dates as main plot treatments viz. 3rd November (D_1), 16th November (D_2) and 30th November (D_3) except in 1992-93, the first planting date (D_1) was on 9th November

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[1] Present address : P. O. Box 15001, SAMA'A, Republic Yemen.

[2] Corresponding address : Department of Agricultural Meteorology, B.A. College of Agriculture, Gujarat Agricultural University, Anand Campus, Anand - 388110.

and four irrigation levels (as sub-plot treatments) viz. irrigation when the available soil moisture (ASM) reached a value of 75% of total ASM (I_1), irrigation when ASM reached a value of 50% of total ASM (I_2), irrigation at 10 to 12 days' interval (I_3) and irrigation when the canopy-air temperature differential (T_c-T_a) ranged between ± 1°C (I_4). The first irrigation of 50 mm depth of water (527/plot) was given to all the plots of each date of planting (5 days before planting). The second irrigation of 50 mm depth of water was (527/plot) common for plots of each date of planting and was given immediately after emergence for obtaining uniform stand of the crop. Thereafter, differential irrigations as per treatments were scheduled with a fixed depth of 50 mm of irrigation water (527/plot). The total number of irrigations applied were 10, 7, 8 and 6 for the treatments of I_1 I_2 I_3 and I_4 respectively in both the years except in D_1I_4 and D_2I_4 respectively of 1991-92 in which seven irrigations were given. The experiment was laid out in split plot design with six replications under the recommended fertilizer practices of 220 : 110 : 220 : N : P : K kg/ha. The entire quantity of phosphorus and potash and half the quantity of nitrogen were applied as basal dose at the time of planting. The nitrogen, phosphorus and potash were applied in the form of urea, di-ammonium phosphate and muriate of potash respectively. The remaining quantity of nitrogen was given as top dressing during the earthing up operation. The number and weight of large (L), medium (M) and small (S) tubers were recorded at the time of harvesting as L > 100 g, 50 < M, < 100 g and S < 50 g. The weekly average values of maximum, minimum and mean temperature as recorded at the agrometeorological observatory were plotted against standard weeks in figure 1.

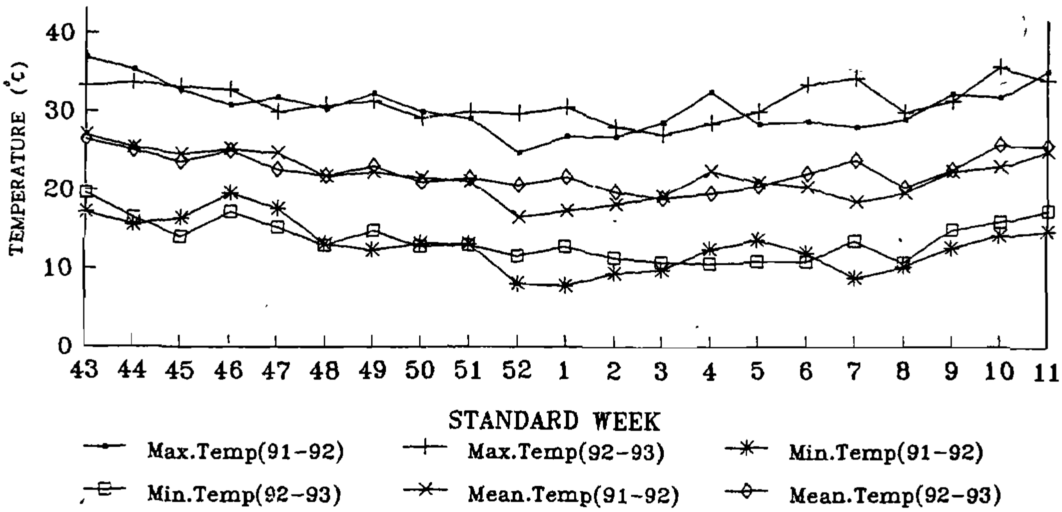

Fig. 1. Variation of air temperature during crop season

Fig. 1. Variation of air temperature during crop season

RESULTS AND DISCUSSION

Tuber yield : Differences in tuber yield were significantly influenced by dates of planting during both the years (Table 1). The treatment D_3 gave significantly higher tuber yield than D_1 and D_2 in both the years. Treatment D_2 produced significantly higher tuber yield than treatment D_1 in both the years. When the data were pooled over the years, the effects on tuber yield due to the dates of planting were non significant. The year to year variation as well as the interaction effect due to Y x D were also significant and the highest tuber yield was produced in 1992-93 under D_3 treatment. There was a progressive delay in days to 50% emergence with early planting due to higher temperatures. In respect to irrigation regimes (Table 1) the treatments I_1 and I_3 were at par with each other in their performance with respect to tuber yield and produced significantly higher tuber yield as compared to I_4 treatment in both the years as well as in pooled analysis. The treatment I_3 in its effect on tuber yield was at par with I_2 in 1991-92

Table 1. Average tuber yield (t ha^{-1}) as influenced by dates of planting and irrigation regimes

Treatments	Average tuber yield (t ha^{-1})		
	1991-92	1992-93	Pooled
Dates of planting			
D_1	24.24	34.86	29.55
D_2	33.31	37.53	35.42
D_3	42.64	42.83	42.74
SEM	0.807	0.614	2.630
C.D. at 5%	2.545	1.935	NS
C.V. %	11.84	7.83	9.79
Irrigation regimes			
I_1	35.10	41.57	38.33
I_2	32.53	37.07	34.80
I_3	34.89	40.64	37.77
I_4	31.06	34.35	32.71
SEM	1.014	0.571	0.582
C.D. at 5%	2.897	1.631	1.628
C.V. %	12.88	6.30	9.72
D x I interaction			
SEM	1.756	0.988	1.007
C.D. at 5%	NS	NS	NS
Average of years	33.40	38.41	—
For pooled data		CD at 5%	
Effect due to years		1.222	
Y x D		2.166	
Y x I		NS	
Y x D x I		NS	

while it yielded significantly higher than the treatment I_2 in 1992-93 as well as in pooled analysis. The data further revealed that the treatment I_2 was at par with treatment I_4 in 1991-92 while it produced significantly higher tuber yield than I_4 in 1992-93 as well as in pooled analysis. The interaction effect due to D x I, Y x I and Y x D x I were, however, non significant. Performance of I_1 and I_3 was superior to that of I_2 and I_4 The increase in tuber yield by supplying 500 mm of water during the whole crop period at 7 to 8 days' interval (I_1 treatment) instead of 400 mm of water supply at 10 to 12 days' interval (I_3 treatment) in both the years as well as in pooled analysis could positively be interpreted as the fact that the crop responded favourably to higher soil moisture regime. However, the increased yields produced under I_1 and $_3$ treatments over those under treatments I_2 and I_4 were not so high to justify the scheduling of irrigation when ASM reached a value of 50% of the total ASM (treatment I_2) or when the canopy-air temperature differential (T_c-T_a) ranged between ± 1°C (treatment I_4) was not satisfactory for obtaining higher tuber yield. These results are in conformity with the earlier findings (2, 3 and 4). Thus, so far as saving of water is concerned, scheduling of irrigation when

Table 2. Average number of tubers per m² as influenced by dates of planting and irrigation regimes

Treatments	Average number of tubers/m²		
	1991-92	1992-93	Pooled
Dates of planting			
D_1	32.72	52.28	42.50
D_2	37.44	63.21	50.33
D_3	50.26	64.35	57.31
SEM	1.592	1.318	2.924
C.D. at 5%	5.05	4.154	NS
C.V. %	19.42	10.77	14.31
Irrigation regimes			
I_1	42.37	64.87	53.62
I_2	39.63	60.34	49.99
I_3	41.38	61.00	51.19
I_4	37.18	53.58	45.38
SEM	1.030	1.085	1.281
C.D. at 5%	2.912	3.069	NS
C.V. %	10.44	7.68	8.97
D x I interaction			
SEM	1.783	1.879	1.295
C.D. at 5%	NS	NS	NS
Average of years	40.14	59.95	—
For pooled data		C.D. at 5%	
Effect due to years		2.489	
Y x D		4.311	
Y x I		4.311	
Y x D x I		NS	

Table 3. Percentage of tuber grades on number basis as influenced by dates of planting and irrigation regimes

Treatments	Average percentage of tuber grades*								
	1991-92			1992-93			Pooled		
	S	M	L	S	M	L	S	M	L
Dates of planting									
D_1	38.00	37.00	25.00	42.00	41.00	17.00	40.00	39.00	21.00
D_2	25.00	39.00	36.00	42.00	38.00	20.00	33.50	38.50	28.00
D_3	28.00	43.00	29.00	37.00	44.00	19.00	32.50	43.50	24.00
SEM	2.036	0.641	1.802	1.252	0.935	0.769	5.550	0.567	4.397
C.D. at 5%	6.416	2.021	5.679	3.946	2.947	2.423	NS	1.673	NS
C.V. %	32.95	7.88	29.28	15.28	11.20	20.83	23.51	9.72	28.21
Irrigation regimes									
I_1	29.00	41.00	30.00	38.00	43.00	19.00	33.50	42.00	24.50
I_2	32.00	39.00	29.00	43.00	40.00	17.00	37.50	39.50	23.00
I_3	29.00	40.00	31.00	38.00	43.00	19.00	33.50	41.50	25.00
I_4	31.00	39.00	30.00	42.00	39.00	19.00	36.50	39.00	24.50
SEM	1.192	1.202	1.233	1.756	1.180	0.794	1.461	0.842	0.892
C.D. at 5%	NS	NS	NS	NS	3.339	NS	NS	2.359	NS
C.V. %	16.70	12.79	16.00	18.56	12.24	18.62	18.8	12.51	17.25
D x I interaction									
SEM	2.064	2.082	1.963	3.042	2.044	1.375	1.838	2.064	1.198
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Average of years	30.27	39.88	30.04	40.16	40.91	18.75	-	-	-
For pooled data	C.D. at 5%								
Effect due to years	2.879	NS	2.360						
Y x D	4.987	NS	4.088						
Y x I	NS	NS	NS						
Y x D x I	NS	NS	NS						

*S = Small, M = Medium, L = Large.

ASM reached a value of 50% of the total ASM (treatment I_2) or the technique of measuring the canopy-air temperature differential could very safely be used for scheduling irrigation in potato crop with (T_c-T_a) differential in the range of ± 1°C without much reduction in tuber yield and with saving of about 33 to 44 per cent of irrigation water over the approach of scheduling irrigation when ASM reached a value of 75% of the total ASM.

Tuber number of percentage of tuber grades : The relative performance of different treatments in relation to average number of tubers (Table 2) and percentage of tuber grade (Table 3) was such that early planting (treatment D_1) produced less number of tubers and higher percentage of 'S' grade tubers, while late planting (treatment D_3) produced significantly higher number of tubers.

The data pertaining to the average number of tubers (Table 2) as influenced by different irrigation regimes revealed that the number of tubers per m^2 were higher in treatment I_1 which was followed by treatment I_3. The increased number of tubers per m^2 due to higher frequency of irrigation had also been reported by a number of research workers (5, 6 and 7).

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YIELD PERFORMANCE AND ECONOMICS OF POTATO PRODUCTION THROUGH TRUE POTATO SEED

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

ABSTRACT: In a trial involving TPS progenies as transplants and the cultivar Kufri Bahar, the yield of Kufri Bahar (311.2 q/ha) and TPS population HPS-I/13 (292 q/ha) were found similar. Kufri Bahar gave a higher proportion of ware size tubers. Per cent survival of seedlings of all TPS progenies was similar to the standard cultivar Kufri Bahar. Population HPS-25/13 recorded the highest number of tubers (150 per sq meter). Growing potato through TPS was highly profitable in comparison to seed tubers.

INTRODUCTION

Traditionally the potato crop is raised from seed tuber, which alone account for more than 50% of the potato production cost (5). Several factors associated with seed tubers viz. quality of seed, health standard etc. are taken care of when TPS is used as seed. If suitable high yielding hybrids of true potato seeds (TPS) are made available, the farmers can raise a successful commercial crop of potato (6) at low cost. The present study was undertaken to evaluate the yield performance of new hybrid TPS progenies and economics of raising the crop by transplanting seedlings in field for ware potato production.

MATERIALS AND METHODS

The study was carried out at Zonal Agricultural Research Station, Chhindwara (M.P.) during 1990-91 crop season and at village Kundalikala during 1991-92. The seedlings of six TPS populations, viz. HPS-I/13, HPS-I/67, HPS-II/13, HPS-7/13, HPS-7/67, and HPS-25/13, were raised in nursery beds as per standard procedure (2). After 25 days of seed sowing 8-10 cm. high seedlings were transplanted in the field. Inter and intra row spacings were kept at 50 and 10 cm, respectively. The standard variety Kufri Bahar was planted using seed tubers at 50 cm inter row and 20 cm intra row spacing. The trial was laid out in radomized block design with four replication having sub plot size 5.0 x 2.0 m. Half of nitrogen (75 kg/ha) and full dose of phosphorus (100 kg/ha) and potassium (100 kg/ha) fertilizer were applied in the field before transplanting. Remaining half of nitrogen (75 kg/ha) was given in two equal split dose at earthing up after 40 and 60 days after transplanting. One prophylatic spray of fungicide at 35 days and three sprays of insecticides alongwith fungicide starting from 50 days after transplanting were given at 15 days interval. Crop was dehaulmed after 105 days and harvested at 115 days after transplanting. The data of per cent seedling survival on transplanting in the field, number of tubers per sq. meter, total tuber yield in different grades of tubers were recorded. The tuber uniformity was recorded visually in grades

[1] Zonal Agricultural Research Station, Chandangaon, Chhindwara-480001 (M.P.).

1-5 with 5 being the most uniform. Economics of crop production through TPS and traditional seed tuber was also worked out.

RESULTS AND DISCUSSION

The average per cent survival of transplanted seedlings in field varied from 94.5 to 97.5 (Table 1). The highest seedling survival was recorded in HPS-I/13 (97.7%) and the lowest in HPS-7/67 (94.5%). The average number of tubers in various TPS progenies was higher than Kufri Bahar. The highest number of tubers (150) was recorded in HPS-25/13 followed by HPS-I/13 (147) which was significantly superior to Kufri Bahar (95).

Table 1. Average yield performance of TPS populations as transplant in field

TPS Progenies	Average Survival (%)	Average number of tubers per sq. m.	Yield q/ha			Percentage of different grades of tubers				Tuber uniformity
			1990-91	1991-92	Mean	< 20 g	20-60 g	60-100g	> 100 g	
HPS-I/13	97.7	146.5	300.7	283.3	292.0	9.64	32.64	41.49	16.21	5
HPS-I/67	97.5	138.5	267.1	257.0	262.0	10.17	31.58	40.22	18.04	4
HPS-II/13	97.0	117.0	234.6	230.7	232.6	7.15	33.59	40.47	18.76	3
HPS-7/13	96 5	139 1	307.6	260.0	283.8	8.41	36.16	40.66	14.78	5
HPS-7/67	94 5	102.1	231.4	222.0	226.7	13.75	33.99	35.38	16.87	3
HPS-25/13	97.0	150.1	233.8	232.0	232.9	8.50	35.27	40.30	15.94	3
C-3	95.8	110.2	255.7	271 8	263.7	9.04	36.33	40.84	13.46	4
K. Bahar	96 0	94.5	299.5	323.0	311.2	4.40	19.39	28.27	47.91	5
SEm ±	-	14.5	10.04	15.3	-	-	-	-	-	-
C.D. at 5%	-	4.50	30.67	46.9	-	-	-	-	-	

Table 2. Economics of potato production from transplanted seedlings

TPS Progenies	Gross Return (Rs./ha)	Total Cost of cultivation (Rs./ha)	Net Income (Rs./ha)	C : B Ratio
HPS-I/13	51.100	12.772	38.378	3.01
HPS-I/67	45.859	12.772	33.137	2.60
HPS-II/13	40.712	12.722	27.990	2.20
HPS-7/13	49.665	12.722	36.943	2.90
HPS 7-67	39.674	12.722	26.952	2.11
HPS-25/13	40.756	12.722	28.034	2.20
C-3	46.617	12.722	33.440	2.62
Kufri Bahar	54.469	19.852	34.617	1 74

The data on tuber yield for two years (Table 1) indicated significant differences among the populations. In both the years the yield of crop raised from transplanted seedlings of HPS-I./13 was at par with Kufri Bahar. In general, the yield of the transplanted crop was lower than the tuber grown crop. Some of the families could possibly yield equal to the cultivar if the dehaulming was delayed up to 110 days (4).

The data on yield of different grads of tubers (Table 1) showed that the crop grown from seed tubers gave higher percentage of ware potato (> 100 g), whereas, the crop from transplanted seedlings gave higher proportion of small (< 20 g) and medium size (20-60 g) tubers. Dubey (1) observed that the tubers from the transplanted crop when used as seed next year, exhibited 31-76% yield increase over the standard variety. The higher proportion of small and medium size tubers in TPS population is thus advantageous for raising the next crop. The data in the present study showed that nearly 40% of the produce of TPS transplanted crop (Table 1) would be available for use as seed next year as compared to only 24% from the seed tuber crop.

The data on uniformity of tubers showed that the produce of HPS-I/13 and HPS-7/13 compared well with the standard variety Kufri Bahar.

Potato production from seedling transplanting of TPS was economical and profitable than from traditional method (Table 2). Maximum net income as well as cost benefit ratio was obtained from population HPS-I/13 followed by HPS-7/13.

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The authors are grateful to the ICAR, New Delhi and Dr. P.C. Gaur, ex Project Coordinator for supplying TPS for field trials. Sincere thanks are also due to Dr. S.M. Paul Khurana, Project Coordinator (Potato), for examining the manuscript and suggestions.

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COMPARISON OF ORTHO-PHENANTHROLINE (pH 3.0) AND HCl METHODS FOR FERROUS ESTIMATION TO EXPLAIN IRON CHLOROSIS IN POTATO PLANTS

S.P. Trehan[1] and J.S. Grewal[2]

ABSTRACT: Ortho-phenanthroline pH 3.0 (O-Ph) and HCl methods for Fe^{2+} estimation were compared to explain iron chlorosis in potato plants. Different strengths of extractant and extractant- plant tissue ratios were used to estimate Fe^{2+} in fresh and dry leaf samples of chlorotic plants and adjoining green plants of potato (cvs. Kufri Jyoti and Kufri Badshah). 1.5N HCl and 1:7.5 extractant-tissue ratio on fresh weight basis explained better or equally good. The visible iron chlorosis in potato plants, compared to O-Ph method. Fe^{2+} iron in chlorotic as compared to non-chlorotic leaves of two cultivars by these methods was 72 to 84%. HCl method eliminates the inherent error arising from extraction of pigments. However O-Ph method can also be used for dry leaf samples for explaining iron chlorosis if O-Ph extracts are analysed for iron with Atomic Absorption Spectrophotometer.

INTRODUCTION

Leaf analysis for total Fe often fails to explain Fe-chlorosis in plants as the chlorotic plants usually have higher total contents of Fe than the corresponding green plants (2). In order to overcome this paradoxical behaviour, Fe^{2+} fraction, more important for, synthesis of chlorophyll, was analysed from fresh rice seedling leaves with acidified 1-10 O-phenanthroline pH 3.0 (O-Ph) and was found to resolve Fe-chlorosis (1). While resolving Fe-chlorosis with this method in *Cicer arietinum* lines, very low concentrations of Fe^{2+} and very small differences between green and chlorotic lines were found (3). Also Fe^{2+} concentration did not correlate well with the degree of chlorosis. This shows that effectiveness of O-Ph method varied with the plant species. Takkar and Kaur (3) reported that HCl method resolved better or equally good, the visible iron chlorosis in rice, wheat and cicer plants, compared to O-Ph method. In this study, an attempt has been made to compare O-Ph and HCl methods to resolve Fe-chlorosis in potato plants.

MATERIALS AND METHODS

Bulk leaf samples, upper four of chlorotic plants and adjoining green plants of potato cv. Kufri Jyoti from field supplied adequately with NPK were collected at 70 days growth stage. Leaf samples were washed successively with 0. 1 N HCl and deionized water. These were sand-witched between sheets of whatman filter paper No. 1 to soak the sticking water and were cut into small pieces with stainless steel scissors. To 2 g sample in 50 ml flasks (each of green and chlorotic sample) 10, 15 and 20 ml solutions of 1.5% 1-10-

[1]Central Potato Research Station, Model Town P.O., P.B. No. 1, Jalandhar-144003 (Punjab).
[2]Central Potato Research Institute, Shimla - 171001 (HP).

O-Ph (pH 3.0), and 1.0 and 1.5 N HCl were added. The flasks were covered and incubated at room temperature for 24 h with occasional shaking and filtered. Three ml HCl extract was taken in duplicate in glass tubes and 0.5 M sodium citrate solution was added to achieve pH 3.0. To one tube one ml 1.5% O-Ph and to the second 1 ml deionized water (referred to as tissue blank, TB) was added and volume was made to 10 ml with deionized water. Optical density (OD) of HCl-extracts was measured against their respective TB. The OD of O-Ph (pH 3.0) extracts was measured against O-Ph blank.

Similarly, 4th leaf samples from Fe-chlorotic and green plants of cv. Kufri, Badshah were collected from the same field and were analysed for Fe^{2+} both with O-Ph (pH 3.0)

Table 1. Comparison of different extractants (O-Ph (pH 3) and HCl) and extractant-plant ratio for extraction of Fe^{2+} (mg/kg dry weight) from Fe-chlorotic (C) and green(G) fresh leaves of potato cv. Kufri Jyoti (n = 6)

Ratio[1]	Leaves	Extractant		
		O-Ph	1.0 N HCl	1.5 N HCl
5.0	G	118efg	110g	114fg
	C	106g	106g	104g
7.5	G	138defg	161d	217c
	C	102g	165d	156de
10.0	G	152def	227 c	328a
	C	140cefg	205c	265b

Any two values having a common letter are not significantly different at the 5% level of significance.
1. Extractant : plant ratio on fresh weight basis.

Table 2. Comparison of different extractants (O-Ph (pH 3.0) and HCl) for extraction of Fe^{2+} (mg/kg dry weight) from Fe-chlorotic (C) and green (G) fresh leaves of potato cv. Kufri Badshah (n = 6)

Extractant[1]	Colorimeteric		AAS[2]	
	G	C	G	C
O-Ph	106g	89g	48h	35h
1.5 N HCl	191e	154f	197de	161f
2.0 N HCl	23abc	199de	231abc	209cde
2.5 N HCl	246ab	216cd	254a	225bc

Any two values having a common letter are not significantly different at the 5% level of significance.
1. Extractant : plant ratio of 7.5 on fresh weight basis
2. AAS = Atomic Absorption Spectrophotometer.

and HCl methods with incubation period of 24 h and extractant plant ratio of 7.5 on fresh weight basis. After drying and grinding, these leaf samples were again analysed for Fe^{2+} both by O-Ph (pH 3.0) and 1.5 N HCI methods with incubation periods of 0, 1, 4 and 24 h and extractant plant ratio of 75 on dry weight basis (15 ml extractant added to 0.2 g dry leaf sample). The data of these studies are given in tables 1-5.

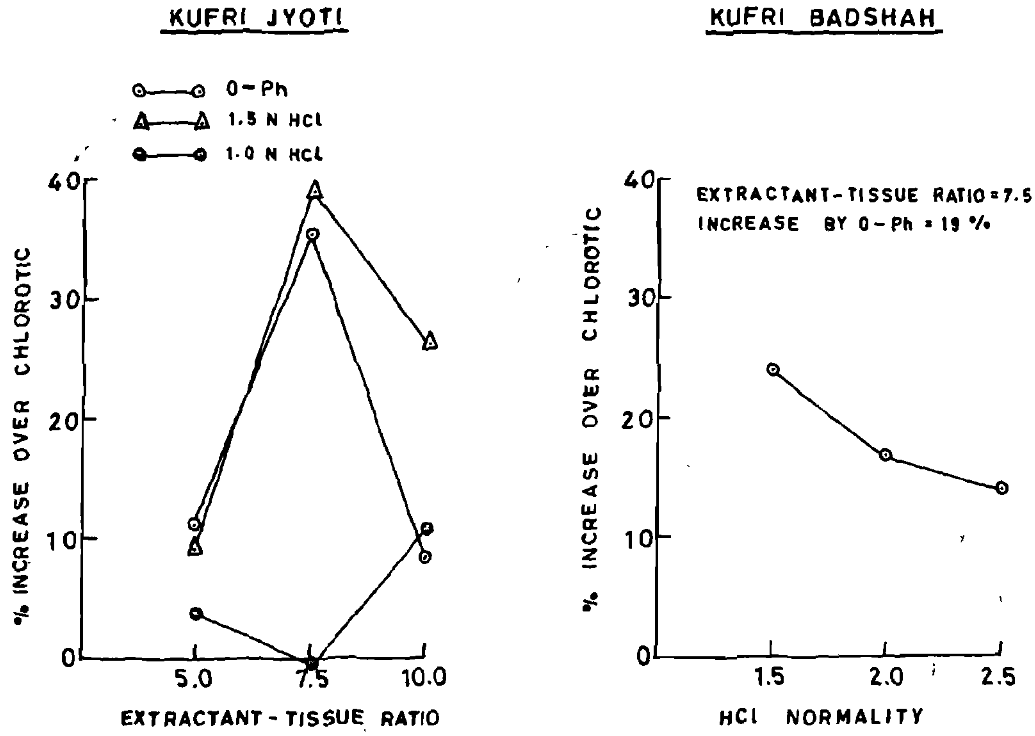

Fig. 1. Per cent increase of Fe^{2+} in green over chlorotic plants with ortho-phenanthroline (O-Ph) or increasing strength of HCl and extractant tissue ratio

RESULTS AND DISCUSSION

Optimum strength of extractant and extractant-plant tissue ratio (fresh leaf samples): O-Ph as compared to HCl extractant extracted significantly and markedly less Fe^{2+} (Table 1) particularly at extractant plant ratio of 5.0. 1.5 N HCl extracted significantly more Fe^{2+} than 1 N HCl at higher extractant-plant ratio. Fe^{2+} in chlorotic tissues was significantly and markedly lower than that of green tissues in both O-Ph and 1.5 N HCl methods and the differences were much wider at extractant plant ratio of 7.5 (Table 1 and Fig. 1). Comparison of different strengths of HCl showed that the differences of Fe^{2+} concentration in leaves between the green and chlorotic tissues did not increase beyond 1.5 N HCl (Table 2 and Fig. 1). The results indicated that both O-Ph and 1.5 N HCl at extractant plant ratio of 7.5 were good enough to resolve Fe-chlorosis in potato.

Comparison of O-Ph (pH 3.0) and HCl extractants for dry leaf samples: 1.5 N HCl showed markedly higher concentration of Fe^{2+} in dry green leaves than that in dry chlorotic leaves (Table 3) but O-Ph extractant showed the reverse trend. When O-Ph (pH 3.0) extracts were analysed for Fe with Atomic Absorption Spectrophoto-meter (AAS), the values were invariably lower than the colorimetric method (Tables 2, 3) and the values were also markedly less in chlorotic tissues than those in green tissues. This indicates that in O-Ph (pH 3.0) extracts some coloured compounds were concurrently

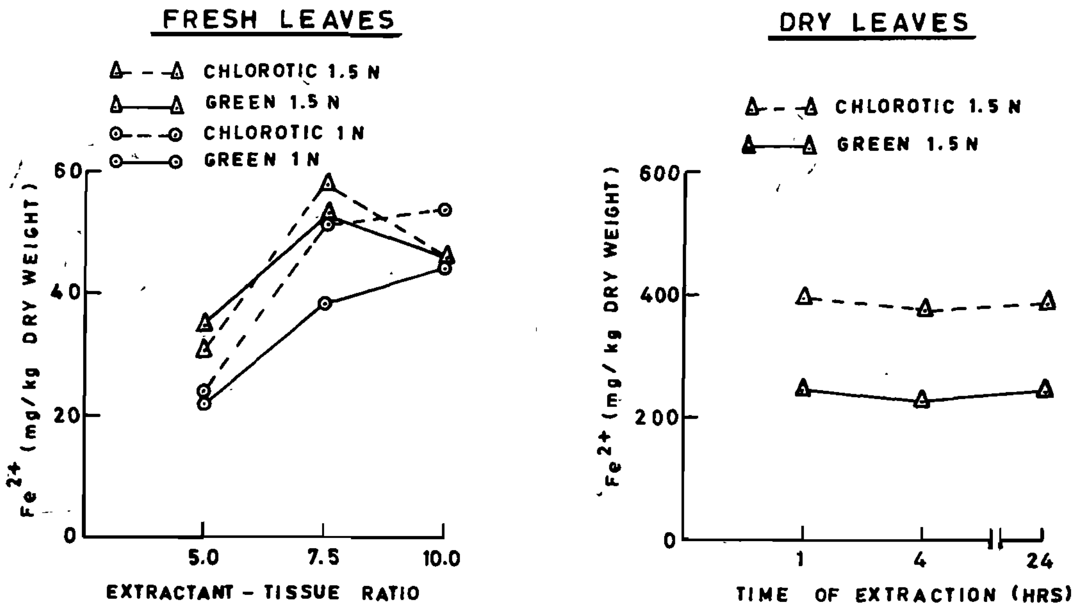

Fig. 2. Influence of strength of HCl, extractant tissue ratio and time of extraction on pigment error, equivalent to Fe^{2+} in tissue blanks of green and chlorotic leaves of potato cv. Kufri Badshah

Table 3. Comparison of different extractants and time of extraction of Fe^{2+} (mg/kg dry weight) from Fe-chlorotic (C) and Green (G) dry leaves of potato cv. Kufri Badshah (n = 6)

Extractant[1]	Time	Colorimeteric		AAS[2]	
	(hrs)	G	C	G	C
O-Ph	1	203def	271c	16.6i	8.3i
	4	217de	295b	19.2i	13.4i
	24	222d	344a	24.9i	16.5i
1.5 N HCl	1	181fgh	162fg	192efgh	168gh
	4	202def	187fgh	195ef	179fgh
	24	206def	197def	196def	185fgh

Any two values having a common letter are not significantly different at the 5% level of significance.
1. Extractant : plant ratio of 75 on dry weight basis.
2. AAS = Atomic Absorption Spectrophotometer.

estimated as Fe^{2+}, and at times may lead to erroneous conclusions in colorimetric method. These observations suggest that O-Ph method can be used for dry leaf samples for resolving iron chlorosis if O-Ph extracts are analysed for Fe with Atomic Absorption Spectrophotometer.

Table 4. Effect of different HCl methods for extraction of Fe^{2+} (mg/kg dry weight) on tissue blank (TB) of green and chlorotic fresh leaves of potato cv. Kufri Jyoti (n = 6)

Category of chlorosis	1.0 N HCl			1.5 N HCl		
	Ratio			*Ratio*		
	5.0	7.5	10.0	5.0	7.5	10.0
Green	22e	39cd	44cd	35de	52ab	46abc
Chlorotic	24e	51ab	54a	31d	58a	46bc
% increase (+)/ decrease (-) over green	(+) 9.1	(+) 34.2	(+) 22.7	(-) 11.4	(+) 11.5	0

Any two values having a common letter are not significantly different at the 5% level of significance.

Table 5. Effect of 1.5 N HCl for extraction of Fe^{2+} (mg/kg dry weight) on tissue blank (TB) of green and chlorotic dry leaves of potato cv. Kufri Badshah (n = 6)

Category of chlorosis	Time of extraction (hrs)		
	1	4	24
Green	258b	238b	258b
Chlorotic	406a	382a	394a
% increase (+)/ disease (-) over green	(+) 57.4	(+) 60.5	(+) 52.7

Any two values having a common letter are not significantly different at the 5% level of significance.

Pigments/coloured compounds in tissue extracts: Tables 4 and 5 show that the TB, a measure of pigment/coloured organic compounds, was quite large in HCl extracts. The error generally increased both with increasing strength and extractant plant ratio (Table 4, Fig. 2). The error was much higher in dry leaves than that in fresh leaves (Table 5 and Fig. 2). The differences of colour compounds between green and chlorotic tissues were quite large and the TB was generally higher in chlorotic tissues than that in green tissues (Tables 4, 5 and Fig. 2).

Effect of pH on Fe^{3+} reduction during estimation of Fe^{2+} by colorimeteric method: To establish that iron estimated by orthophenanthroline. (O-Ph) is the factual Fe^{2+} and low pH is not involved in Fe^{3+} reduction, solutions having different proportions of Fe^{2+} and Fe^{3+} were analysed by O-Ph (colorimetrically) and Atomic Absorption Spectrophotometer (Table 6). Stock solutions of 10 mg/1 of Fe were prepared from $FeSO_4$ $FeCl_3$. Different proportions of these two stock solutions were mixed and diluted in glass tubes with HCl-sodium citrate solution, pH 3.0 to give 16 combinations of ferrous (Fe^{2+}) and ferric Fe^{3+}) iron (Table 6). Iron in these 16 tubes was estimated colorimetrically after adding one ml O-Ph (1.5%) solution and measuring optical density (OD) against the respective buffer blank and by Atomic Absorption Spectrophotometer (AAS). Data in table 6 indicated that O-Ph measured Fe^{2+} only and Fe^{3+} was not reduced to Fe^{2+} at low pH during estimation whereas AAS measured both Fe^{2+} and Fe^{3+}.

Table 6. Estimation of different forms of iron (ferrous) (Fe^{2+}) and ferric (Fe^{3+}) by colorimeteric method and Atomic Absorption Spectrophotometer

S. No.	Concentration (ppm) of Fe^{2+} and Fe^{3+} in test solution			Concentration of iron estimated (ppm)	
	Fe^{2+}		Fe^{3+}	Colorimeteric	AAS[1]
1	0	+	0.0	0.0	0.0
2	0.5	+	0.0	0.5	0.50
3	1.0	+	0.0	1.0	0.98
4	1.5	+	0.0	1.5	1.50
5	0	+	0.5	0.0	0.52
6	0.5	+	0.5	0.5	1.00
7	1.0	+	0.5	1.0	1.55
8	1.5	+	0.5	1.5	2.04
9	0	+	1.0	0.0	0.99
10	0.5	+	1.0	0.5	1.45
11	1.0	+	1.0	0.94	1.98
12	1.5	+	1.0	1.5	2.52
13	0	+	1.5	.0	1.43
14	0.5	+	1.5	0.5	1.97
15	1.0	+	1.5	0.94	2.41
16	1.5	+	1.5	1.5	2.89

1. Atomic Absorption Spectrophotometer

The results showed that 1.5 N HCl and 1: 7.5 ratio resolved better or equally good, the visible iron chlorosis in potato plants, compared to O-Ph (pH 3.0) method. HCl method eliminates the inherent error arising from extraction of pigements. However O-Ph method can also be used for dry leaf samples for resolving iron chlorosis if O-Ph extracts are analysed for Fe with Atomic Absorption Spectrophotometer.

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PROCESSING AND NUTRITIVE QUALITIES OF POTATO TUBERS AS AFFECTED BY FERTILIZER NUTRIENTS AND SULPHUR APPLICATION

J.P Singh, R.S. Marwaha[1] and O.P. Srivastava[2]

ABSTRACT: In a low fertility alluvial soil, tuber yield of potato cv. Kufri Badshah increased by 67, 69 and 39 q ha^{-1} due to application of 80, 150 and 25 kg ha^{-1} of phosphorus (P_2O_5), potassium (K_2O) and sulphur, respectively. Balanced fertilization of NPK increased the per cent dry matter and soluble protein in tubers, while decreased the total phenols free amino acids and reducing sugars (glucose + fructose) compared to unbalanced fertilization. Application of sulphur generally increased the per cent dry matter, soluble protein, free amino acids and total phenols, while decreased the reducing sugars. Minimum amount of amino acids coupled with low amount of reducing sugars in harvested potato tubers was obtained with balanced fertilization of NPKS. These tubers yielded light coloured acceptable chips on frying. However, the main effect of sulphur on chip colour was not significant. Balanced fertilization of NPKS tended to increase the content of elements Ca, Mg, S, Cu and Fe in tubers.

INTRODUCTION

Fertilizer nutrients (NPK) are universally known to influence the potato tuber yield and quality. Potato also responds to sulphur application, if soil and irrigation water are deficient in sulphur (9, 10). However, information about the effect of sulphur and its interaction with fertilizer nutrients on tuber yield and quality is lacking. Therefore, an experiment was conducted to study the effect of sulphur under balanced and unbalanced combinations of fertilizer nutrients on tuber yield, processing and nutritive qualities of tubers of irrigated potato crop.

MATERIALS AND METHODS

A field experiment was conducted at Vegetable Research Farm of Banaras Hindu University, Varanasi (25.2°N latitude and 83.1°E longitude) in year 1989-90. The soil of the experimental site was sandy loam in texture and had pH 7.8, electrical conductivity 0.165 dS m^{-1}, organic carbon 3.75 g kg^{-1}, and available N-P-K as 150-17-134 kg ha^{-1}. The soil was deficient in sulphur with 9.6 kg SO_4 ha^{-1} (0.15% $CaCl_2$ extractable). Treatments consisted of combinations of fertilizer nutrients (N, NP, NK, NPK) and 3 levels of S (0, 25, 50 kg ha^{-1}). N, P as P_2O_5 and K as K_2O were applied at the rate of 180, 80 and 150 kg ha^{-1}, respectively. In all, there were 12 treatments replicated 3 times in a randomized block design. Plot size was 4.2 m x 2.8 m (7 rows of 14 tubers each). The NPK was applied through urea, diammonium phosphate and muriate of potash respectively. Sulphur was applied through gypsum. Nitrogen was applied in two equal

[1]Central Potato Research Station, Jalandhar - 144003 (Panjab).

[2]Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi - 221005 (U.P.).

splits at planting and 25 days after planting. Pre-sprouted tubers (50-55 g) of cv. Kufri Badshah were planted in the last week of October and harvested in mid February at full maturity. Crop was optimally irrigated with low sulphur (1.5 ppm SO_4-S) containing water drawn from a deep tube well, manually weeded and normal plant protection measures were followed.

Representative composite samples of freshly harvested tubers were collected from each treatment, washed, wiped and air dried for various biochemical analyses. Dry matter in the tuber was estimated by chopping and drying in oven at 70°C to constant weight. Tubers were analysed for free amino acids (6), soluble protein (12), total phenols (13), reducing sugars (7), total fructose (14) and sucrose (15). Glucose was calculated from the difference of reducing sugars and free fructose. The fresh fried chips were subjectively scored for colour and assigned a value according to the scale of 1 to 10 (lower number meant better colour). Chips up to score of 5 were considered acceptable. Tubers were analysed for the concentration of P, K, S, Ca and Mg in the dry matter by the procedures as described by Jackson (4), while Cu and Fe were estimated by atomic absorption spectrometer.

RESULTS AND DISCUSSION

Tuber dry matter : The per cent dry matter in harvested tubers was increased invariably by sulphur application with all combinations of fertilizer nutrients (Table 1). It was maximized to 20.91% with NS_{50} followed by $NPKS_{50}$ (20.57%) and NPS_{50} (20.17%). Lowest dry matter was obtained with NK. Dry matter content due to the main effect of NK was significantly lower than N, NP and NPK. Brody (1) reported that potatoes having more than 20% dry matter are good for making chips. Thus sulphur along with balanced application of fertilizer nutrients (NPK) tended to improve the processing quality of tubers.

Free amino acids : Sulphur increased the free amino acid content in tubers with all combinations of fertilizer nutrients (Fig. 1). However, in presence of NPK the amino acid content was minimum. Sulphur being a constituent of amino acids cysteine and methionine on one hand and because of its role in nitrate reduction and nitrogen metabolism on the other (2), is likely to increase the amino acid content. The decrease in the content of free amino acids under balanced application of NPK was probably due to their faster conversion into soluble proteins in tuber resulting in the low accumulation of free amino acids (Fig. 1).

Soluble protein : Soluble protein content in tubers due to the main effects of N, NP, NK and NPK was 882, 908, 1180 and 1241 mg 100 g^{-1} fresh weight. Application of 25 and 50 kg S ha^{-1} increased the mean soluble protein content by 11 and 13% over 0 kg S ha^{-1}, respectively (Fig. 1). Protein was maximized under balanced application of NPKS probably due to enhanced conversion of free amino acids into proteins (Fig. 1). Role of sulphur in protein synthesis is indicated by its pronounced effect on plant height, leaf expansion and crop growth rate leading to increased tuber yield (11).

Total phenols :Mean total phenol content of tubers due to the main effect of N, NP, NK and NPK was 73.3, 78.3, 66.2 and 67.6 mg 100 g^{-1} fresh weight (Fig. 1). The trend

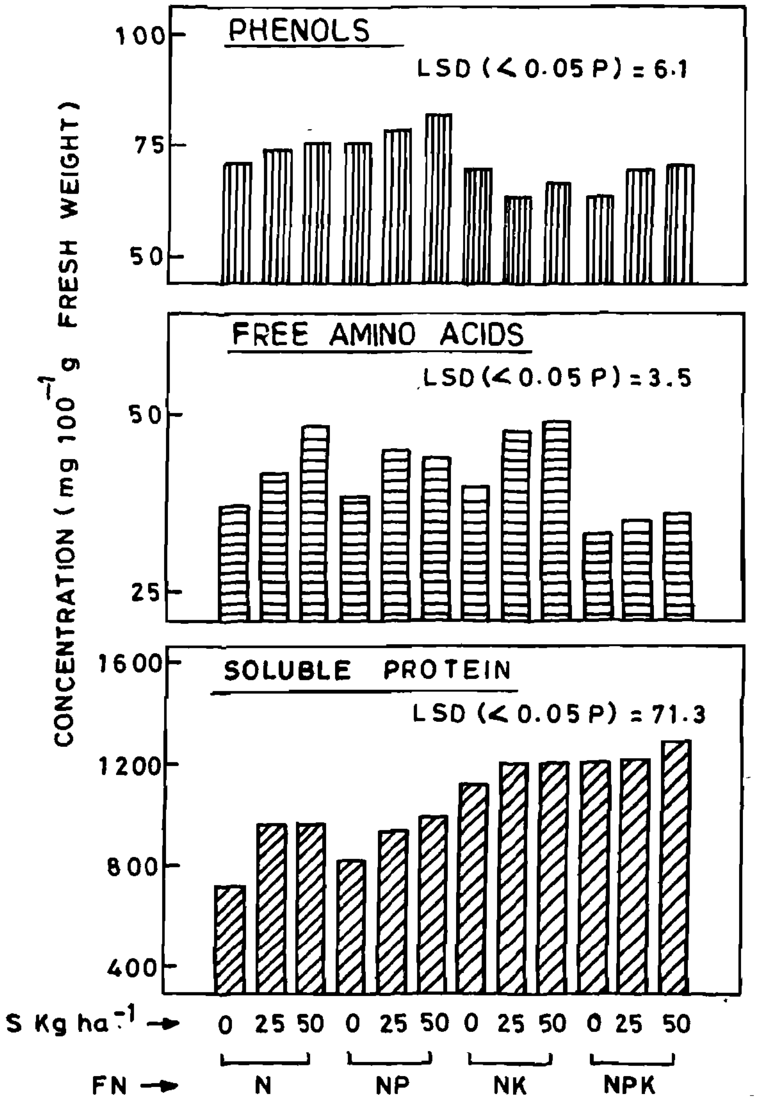

Fig. 1. Effect of fertilizer nutrients (FN) and levels of sulphur (S kg ha^{-1}) on concentration of protein, free amino acids and phenols in potato tubers of cv. 'Kufri Badshah'.

clearly shows that application of P significantly increased the phenols, while K decreased it. Application of sulphur consistently and significantly increased the phenols with N, NP, and NPK, while decreased with NK. However, differences between levels S_{25} and S_{50} were not significant except in combination with NP. Phenol content was maximized to 81.3 mg 100 g^{-1} fresh weight with NPS_{50}. Phenolic compounds are implicated in enzymic discolouration of tubers on peeling and exposure to air, and in after cooking darkening of potato tubers. Thus the increase in the amount of phenols by sulphur application is not desirable. However, effect of a treatment on processing quality depends on the net effect of tuber characteristics like dry matter, sugars, free amino acids and phenols (5).

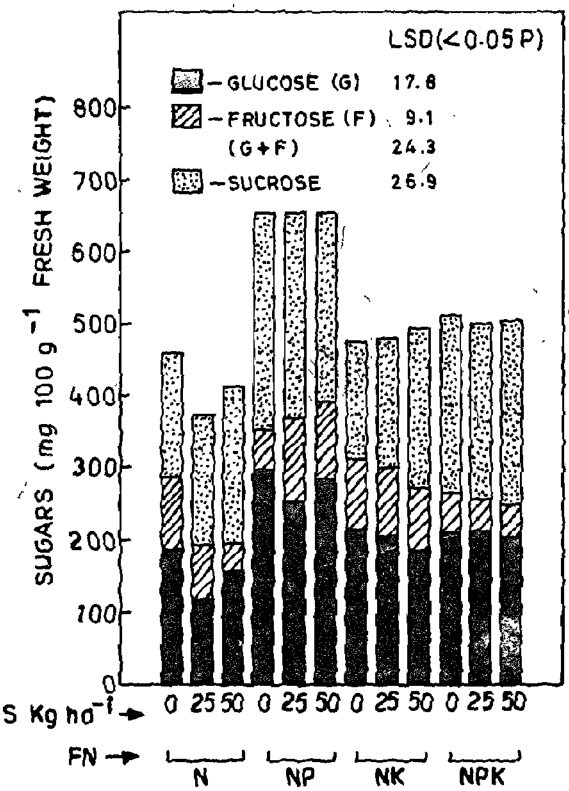

Fig. 2. Effect of fertilizer nutrients (FN) and levels of sulphur (S kg ha⁻¹) on concentration of sugars in potato tubers of cv. 'Kufri Badshah'.

Sugar : The content of sugars, particularly reducing sugar (glucose and fructose) are important parameters from processing point of view, as they are responsible for undesirable colouration of chips and french fries. Mean total sugar content was maximum (654 mg 100 g⁻¹ fresh weight) with NP and minimum with N alone (Fig. 2). Application of K with or without P significantly reduced the total sugar content as compared to NP mainly due to reduction in glucose and sucrose. Balanced application of NPK reduced the content of fructose too (Fig. 2). Application of sulphur significantly decreased the reducing sugars mainly through decrease in glucose. Sucrose did not show much variation (Fig. 2). Sulphur increases the starch content in potato tubers (8). This explains the decrease in reducing sugars, as sugars may have been utilized for starch synthesis.

Chip colour score : The test cv. Kufri Badshah gives dark coloured chips on frying (5). It was chosen purposely, as any improvement in chip colour can be easily attributed to effect of the treatments. Sulphur in combination with balanced application of NPK gave acceptable chip colour score of 5 (Table 1). Unbalanced combinations resulted in significantly high chip colour score of 7 to 9. However, the main effect of sulphur was

Table 1. Effect of fertilizer nutrients and sulphur application on dry matter content, elemental Composition and colour of fresh fried chips of potato cv. 'Kufri Badshah'

Treatments	Dry matter (%)	Elemental composition (mg-100 g^{-1} fresh weight							Chip colour score
		P	K	Ca	Mg	S	Cu	Fe	
NS_0	19.54	36	220	28	14	23	0.11	1.48	7
NS_{25}	20.66	36	206	26	14	24	0.10	1.60	8
NS_{50}	20.91	35	202	26	14	25	0.09	1.24	7
NPS_0	19.67	36	214	22	14	22	0.09	1.36	8
NPS_{25}	19.25	38	198	26	14	23	0.09	1.66	8
NPS_{50}	20.17	36	220	26	14	25	0.10	1.64	9
NKS_0	19.46	36	222	26	14	23	0.12	1.40	7
NKS_{25}	19.77	34	218	26	14	25	0.14	1.50	8
NKS_{50}	19.59	34	224	26	14	25	0.17	1.60	7
$NPKS_0$	20.06	36	198	32	22	22	0.12	1.24	6
$NPKS_{25}$	20.43	35	204	32	22	24	0.14	1.56	5
$NPKS_{50}$	20.57	35	196	32	22	24	0.14	1.24	5
Main effects (FN)									
N	20.37	36	209	27	14	24	0.10	1.44	7.33
NP	19.83	37	211	25	14	23	0.09	1.55	8.33
NK	9.60	35	221	26	14	24	0.14	1.50	7.33
NPK	20.35	35	199	32	22	23	0.13	1.35	5.33
(Levels of S)									
0	10.68	36	213	27	17	22	0.11	1.37	7.00
25	20.13	36	206	27	17	24	0.12	1.58	7.25
50	20.31	35	210	27	17	25	0.12	1.43	7.00
LSD (< 0.05 P)									
FN	0.20	NS	5	3	3	NS	0.03	0.05	0.41
S	0.17	NS	4	NS	NS	2	0.02	0.04	NS
FN x S	0.35	NS	9	NS	NS	NS	NS	NS	0.72

Subscript 0, 25 and 50 denote levels of applied sulphur @ 0, 25 and 50 kg ha^{-1} respectively

not significant. Colour intensity of chips, depends on relative amounts of reducing sugars and free amino acids in fresh tubers (5). These react at frying temperatures to give colouration in fried chips (3). Low content of reducing sugar coupled with least amount of free amino acids under balanced application of NPKS (Fig. 1 & 2), explain the lowest chip colour score.

Nutritive value of tubers : Concentration of certain elements in fresh potatoes is important from human nutrition point of view. Elements P and Ca are involved in bone formation, K helps in heart aliments, S provides resistance against skin diseases and Fe is needed for blood haemoglobin formation. On balanced application of NPK, mean content of elements P, K, Ca, Mg, S, Cu and Fe was 35, 196, 32, 22, 23, 0.12 and 1.35 mg 100 g^{-1} fresh weight of tubers, respectively (Table 1). Unbalanced application of N, P and K notably reduced the content of Ca, Mg and Cu without much affecting the P and K content. Sulphur application alongwith balanced dose of NPK did not affect the P, K and Ca concentration in tuber but tended to increase S and Fe.

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GENETIC DIVERGENCE IN SOME INDIAN AND EXOTIC VARIETIES AND ADVANCED POTATO HYBRIDS*

S.K. Pandey[1] and P.K. Gupta[2]

ABSTRACT : Fifty two cultures representing *tuberosum*, *andigena* and *andigena-tuberosum* hybrids were studied for genetic divergence on the basis of 11 plant and tuber characters. The cultures were grouped in 11 clusters. The Indian potato varieties released in past showed considerable genetic diversity in constrast to the advanced stage pre release hybrids indicating their development from a narrow ,genetic base. The *tuberosum and andigena* cultures segregated in different clusters indicating genetic diversity between them and possibility of getting heterotic effects for various characters on corssing. The cultures with wild species in their pedigree showed high genetic diversity and were distributed in almost all clusters. However cultures with common species in their pedigree showed a low diversity. The cultures developed from the same parentage or those involving one common parents also showed low genetic diversity.

INTRODUCTION

The importance of genetic diversity in selecting parents for hybridization is well known. It is also known that degree of heterosis is related to magnitude of genetic divergence between the parental lines. A limited studies have been made on genetic divergence in potato either at tetraploid (3, 11, 12) or at diploid level (2). Information on genetic diversity in the available germplasm collection is, therefore, of paramount importance. Present study was, conducted with a view to identifying and selecting genetically diverent parents that upon crossing would give high heterotic effect in their progenies for economic characters like yield.

MATERIALS AND METHODS

The material used in the study were from germplasm collection maintained by Central Potato Research Institute, Shimla. It included 52 genotypes of potato (*Solanum tuberosum* L.) representing ssp. *andigena* (4), ssp. *tuberosum* (35), and spp. *andigena* x ssp. *tuberosum* crosses (13). The genotypes represented 8 Indian commercial varieties, 13 exotic genotypes and 31 advance generation hybrids being evaluated under All India Coordinated Potato Improvement Project.

The details about the genotypes used are given in table 1. and experiment was laid out at Modipuram, Meerut (UP) during autumn of 1988. Twenty tubers each of 52 genotypes were planted in each of three replications in a randomized block design with an inter-row spacing of 60 cm and intra-row spacing of 20 cm. Five competitive plants of each genotype were used in each replication for recording observations on haulm, yield and biochemical characters.

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[1]Central Potato Research Institute, Shimla-171 001 (H.P.).
[2]Department of Agricultural Botany, Meerut University, Meerut-250 005 (U.P.).

Table 1. Origin and parentage of potato genotypes used in the study

S. No.	Genotypes	Source	Parentage
1.	Adina	Australia	Hindenbern x Allerfruhshte Gelbe
2.	Craigs Defiance	UK	Arose from naturally formed berry on a plant like Sutton's Abundance
3.	Dekama	The Netherlands	IVP 354 x Libertas
4.	Febricia	Germany	Prumell K-264 x Metador
5.	Froma	Ther Netherlands	Record x Triumph
6.	Gineke	-do-	Ultimus x Record
7.	Great scot	UK	Imperator x Champion
8.	Katahdin	USA	Busola x Sutton's Flourball
9.	Kerr's Pink	Belgium	Forty fold x Smith's early
10.	Libertas	The Netherlands	Record x Souvenir x Bato
11.	Majestic	UK	Unknown variety x British Queen
12.	Maritta	The Netherlands	Seedling 66/102 x Mittle fruhe
13.	Up-to-Date	UK	Paterson's Victoria x Blue Don
14.	Kufri Chandramukhi	India	S. 4485 x (*S. curtilobum* x *S. tuberosum*) x *S. andigena*
15.	Kufri Bahar	-do-	Kufri Red x Gineke
16.	Kufri Badshah	-do	Kufri Alankar x Kufri Jyoti
17.	Kufri Kuber	-do-	*S. curtilobum* x Gloriosa x *S. andigena* var. A-6-3
18.	Kufri Jeevan	-do-	M. 109.3 x 698.10
19.	Kufri Jyoti	-do-	3069 d(4) x 2814 a(1)
20.	Kufri Lauvkar	-do-	Serkov x Adina
21.	Kufri Sheetmam	-do-	Craig's Defiance x Phulwa
22.	AB 286	-do	Kufri Jyoti x SS-1603
23.	AB 455	-do-	-do-
24.	AB 539	-do-	-do-
25.	AB 667	-do-	-do-
26.	EB/A-708	-do-	-do-
27.	JF-246	-do-	Kufri Alankar x CPS 759
28.	JF-4841	-do-	Kufri Alankar x Kufri Jyoti
29.	JH-222	-do-	Kufri Neelamani x Kufri Jyoti
30.	JN-2303	-do-	-do-
31.	JI-1857	-do-	Kufri Alankar x Kufri Jyoti
32.	JI-5857	-do-	Kufri Bahar x Kufri Alankar
33.	JP-132	-do-	Kufri Jyoti x JEX/B 1465
34.	MS-78-56	-do-	Kufri Jyoti x EM/H-1601
35.	MS-78-61	-do-	-do-
36.	MS-78-62	-do-	-do-
37.	MS-78-90	-do-	K. 58 x K. 10
38.	MS-80-46	-do-	Dekama x C. pollen
39.	MS-80-758	-do-	K-2500 x Kufri Jeevan
40.	MS-79-10	-do-	Kufri Jyoti x Dekama
41.	MS-80-145	-do-	JI-1846 x Kufri Jyoti
42.	PJ-376	-do-	President x Kufri Safed
43.	PS/E-787	-do-	Kufri Naveen (self)
44.	PH/F-1545	-do-	PH 14-10 x PH 42-53
45.	SLB/D-192	-do-	President x Libertas
46.	SLB/Z-405(a)	-do-	3070 (Z) x 2181 (1)
47.	SLB/M-70	-do-	3046 (1) x M-109-3
48.	VB-8	-do-	30699-(4) x 2814 a(1)
49.	EX/A-680-16	-do-	A clone of *S. andigena*
50.	EX/A-679-10	-do-	-do-
51.	EX/B-687	-do-	-do-
52.	EX/B-723	-do-	-do-

a) Haulm characters

i) *Plant height*: The plant height was measured in centimetres from base to the top of the plant.

ii) *Number of stems*: Shoots emerging from the soil were counted as the number of stems in a plant.

iii) *Number of leaves*: Total number of leaves on all the shoots in a plant were counted.

b) Yield characters

i) *Tuber yield*: Tuber yield in grams was recorded separately for each of the randomly picked up plants at the time of harvest.

ii) *Number of tubers*: Total number of tubers produced by each of selected plant were counted separately at the time of harvest.

iii) *Average tuber weight*: The tuber yield per plant was divided by number of tubers to obtain average tuber weight.

c) Biochemical characters

For biochemical analysis, a composite sample of 10 tubers from each treatment was randomly drawn. Each tuber was cut from rose to heel end in two halves. One half was discarded and the other half was again cut lengthwise in two quarters. One quarter from each tuber was discarded and the other was used in preparation of a composite sample. The tuber quarters were chopped into small pieces and mixed thoroughly. Appropriate amounts from this mixed portion were taken for various analyses. Observations were recorded for the following characters:

i) *Per cent dry matter*: % dry matter was determined using 100g of chopped tuber tissue dried at 105°C for 18 hr to a constant weight. The dried material was weighed and dry matter was converted to per cent fresh weight.

ii) *Ascrobic acid (Vit. C)*: The ascorbic acid was determined by volumetric method of Roe and Osterling (9).

iii) *True protein*: It was estimated by bromophenol blue dye binding technique of Swaminathan et al. (13).

iv) *Total tuber dry matter per plant*: Total tuber dry matter per plant was worked out from the tuber yield and per cent tuber drymatter.

v) *Chlorophyll*: A composite sample of 4 fresh leaves was ground in a porcelain mortar with 80% acetone, a pinch of $CaCO_3$ and acid washed sand. The suspension was filtered by washing with 80% acetone upto a known volume, until colour-less. The optical density was measured in SPEKOL-10 Spectrocalorimeter at 645 nm and 663 nm using one cm path. The chlorophyll contents were calculated according to Holden (5).

Following the analysis of variance the data were subjected to multivariate analysis using the characters for which significant differences were observed. The genetic divergence between all the possible pairs of fifty two genotypes was estimated following the method of Mahalanobis (1936). In order to establish clusters, Tocher's method (8) was followed. The criterion of clustering was that the average intra-cluster distance should be lower than the corresponding inter-cluster distance.

RESULTS AND DISCUSSION

The analyses of variances revealed significant differences among varieties/hybrids for all the characters studied. The D^2 values were calculated corresponding to all possible 1326 combinations involving paired comparisons among 52 genotypes. The uncorrelated linear combinations of the characters differed in their contribution to D^2 estimates. These were used for making clusters (Table 2) and for estimation of inter and intra-cluster distances (Table 3). The D^2 values ranged from as small as 18.49 between the hybrids AB-455 and MS/78-61 to as large as 1628.76 between hybrids AB-569 and PS/E-787.

Fifty two genotypes used in the present study were grouped in 11 clusters on the

Table 2. Clusterwise distribution of 52 varieties and hybrids

Cluster	No. of genotypes	Genotypes	Country of origin
I	8	Adina, Dekama, Katahdin, Libertas, Maritta, Majestic, Kufri Lauvkar, Kufri Jyoti	Australia, UK, USA, India
II	14	Febricia, Kufri Badshah, Kufri Bahar, AB-455, AB-667, EB/A-708, JI-5857, JI-1857, JP-132, MS/78-61, MS/78-90, MS/80-145, JF-4841, PH/F-1545	Germany, India
III	4	Kufri Chandramukhi, Kufri Jeevan, Up-to-Date, SLB/D-192	India
IV	4	Kerr's Pink, EX/A-680-16, EX/A-679-10, EX/B-687	Belgium, India
V	11	Great scot, Froma, Kufri Sheetman, AB-286, AB-539, JH-222, MS/78-62, MS/79-10, MS/80-758, PJ-376, PS/E-787	The Netherlands UK, India
VI	6	Gineke, Kufri Kuber, Craig's Defiance, MS/78-56, MS/80-46, JN-2303	The Netherlands UK, India
VII	1	VB-8	India
VIII	1	EX/B-723	India
IX	1	SLB/Z-405(a)	India
X	1	JF-246	India
XI	1	SLB/M-70	India

basis of their D² values (Table 2). Cluster II was the largest and included 14 genotypes followed by cluster V with 11 genotypes and cluster I with 8 genotypes. All three clusters were highly heterogeneous with respect to the sources of the origin of their constituent varieties, and together included 9 out of the 13 (69.2%) exotic genotypes studied. The remaining 19 genotypes were distributed in 8 clusters of which 5 had single genotype, indicating their unique and wide divergence.

The intra-and inter-cluster D^2 values are presented in Table 3. The minimum inter-cluster distance (9.44) was recorded between clusters III (Kurfi Chandramukhi, Kufri Jeevan, Up-to-Date and SLB/D-192) and VII (VB-8). The maximum inter-cluster distance (387.8) was observed between clusters I (Adina, Dekama, Katahdin, Libertas, Maritta, Majestic, Kufri Lauvkar and Kufri Jyoti) and XI (SLB/M-70). The minimum intra-cluster distance was observed in cluster I (85.05) and the maximum (291.58) in cluster IV, both including varieties/hybrids from Europe and India.

From the clustering pattern (Table 2) it is clear that the varieties did not follow their geographic distribution hence all the 6 major clusters were heterogenous with respect to the varieties and countries of their origin. This is not unexpected since there is a free exchange of genetic material for various breeding programmes all over the world. Further, it is also possible that the genetic divergence among varieties/clusters from different sources was low, because selection for important economic charactes had proceeded along similar lines in all these countries reducing the contribution of these

Table 3. Intra and inter cluster D^2 values among 52 potato genotypes

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
I	(85.08)	194.62	451.14	399.57	349.00	460.58	296.62	379.87	311.22	448.44	472.88
II		(123.28)	239.73	479.79	331.35	246.50	350.24	519.60	278.84	.384.92	268.69
III			(146.96)	815.93	633.67	275.86	443.26	982.39	265.90	542.16	318.10
IV				(181.58)	377.95	864.89	681.36	510.66	735.25	875.82	434.35
V					(194.99)	407.03	758.58	720.66	408.22	858.85	489.45
VI						(211.24)	737.57	1081.81	293.56	726.69	511.29
VII							(0.00)	455.03	439.27	631.18	689.88
VIII								(0.00)	981.78	1153.19	687.02
IX									(0.00)	490.54	572.91
X										(0.00)	765.11

Average intra-cluster distances are given in parentheses.

characters to the divergence between varieties from different sources. However, varieties from different countries did show some divergence as these were found distributed in different clusters indicating some genetic diversity in the material selected under similar agroclimatic conditions. Gaur et al. (3) in their study with 67 and Singh et al. (12) with 40 genotypes also observed that clustering pattern was not influenced by geographic diversity of the varieties. It would, therefore, appear that geographic diversity of material would not help in selecting for genetically divergent parents.

When the clustering pattern (Table 2) was observed keeping in view the subspecies background of a genotype, it was observed that most of the *tuberosum* varieties separated from the *andigena* genotypes which were confined to clusters IV and VIII only, the only exception being old European variety Kerr's Pink. This indicated the genetic diversity between the two subspecies and the possibility of getting heterotic effects in the progeny of *tuberosum* x *andigena* crosses as observed by many workers (1, 4, 14).

Most of the *tuberosum* varieties were grouped in cluster I indicating low genetic diversity among these genotypes. This could be due to their narrow genetic background (1, 6). The vairability of *tuberosum* seem to have also been lost partly due to continuous selection for yield, shape and size of tubers, crop maturity, etc.

The varieties/clusters with both *tuberosum* and *andigena* in their pedigree showed considerable genetic diversity and were distributed in clusters II, V and VI. These fell either in clusters close to *tuberosum* cluster I or the *andigena* clusters IV and VIII depending on the extent of variability introduced by the two subspecies in their pedigree. Thus the variety Kufri Bahar and the cultures AB-455, AB-667, EB/A-708, JI-5857, JP-137 and MS/78-90 were clubbed in cluster II (Table 2) showing minimum inter cluster distance (Table 3) with cluster I which had predominantly *tuberosum* genotypes. Similarly, the *andigena-tuberosum* variety Kufri Sheetman and the hybrids AB-286, AB-539, PJ-376 were clubbed together in cluster V and were closer to cluster IV which had pre-dominantly *andigena* genotypes. The greater genetic divergence observed in *tuberosum-andigena* hybrids as compared to *tuberosums* confirmed the observations of Garg (2) in dihaploids and of Gaur et al. (3) in tetraploids indicating that introgression of *andigena* in *tuberosum* increases the level of divergence.

In the present study, the varieties/cultures having wild species in their pedigree (viz. Kufri Chandramukhi, Kufri Kuber, Kufri Jeevan, Kufri Jyoti and the hybrids JF-4841, JH-222, JN-2203, JI-5857, MS/78-56, MS/78-61, MS/78-62, MS/80-758, MS-79-10, MS/80-145, PS/E-787, SLB/Z-405(a), SLB/M-70 and VB-8) showed the highest genetic diversity as inferred from their distribution in almost all the clusters (Table 2). The diversity in this group was more than that in the *tuberosum-andigena* hybrids. This is probably because the wild tuber bearing *Solanum species* are genetically far more away from *tuberosum* than the *tuberosum* is from *andigena*. When distribution of genotypes involving single species (*S. demissum*) as donor parent was examined, the divergence was found to be poor, since 16 out of 21 genotypes having *S. demissum* in their pedigree fell in closely two related clusters namely cluster II (Kufri Badshah, AB-455, AB-667, EB/A-708, JF-4841, JI-1857, JP-132, MS-78-61, MS/80-145) and cluster V (AB-2886, AB-539, JH-222, MS/78-62, MS/80-758, MS/79-10 and PS/E-787).

Eight Indian varieties (viz. Kufri Badshah, Kufri Bahar, Kufri Chandarmukhi, Kufri Jeevan, Kufri Jyoti, Kufri Kuber, Kufri Lauvkar and Kufri Sheetman) included in the present study, were distributed in five clusters indicating considerable genetic diversity in this material. The varieties Kufri Sheetman and Kufri Kuber were very divergent from the remaining Indian varieties as was also observed by Gaur et al. (3) and Garg (2) in the dihaploids of these varieties. On the other hand, clustering pattern in the material representing cultures in advanced stages of trials in All India Coordinated Potato Improvement Project (Table 2) showed low divergence among themselves as inferred from their inclusion mainly in the closely related clusters II and V. This indicates their development from a narrow genetic base which is also confirmed from their parentage (Table 1).

The hybrids having the same parentage (Table 1) exhibited some genetic diversity and fell in different clusters (II, V and VI), the inter cluster distances between these clusters were relatively low (Table 3). Similarly, variety Kufri Badshah and the cultures JI-4841 and JI-5857, all derived from the cross Kufri Alankar x Kufri Jyoti, were grouped together in cluster II with low inter cluster distance from cluster I where one of the parents i.e. Kufri Jyoti is grouped. The hybrids except MS/78-56 involving one common parent (Table 1) also showed limited diversity, as inferred from their placement mainly in clusters II and V, both of which were close to each other and to the cluster I, where to, the common parent Kufri Jyoti belongs.

The above findings indicate that use of parents selected from the same cross or from a cross involving a common parent should be avoided in hybridization. On the other hand, the *tuberosum* genotypes falling in divergent clusters may be preferred over those falling in the same or closely related clusters. Since *andigena* and *tuberosum* types showed considerable genetic divergence between them and they are also known to provide heterotic effects for economic characters, it would be useful to screen the germplasm in each subspecies for isolating good combiners.

The present results revealed that use of agronomically superior selections from cluster I (predominatly *tuberosum*) viz. Dekama, Katahdin and Kufri Jyoti in crosses with selections EX/A-680-16, EX/A-67-9-10, EX/B-687 and EX/B-723 from clusters IV and VIII (pre-dominantly *andigena*) are expected to give heterotic effect for yield in the progeny. The selections of cluster I, avoiding full sib and half sib relationship and common species background, can also be suitably used in combination with the genotypes of clusters III, VI, X and XI. Similarly, use of high yielding varieties Kufri Bahar and Kufri Badshah from cluster II in crosses with selections from *andigena* cluster IV and VIII, and *tuberosum* clusters VII and X would result in high yielding progenies.

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FREE SUGARS AND INVERTASE ACTIVITY IN STORED POTATO TUBERS

D.S. Uppal[1]

ABSTRACT: Free sugars and invertase activity in tubers of 8 potato varieties were estimated at the time of storage and during storage at 5-7°C for 90 days. Significant varietal differences were observed in sugar content and invertase activity at the time of storage and during storage. During storage, reducing sugar content increased about 37% and invertase activities coincided with the accumulation of sugars. Sucrose content decreased during storage. Both basal and total invertase activities increased during storage, however, basal activity was about 50% of the total. Tubers of Kufri Sherpa contained minimum level of free sugars and invertase activity.

INTRODUCTION

Potato tubers (*Solanum tuberosum* L) stored below a temperature of 10°C accumulate an undesirably high concentrations of reducing sugars which results in dark coloured chips during frying through Maillard reaction (2, 7). The pattern of accumulation of sugars is largely dependent upon the potato varieties and storage temperatures (1, 3, 4, 17). The temperature of storage affects the permeability of amyloplast membrane and/or synthesis of certain enzymes or inhibitors which regulates the levels of free sugars in tubers (8, 15).

The formation of reducing sugars from sucrose, is regulated by comparative levels of invertase and invertase inhibitor present in tubers (11, 14). The sugar content and invertase activity increased in potatoes stored at low temperature and a significant correlations between reducing sugars and invertase activity was observed (13, 18). The accumulation of sugars and invertase activity of the tubers of a variety depends upon the temperature of storage (1, 13).

Burton (2) reported minimum respiration rate for several potato varieties when stored in the region of 5-7°C. Sparks (16) and Linnemann *et al.* (9) observed that over the range of 5 to 7°C, fresh weight loss of potatoes is marginal over a storage period of 6-8 months. Storage of potatoes at temperature higher than 7°C without the use of sprout suppressant is impossible whereas storage below 4°C inhibits sprouting but increases sugar content. Keeping in view the above informations, the tubers of some varieties were stored at 5-7°C to ascertain the status of sugars and invertase activity in relation to processing.

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[1] Central Potato Research Station, Jalandhar - 144003 (Panjab).

MATERIALS AND METHODS

Eight potato varieties (Table 1) were grown at Central Potato Research Station, Jalandhar (Punjab) from October to January. Uniform tubers were selected at the time of harvest and these were cured for 30 days at ambient room temperature (day temperature 20-25°C, night temperature 9-11°C, R.H 70-80%). The tubers were then stored at 5-7°C for 90 days. Tubers of each variety were analysed for sugars and invertases activities at the time of storage (0 day) and 30, 60 and 90 days after storage. At each sampling date, 10 tubers of each variety were finely cut into small pieces and mixed thoroughly. Ten and 20 g samples were taken for sugars and invertase estimations, respectively.

Estimation of sugars : Free sugars were extracted from the tuber samples (2 x 10 g) by refluxing for 1 (x4) h with 50 ml of 80% isopropanol. The extracts were clarified and reducing sugars were estimated according to the methods of Nelson (12) and sucrose by anthrone method (19).

Invertase estimation : Enzyme extracts were prepared by homogenizing tuber tissue (2 x 20 g) in 100 ml precooled 0.2 M sodium acetate buffer (pH 4.75). The homogenate was filtered through 4 layers of muslin cloth and made up to a known volume with buffer. The extracts were centrifuged at 5000 xg for 15 min. at 4°C. The supernatant thus obtained was dialysed against the extracting buffer and known volume was made. The estimation of basal and total invertase activities was done from the dialysed extracts as reported (18).

RESULTS AND DISCUSSION

Sugar content varied among varieties at the time of storage (Table 1). Reducing sugars were highest (7.5 mg/g fresh weight) in tubers of Kufri Jyoti and lowest (2.1 mg/g) in Kufri Sherpa. The sucrose content ranged between 1.7 and 3.0 mg/g fresh weight. At the time of storage, basal invertase activity was not observed in Kufri Sherpa, whereas total invertase activity was present in all the varieties (Table 2). Both the activities were highest in tubers of Kufri Lalima and lowest in Kufri Sherpa. A significant varietal differences were observed in sugar content and invertase activity. Freshly harvested tubers contained low levels of reducing sugars because of no/or very low invertase activity (11, 13). Tubers of Kufri Jyoti, Kufri Badshah and Kufri Bahar contained more than 0.5% reducing sugars on fresh weight basis, the maximum permissible limit for producing acceptable chip colour (17). Sucrose and total sugar content did not exceed permissible limit for processing potatoes.

Reducing sugars and total sugars content of all the varieties increased significantly during storage at 5-7°C whereas sucrose content decreased at 60 (1.7 to 2.4 mg) and 90 (1.9 to 2.5 mg) days after storage as compared to the initial values. After storage, the mean values of reducing and total sugars increased about 37% and 18% on fresh weight basis respectively as compared to the initial values. The tubers of Kufri Jyoti had maximum and Kufri Sherpa minimum amount of reducing sugars during storage. There were considerable differences in reducing sugars forming potentials among varieties. At the end of storage the increase in accumulation of reducing sugar was maximum (120%)

Table 1. Sugar content (mg/g fresh weight) of different potato varieties' tubers stored at 5-7°C

Varieties	Storage period (days) 0			30			60			90			Mean		
	RS	S	TS	RS	S	TS	RS	S	TS	RS	S	TS	RS	S	TS
Kufri Badshah	6.7	2.7	9.4	7.0	2.5	9.5	7.6	1.9	9.5	7.9	2.1	10.0	7.3	2.3a	9.6
Kufri Bahar	7.2	3.0	10.2	7.3	3.0	10.3	7.9	2.3	10.2	8.0	2.4	10.4	7.6	2.7b	10.3
Kufri Chandramukhi	3.5	2.7	6.2	4.4	2.6	7.0	7.5	2.1	9.6	7.7	1.9	9.6	5.8	2.3a	8.1
Kufri Dewa	3.3	2.7	6.0	3.6	3.0	6.6	4.4	1.8	6.2	4.6	2.1	6.7	4.0	2.4a	6.4
Kufri Jyoti	7.5	2.7	10.2	8.7	3.8	12.5	9.0	1.6	10.6	9.3	2.5	11.8	8.6	2.7b	11.3
Kufri Lalima	4.1	2.4	6.5	4.9	5.2	10.1	5.5	2.4	7.9	5.5	2.3	7.8	5.0	3.1c	8.1
Kufri Sherpa	2.1	1.7	3.8	2.5	1.8	4.3	2.8	1.7	4.5	3.2	1.9	5.1	2.7	1.8	4.5
Kufri Sindhuri	2.5	3.0	5.5	3.2	5.1	8.3	3.6	1.9	5.5	4.1	2.0	6.1	3.4	3.0c	6.4
Mean	4.6	2.6	7.2	5.2	3.4	8.6	6.0	2.0	8.0	6.3	2.2	8.5			

	Reducing sugars CD (5%)	Sucrose CD (5%)
Storage period (S)	0.05	0.13
Varieties (V)	0.07	0.18
S X V	0.14	0.36

RS = Reducing sugars, S = Sucrose, TS = Total sugars (RS + S)

Means marked with same letter are not significantly different.

Table 2. Basal and total invertase activity (n Kat/g fresh weight) in potato tubers stored at 5-7°C

Varieties	Storage period (days)									
	0		30		60		90		Mean	
	Basal[a]	Total[b]	Basal	Total	Basal	Total	Basal	Total	Basal	Total
Kufri Badshah	1.1	1.8	1.8	2.8	2.1	2.6	2.3	4.3	1.8c	2.9
Kufri Bahar	0.6	2.1	1.6	4.3	1.9	4.3	2.8	6.0	1.7c	4.2e
Kufri Chandramukhi	1.1	2.1	1.8	3.0	1.3	4.4	4.2	6.7	2.1d	4.1ef
Kufri Dewa	0.9	2.5	1.6	3.3	1.7	3.4	4.0	6.8	2.1d	4.0f
Kufri Jyoti	1.3	2.4	2.3	3.3	2.5	5.0	3.2	8.1	2.3d	4.7
Kufri Lalima	2.1	4.7	2.3	5.3	3.2	5.8	4.2	7.0	3.0	5.7
Kufri Sherpa	0.0	0.8	0.3	1.4	0.7	1.2	0.9	5.0	0.5	2.1
Kufri Sindhuri	0.7	3.3	1.4	3.9	2.1	4.9	4.4	7.6	2.2d	4.9
Mean	0.98	2.5	1.6	3.4	1.9	4.0	3.3	6.4		

	Basal invertase CD (5%)	Total invertase CD (5%)
Storage period (S)	0.17	0.11
Varieties (V)	0.25	0.16
S X V	0.49	0.31

[a] Basal invertase activity was determined in the presence of naturally occurring invertase inhibitor

[b] Total invertase activity was determined after destroying the naturally occurring invertase inhibitor

Mean marked with same letter are not significantly different, rest are significant.

in tubers of Kufri Chandramukhi and minimum (11%) in Kufri Bahar as compared to the initial levels.

During storage, invertase activity increased significantly. Mean basal and total invertase activity increased from 0.98 to 3.3 & 2.5 to 6.4 n Kat/g fresh weight, respectively. The basal invertase activity was about 52% of total activity, indicating the substantial amount of inhibitor was present. Invertase activity was highly variable in different varieties during storage. The tubers of Kufri Sherpa had both the activities minimum at 90 days, and basal activity was about 18% of the total activity.

The results of this investigation showed only about 37% increase in reducing sugar content as compared to the initial levels. However, larger increase, (260 to 330%) in reducing sugar content in tuber stored at 2-5°C for the same periods were reported earlier (16, 18). Pressey and Shaw (13) reported an accumulation of reducing sugars from 0.1 to 1.4% in tubers stored at 4°C. Dewelle and Stallknecht (5) had shown that even the small change in storage temperature (± 1.4) can aeffect the level of reducing sugar by ± 0.8 to 5.2% on dry weight in tubers of different varieties. Linnemann *et al.* (9) reported a marginal decrease in reducing sugar content in tuber stored at 7°C for 12 weeks whereas we observed an increase, this may be due to the varietal differences. Basal and total invertase activities were low by 26% and 37% respectively in tubers stored at 5-7°C than in tubers stored at 3-5°C (18). Pressey and Shaw (13) also observed the reduction in invertase activity at higher temperature. The decrease in activity may be because of the synthesis of invertase inhibitor or inactivation of the enzyme (13, 18). During storage, invertase activity and reducing sugar accumulation was parallel. Reducing sugar accumulation was related to the sugar content present at the time of storage in all the varieties, except Kufri Chandramukhi, and is in agreement with the results reported by Samotus *et al.* (17). At the end of 90 days storage the tuber weight loss was within the permissible limits of processing. The concentration of reducing sugars in tubers of Kufri Sindhuri, Kufri Dewa and Kufri Sherpa were below the critical levels required for producing good chip colour. Total sugars were below 1.25% in the varieties tested and did not taste sweet when consumed (6)

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N-REQUIREMENT FOR RAISING CUT-SHOOT POTATO CROP

M.J. Hossain, M. Elias, A.K.M.A. Habib, M.A. Akhtaruzzaman and M.S. Islam[1]

ABSTRACT: Experiments were conducted to find out the optimum dose of nitrogen for raising cut-shoot-potato crop during 1987-88 and 1988-89 winter seasons. Application of nitrogen enhanced plant height from 48.3 cm to 77.4 cm, number of leaves per plant from 12.8 to 17.4, leaf length from 10.3 cm to 22.8 cm, foliage coverage at 40 DAP from 15.3 to 50.5% and at 60 DAP from 33.6 to 67.1%, respectively at N_0 and N_{200} while higher doses of nitrogen significantly delayed both days to tuberisation (36 days) and maturity of crop (92.3 days). Most of the yield attributes including tuber yield (t/ha) were statistically similar for 120 and 160 kg N/ha indicating that the optimum dose of N is 120 kg/ha.

INTRODUCTION

Potato is one of the important vegetatively propagated food crops of the world which is usually grown from tuber. But it can also be propagated by different types of cuttings, such as slips, sprout cutting, stem cutting, leaf-bud cutting, shoot cutting, etc. Tuber size of cut-shoot potato crop is comparatively smaller than that of tuber-grown crop but it shows promise in terms of total tuber yield. Reports on influence of nitrogen on growth and tuber yield of cut-shoot potato crop are scarce. Keeping this in view, the present study was undertaken to find out the optimum dose of N for cut-shoot potato crop.

MATERIALS AND METHODS

The experiments were conducted under nethouse at the Tuber-Crops Research Centre, Joydebpur, Bangladesh during 1987-88 and 1988-89. Variety Cardinal was used in this study. The initial soil nutrient status of the experimental plots was 16, 8, 3 and 7 mg/ml of NH_4-N, P, Zn and S respectively; and 0.10, 1.8 and 0.68 meq/100 ml of K, Ca and Mg respectively, and OM-0.78%. The pH of the soil was 6.3. Six levels of nitrogen as urea (0, 40, 80, 120, 160 and 200 kg N/ha) in combination with a fixed dose of phosphorus as triple super phosphate (75 kg P_2O_5 /ha) and potash as muriate of potash (120 kg K_2O/ha) were used in the randomised complete block design with four replications. In both the years, 3-4 cm long top shoots were cut and soaked immediately with rooting hormone (IBA 16 mg^{-1} and NAA 8 mg^{-1}) for a few seconds prior to planting in sand bed contained in wooden box. After 7 days, the rooted cuttings were transplanted in soil on Nov. 22 at 20 x 10 cm spacing accommodating 150 cuttings in unit plot of 1 x 3 m. Full dose of phosphorus and potash were applied in soil before 15

[1] Tuber Crops Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur - 1701 (Bangladesh).

days of planting the rooted cuttings and 50% urea was applied after establishment of the cuttings in the soil i.e. 10 days after transplanting. The remaining 50% urea was side dressed during earthing up of the crop after 35 days of planting. Usual cultural practices were followed to raise the crop and harvesting was done after 90 days of planting.

RESULTS AND DISCUSSION

Growth characters : Almost all cuttings were successfully established in the soil. New shoot growth of cuttings was first noticed after 9 days of planting. The days for shooting varied from 9.0 to 10.3 days. Tuberisation of cuttings was significantly delayed with the application of higher doses of N (Table 1). Nitrogen increased plant height upto 120 kg N/ha. Number of leaves per plant was maximum (17.4 leaves) for 200 kg N/ha and minimum (12.8 leaves) when no N was applied. Prominent effect of N on foliage coverage (FC) both at 40 and 60 DAP was observed. The maximum percentage of FC was obtained when 200 kg N/ha was applied both at 40 and 60 DAP. FC. percentage was minimum for the control, being 25.3% and 33.6% at 40 DAP and 60 DAP, respectively. Average length of each compound leaf was significantly increased with the application of 120-2-00- kg N/ha. The length of leaf was maximum 22.8 cm for 220 kg N/ha and the minimum 10.3 cm for the control. Crop maturity was significantly delayed due to application of N and reached earlier for the treatment which did not receive any N (70 days). The highest dose of N delayed maturity to a considerable extent (92 days). The results of the present study are in close conformity with those reported by Elias *et al.* (3).

Table 1. Growth characters of cut-shoot crop of potato var. Cardinal as affected by different levels of nitrogen during 1987-89 (pooled data)

Treatment	Days to tuberisation	Plant height (cm)	Leaves		Foliage coverage at DAP		Days to maturity
			no.	length (cm)	40	60	
N_0	32.6	48.3	12.8	10.3	25.3	33.6	70.3
N_{40}	32.8	56.0	13.3	11.5	33.1	40.3	75.3
N_{80}	33.3	68.6	13.5	13.5	38.4	48.1	79.3
N_{120}	33.7	73.1	15.8	20.2	46.1	55.6	83.6
N_{160}	36.1	76.3	16.3	22.1	48.2	60.3	88.2
N_{200}	36.0	77.4	17.4	22.8	50.5	67.1	92.3
Mean	34.1	66.6	14.3	19.4	40.3	50.8	81.5
LSD 5%	2.3	14.4	3.5	2.9	11.0	7.5	11.2

Yield components : Increase in the number of tubers per plant was not remarkable with the application of N (Table 2). Nitrogen significantly increased tuber weight per

Table 2. Yield components, tuber yield and tuber grades of cut-shoot potato var. Cardinal during 1987-89 (pooled data)

Treatment	No. tuber per plant	Wt. tuber per plant (g)	Av. tuber wt (g)	Tuber yield (t/ha)	Tuber grades no (%) < 10	10-20	20-30	>30mm	Tuber grades wt (%) <10	10-20	20-30	>30mm
N_0	4.3	45.2	10.5	22	37	48	15	0	26	47	17	0
N_{40}	4.2	52.9	12.6	28	34	44	18	9	22	51	18	6
N_{80}	4.4	66.4	15.1	33	20	53	20	7	12	52	22	12
N_{120}	4.8	108.5	22.6	57	12	52	23	13	17	52	25	17
N_{160}	4.6	110.9	24.1	61	10	55	22	13	6	55	24	15
N_{200}	4.7	118.9	25.3	63	3	53	23	17	1	58	24	17
Mean	4.5	83.8	18.4	43.8	19.3	50.8	20.2	9.8	14	54	22	11
LSD 5%	ns	20.2	5.0	14.3	8.8	ns	ns	4.1	5.1	ns	ns	5.2

plant, which was maximum 118.9 g with the highest level of N. The value was found to be statistically similar to 160 kg N/ha (110.9 g) and 120 kg N/ha (108.5 g). Average tuber weight was significantly higher 25.3 g when 200 kg N/ha was applied which was statistically similar to 160 kg N/ha (24.1 g) and 120 kg N/ha (22.6 g) and the minimum 10.5 g for the treatment which received no N (Table 2). The yield rose significantly with the application of 120-200 kg N/ha (57.63 t/ha). Tuber yield per hectare was high, mainly because of higher plant population. There was a significant and positive relationship between nitrogen dose and tuber yield ($r = 0.96^{**}$). Elias *et al.* (3) in a nitrogen experiment with tuber-grown-potato crop, obtained 6 tubers at N_0 and 10 tubers at N_{225} level. Experimental results at non-calcareous soils showed that 120 kg N gave significantly better tuber yields.

Tuber grades : Pooled data of two years revealed that the percentage of tubers by number in the 10-20 mm grade in the total produce was significantly higher. Maximum seed-size tubers (20-30 mm) was produced when 120 kg and 200 kg N/ha (23%) was applied. Tubers below 10 mm size was minimum at the highest level of N (N_{200}) and maximum for the control (N_0) which also did not produce any tuber above 30 mm grade, while 200 kg N/ha produced maximum percentage of tubers above 30 mm grade. The percentage of tubers by weight in the 10-20 mm grade in the total produce was significantly higher. Maximum percentage of tubers of 10-20 mm and above 30 mm grades were produced when 200 kg N/ha was applied, while N_{120} and N_0 produced maximum seed-size and below 10 mm grade tubers, respectively. Percentage of tubers below 10 mm grade gradually decreased with higher levels of N but vise versa for above 30 mm grade tuber. It is evident that the optimum level of N for raising potato crops from cut shoots is 120 kg/ha.

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INSTABILITY OF POTATO PRODUCTION IN ORISSA-A RESIDUAL ANALYSIS APPROACH

Debdutt Behura[1], Suruchi Jena[2], Durgesh Nandini Ray[2], Dibakar Naik[3]

ABSTRACT : Area, production and productivity of potato in Orissa had increased considerably form 1950-51 to 1970-71. But thereafter it decreased considerably during the next decade. During eighties and early nineties area, production and productivity of the crop have marginally increased. Cuttack ranks first both in acreage and production of the crop contributing 35.8% and 43.7% of the State's acreage and production respectively. Cuttack district has the highest productivity of 123.9 q/ha. Kalahandi has the lowest acreage under the crop and its production is also the lowest among all the districts. Phulbani district has the lowest productivity of 67.3 q/ha. The growth rates of area and production of potato varied from 3.4% and 1.4% in Kalahandi district to 6.6% and 10.77% Balasore district, respectively. The compound growth rates of productivity of potato for different districts showed that Puri had the highest positive growth rate of 5.0% followed by Kalahandi (4.3%), Phulbani (4.0%), Cuttack (4.0%), Balasore (3.9%), Dhenkanal (3.8%) and lowest productivity growth is observed in Sundergarh district (0.7%). Significant positive growth rates of productivity of crop in almost all the districts of Orissa and the State indicates that the farmers of the State have sufficient awareness to adopt modern yield raising technology. But lack of suitable market support and cold storage facilities constrain the growers in expanding the acreage under the crop. Instability in potato production was observed for all most all the districts of Orissa except for Kalahandi, Keonjhar, Mayurbhanj and Sambalpur. Acreage under the crop and productivity have been responsible for bringing stability in potato production in Keonjhar, Mayurbhanj and Sambalpur district. Whereas in Kalahandi district it is productivity which contributes more towards stability in potato production. The year, 1989-90 was observed to be the most abnormal year followed by 1984-85, 1990-91 and 1992-93 for bringing instability in potato production. To reduce the degree of instability in potato production, crop planning should be made depending upon to agro-climatic parameters to reduce the degree of instability in production of potato in the State.

INTRODUCTION

Potato production in India has made a great stride. Its area and production have increased from 0.48 million hectares to 1.08 million hectares and 4.8 million tons to 15.7 million tons, respectively during 1970-71 to 1992-93 in India. Similar trend in productivity was observed too recording a rise from 99.8 q/ha to 146.2 q/ha during the period.

Orissa shared only 0.9 and 0.7% of the national area and production respectively during 1992-93. Its area, production and productivity have declined significantly during 1970-71 to 1980-81 and increased marginally during 1980-81 to 1992-93. The productivity of potato in Orissa was only 98.2 q/ha during 1992-93 as against the national average of 146.2 q/ha. The productivity among the districts of Orissa varies

[1]Dept. of Agril. Economics, OUAT, Bhubeneswar.
[2]Cost of Cultivation Scheme, OUAT, Bhubeneswar.,
[3]Planning, Monitoring and Evaluation Unit, OUAT, Bhubaneswar 751003 (Orissa).

between 67.3 q/ha in Phulbani to 123.9 q/ha in Cuttack district during the triennium period 1990-91 to 1992-93 , indicating a wide fluctuation in productivity over time in Orissa. In this paper an attempt has been made to :

1) analyse the growth rate of area, production and productivity of potato in different districts of Orissa over the period,
2) examine the extent of instability in potato production in different districts of Orissa and the State over the years, and
3) examine the relation between growth and instability over the years.

MATERIALS AND METHODS

The data relating to area, production and productivity of potato in different districts of Orissa for the period 1977-78 to 1992-93 were collected from different issues of the "Orissa Agricultural Statistics", published by the Directorate of Agriculture and Food Production, Government of Orissa. The compound growth rates of area, production and productivity of potato were calculated by using Log-linear function i.e. Log y = a + bt, where `y' is area/production/productivity of potato, `t' represents time variable and growth rate is given by $(e^b-1) \times 100$.

Table 1. Area, production and yield of potato in Orissa during 1950-51 to 1991-92

Year	Area in 000' hectares	Production 000' tonnes	Yield q/ha
1950-51	3	23	82.49
1955-56	9	29	33.10
1960-61	10	29	27.44
1965-66	.31	317	103.02
1970-71	21	223	107.90
1975-76	7	80	86.16
1980-81	8.08	60.34	74.66
1985-86	8.74	83.65	95.71
1990-91	9.23	87.31	94.64
1991-92	10.29	114.36	111.14
1992-93	10.89	106.97	98.23

Sources : Orissa Agricultural Statistics, Directorate of Agriculture and Food Production, Govt. of Orissa, Bhubaneswar.

To examine the instability, the coefficient of variation of area/production/productivity of potato of different districts of Orissa and the State were tested statistically. To

Table 2. Triennial averages of area, production and productivity of potato in different districts of Orissa during 1990-91 to 1992-93

Districts	Area 000' ha	Production 000' tonnes	Yield q/ha
Balasore	0.40 (3.95)	3.88 (3.77)	97.00
Balangir	0.12 (1.18)	1.02 (0.99)	85.00
Cuttack	3.63 (35.83)	44.99 (43.73)	123.94
Dhenkanal	0.91 (8.98)	8.95 (8.70)	98.35
Ganjam	0.45 (4.44)	3.28 (3.20)	72.89
Kalahandi	0.02 (0.2)	0.17 (0.16)	85.00
Keonjhar	0.19 (1.88)	1.67 (1.62)	87.89
Koraput	0.51 (5.03)	4.25 (4.13)	83.33
Mayurbhanj	0.14 (1.38)	1.10 (1.07)	78.57
Phulbani	0.52 (15.60)	3.5 (3.40)	67.31
Puri	1.58 (15.60)	16.4 (15.94)	103.80
Sambalpur	1.13 (11.15)	9.64 (9.37)	85.31
Sundergarh	0.53 (5.23	4.03 (3.92)	76.04
Orissa state	10.13	102.88	101.56

Figures in the parentheses indicate percentage of the total.

examine the nature of instability in the growth of potato output, the linear growth model $y_t = A + B\,t + U_t$ was fitted to the indices of production of potato obtained by considering the average of first five year's production of each district separately as the base year production. y_t represents production indices of potato in the year t. A and B are to be estimated through regression analysis. U_t is the random error assumed to be distributed normally with zero mean and unit variance. The estimated values of residuals were plotted (not shown here) and two separate linear lines were fitted, one $y_{(+)} = A_{(+)} + B_{(+)}\,t + U_{(+)}$ for the positive residuals (positive deviations) and another $y_{(-)} = A_{(-)} + B_{(-)}\,t + U_{(-)}$ for the negative residuals (negative deviations) obtained by $e_t = (y_t - \hat{y}_t)$. illustrates the distribution of it is the nature of instability in growth of potato output over the years. In other words, comparing the slopes of these lines, the nature of instability has been studied. The favourable and unfavourable conditions to study the nature of instability have been depicted in the concerned table.

In order to measure the extent of instability and the locate the abnormal years during the study period, the e_i of the regression analysis were considered. The studentised residuals, e_{is} have been calculated as e_{is}/s = where s^2 is the variance of the residuals. Large absolute value of e_{is} indicates abnormality, which causes instability.

RESULTS AND DISCUSSION

The area and production of potato in Orissa were 3 thousand hectares and 23 thousand tons in 1950-51. The area increased more than 10 times during 1965-66

Table 3. Compound growth rates of area, production and productivity of potato for different districts of Orissa during 1977-78 to 1992-93

Districts	Area	Production	Productivity
Balasore	6.59**	10.77**	3.91**
	(3.83)	(5.94)	(6.11)
Balangir	1.28NS	4.75*	3.49**
	(0.84)	(2.39)	(3.81)
Cuttack	1.53*	5.59**	4.01**
	(2.92)	(6.62)	(7.78)
Dhenkanal	3.54**	7.44**	3.85**
	(3.27)	(4.38)	(3.95)
Ganjam	3.35**	5.43**	1.81*
	(2.14)	(2.91)	(2.16)
Kalahandi	-3.39NS	1.44NS	4.28**
	(1.24)	(0.59)	(4.27)
Keonjhar	3.68*	5.86*	2.20*
	(2.35)	(2.49)	(2.38)
Koraput	3.42*	7.51**	3.89**
	(2.60)	(3.80)	(4.12)
Mayurbhanj	0.65NS	3.43*	2.82**
	(0.47)	(2.35)	(5.04)
Phulbani	3.21**	7.30**	4.04**
	(3.12)	(3.71)	(3.60)
Puri	1.48NS	6.56**	5.02**
	(1.25)	(4.47)	(3.65)
Sambalpur	2.77**	6.27**	3.41**
	(3.97)	(4.30)	(3.65)
Sundergarh	3.21*	3.93*	0.67NS
	(2.30)	(2.56)	(0.84)
Orissa State	2.18**	5.87**	3.61**
	(4.48)	(7.45)	(7.25)

Figures in the parentheses indicate t value.
** Significant at 1%
* Significant at 5%
NS Not significant.

recording 31 thousand hectares and production increased to a level of 317 thousand tons recording almost 14 times rise by the same year. But after 1965-66, the acreage under potato reduced year after year and reached seven thousand hectares during 1975-76 with a production of 80 thousand tons.

There was marginal rise in area as production recording 10.9 thousand hectares and 106.9 thousand tons in 1992-93. Further, it is observed that (Table 1) there is a wide variation in the productivity of potato. Productivity of potato which was 82.49 q/ha in 1950-51 declined to 27.4 q/ha in 1960-61. But again it increased to 103.02 q and 107.9 q/ha in 1965-66 and 1970-71, respectively. After 1970-71 it started declining and even reached to a level of 74.6 q per hectare in 1980-81. Productivity of potato again increased to 95.7 q/ha in mid eighties. Then it recorded a marginal decline in productivity in 1990-91 recording 94.64 q/ha. But in 1991-92 it again increased to 111.2 q/ha indicating an instability in productivity trend.

Table 2 depicts the triennial averages of area, production and productivity of potato in different districts of Orissa during the period 1990-91 to 1992-93. Cuttack district leads in acreage alongwith production sharing 35.8% and 43.7% respectively to the State's area and production. It is followed by Puri, Sambalpur and Dhenkanal (Table 2). Kalahandi has the lowest acreage (0.2 thousand hectares) under the crop. Similarly the quantum of production is followed by Puri, Sambalpur and Dhenkanal. The lowest production of 0.17 thousand tons was observed in Kalahandi district. The productivity of potato was 123.9 q/ha in Cuttack district followed by Puri, and Balasore. Lowest productivity of 67.3 q/ha was observed in Phulbani district. The triennial averages of area, production and productivity of potato in Orissa stood at 10.1 thousand hectares, 102.8 thousand tons and 101.6 q/ha.

The compound growth rates of area, production and productivity of potato for the period 1977-78 to 1992-93 were analysed for all the districts of Orissa and presented in table 3. The growth rate of area varied from (-) 3.39 % in Kalahandi district to 6.5% in Balasore district. The growth rate of area under potato for other districts like Cuttack, Dhenkanal, Koraput, Phulbani and Sambalpur district were positive and statistically significant. Negative insignificant growth rate of area under potato in Kalahandi relates to the low irrigation facilities in the *Rabi* season alongwith unfavourable soil conditions. The compound growth rates of production of potato varied from 1.4% in Kalahandi district to 10.7% in Balasore district. Positive significant growth rate of production were observed in almost all the districts except in Kalahandi. The compound growth rate of productivity of potato varied from 0.67% in Sundergarh district to 5.02% in Puri district. Productivity growth rate for almost all the districts were positive and significant except Sundergarh. As a whole Balasore, Cuttack, Dhenkanal, Keonjhar, Koraput, Phulbani and Sambalpur showed positive significant growth rates in acreage, production and productivity of potato. In Orissa for the period 1977-78 to 1992-93 these growth rates were 2.2, 5.9 and 3.6% respectively. Thus it is clearly evinced that the farmers of the State have expanded the area under potato significantly and for which its production has increased to a significant extent during the last decade. Although the productivity of potato has increased during the period, still it is much below the national average. Due to lack of suitable storage facilities producers are forced to sell the produce immediately after harvest at very low prices. Thus it keeps the producers in a sense of insecurity in raising potato. Adequate storage facility should therefore be created to encourage the farmers to expand the acreage under the crop which will tend to adopt the yield raising technology, through which productivity can be shifted to a higher level.

Table 4 depicts the districtwise coefficient of variation of area, production and productivity of potato for the period 1977-78 to 1992-93 . The coefficient of variations of area, production and productivity of potato for different districts of Orissa as well as the State are highly significant indicating the instability. So it needs to examine the nature and extent of instability in production of potato.

Table 4. Districtwise co-efficient of variation of area, production and productivity of potato for the period 1977-78 to 1992-93

Districts	Area	Production	Productivity
Balasore	36.17**	51.88**	20.53**
Balangir	24.90**	38.57**	21.23**
Cuttack	11.60**	28.99**	39.78**
Dhenkanal	23.48**	35.74**	46.75**
Ganjam	33.02**	38.65**	16.28**
Kalahandi	69.80**	46.64**	23.57**
Keonjhar	27.43**	37.74**	16.94**
Mayurbhanj	18.38**	22.71**	15.76**
Phulbani	22.29**	39.01**	33.90**
Puri	17.77**	29.77**	24.26**
Sambalpur	16.43**	31.36**	18.95**
Sundergarh	27.85**	33.48**	13.29**
Orissa state	12.70**	27.64**	17.66**

** Significant at 1%

The estimated values of slopes for linear production functions of different districts of Orissa has been depicted in (Table 5). The table clearly indicates instability in potato production in all the districts of State except for Kalahandi, Keonjhar, Mayurbhanj and Sambalpur. The condition $b_{(+)}>b>b_{(-)}$ for Dhenkanal, Ganjam, Koraput, Puri and for the State illustrates that the gap between upper line and lower line and lower line has increased over the period. It also indicates that the rate of gap between upper line and middle line is higher than that of lower line and middle line. Thus it clearly indicates the contribution of depression years is more towards instability in potato production. On the other hand the condition, $b_{(+)}>b<b_{(-)}$ for Mayurbhanj indicates the reduction of

the gap between upper and lower lines. The rate of gap between upper and middle line has increased while the rate of gap between lower and middle line has decreased. This illustrates that fluctuations due to upper deviation contributes negatively to growth of potato production indicating stability. In Sambalpur district the upper and middle trend lines are appeared to be parallel indicating the contribution of upper trend line towards stabilisation in production. Also condition $b_{(+)}<b<b_{(-)}$ in case of Kalahandi and Keonjhar districts also indicate favourable trend to bring stabilisation in production, as the rate of gap between upper and lower trend with respect to middle trend line has decreased.

Table 5. Estimated values of slopes for linear production function of potato for different districts of Orissa

Districts	$b_{(+)}$	b	$b_{(-)}$	Conditions in lower case (Favourable/unfavourable towards stability
Balasore	15.94**	17.38**	15.50**	$b_{(+)} < b > b_{(-)}$ (Un-favourable)
Balangir	5.19*	5.56*	5.37*	$b_{(+)} < b > b_{(-)}$ (Un-favourable)
Cuttack	6.87*	7.64**	6.15**	$b_{(+)} < b > b_{(-)}$ (Un-favourable)
Dhenkanal	11.63*	9.67**	9.59**	$b_{(+)} > b > b_{(-)}$ (Un-favourable)
Ganjam	8.16*	6.94*	5.09^NS	$b_{(+)} > b > b_{(-)}$ (Un-favourable)
Kalahandi	-3.93^NS	2.70^NS	2.92***	$b_{(+)} < b < b_{(-)}$ Favourable)
Keonjhar	1.36^NS	6.09**	6.97**	$b_{(+)} < b < b_{(-)}$ (Favourable)
Koraput	11.19**	9.62**	7.92**	$b_{(+)} > b > b_{(-)}$ (Un-favourable)
Mayurbhanj	3.82**	3.37*	4.37*	$b_{(+)} > b < b_{(-)}$ (Favourable)
Phulbani	7.90**	8.00**	6.31**	$b_{(+)} = < b > b_{(-)}$ (Un-favourable)
Puri	8.10	7.70	7.40	$b_{(+)} > b < b_{(-)}$ (Un-favourable)
Sambalpur	7.84**	7.76**	8.46**	$b_{(+)} = b < b_{(-)}$ (Favourable)
Sundergarh	6.13^NS	4.83*	3.20**	$b_{(+)} < b < b_{(-)}$ (Un-favourable)
Orissa state	10.02**	9.14**	7.92**	$b_{(+)} > b > b_{(-)}$ (Un-favourable)

* Significant at 5% level
** Significant at 1% level
*** Significant at 10% level
NS Not significant

(Table 6) indicates another approach for confirmation of the results obtained from table 5.

Table 6. Nature of instability in potato production

Districts	Difference in slopes		Favourable/Un-favourable
	Upper trend	Lower trend	
Balasore	-	-	Un-favourable
Balangir	-	-	Un-favourable
Cuttack	-	-	Un-favourable
Dhenkanal	+	-	Un-favourable
Ganjam	+	-	Un-favourable
Kalahandi	-	+	Favourable
Keonjhar	-	+	Favourable
Koraput	+	-	Un-favourable
Mayurbhanj	+	+	Favourable
Phulbani	-	-	Un-favourable
Puri	+	-	Un-favourable
Sambalpur	+	+	Favourable
Sundergarh	-	-	Un-favourable
Orissa state	+	-	Un-favourable

Table 7 depicts the absolute studentised residuals indicating abnormal years for different districts. Table 8 indicates the frequency of occurrence of abnormal years. It is observed from table 8 that the year 1989-90 has occurred more number of times (four times) as abnormal years following the year 1984-85, 1990-91 and 1992-93 which have occurred three times exhibiting abnormality for bringing instability in potato production.

Table 9 depicts the relationship between compound growth rates and instability in potato production for different districts of Orissa as well as for Orissa. Though compound growth rates of production for all the districts are positive, instability has been observed in case of almost all the districts except Kalahandi, Keonjhar, Mayurbhanj and Sambalpur. In case of Kalahandi district compound growth rate of area under the crop is negative indicating that productivity of the crop in the district contribute more towards, viz. Keonjhar, Mayurbhanj and Sambalpur, both acreage and productivity of the crop contribute towards stability of crop production.

Table 7. Values of absolute studentised residuals and corresponding abnormal years indicating instability

Districts	Values of e_{ts}	Corresponding abnormal years
Balasore	1.76	1977-78
	2.10	1986-87
Balangiri	1.92	1988-89
	1.86	1989-90
Cuttack	2.82	1989-90
	2.01	1990-91
Dhenkanal	2.63	1984-85
	1.31	1992-93
Ganjam	1.99	1984-85
	1.66	1989-90
Kalahandi	1.23	1983-84
	1.79	1991-92
Keonjhar	1.44	1983-84
	1.60	1985-86
Koraput	1.25	1981-82
	2.19	1987-88
Mayurbhanj	2.43	1979-80
	1.43	1992-93
Phulbani	1.68	1980-81
	1.26	1986-87
Puri	1.79	1977-78
	1.73	1990-91
Sambalpur	1.69	1979-80
	1.61	1982-83
Sundergarh	2.98	1984-85
	1.30	1992-93
Orissa state	3.89	1989-90
	1.45	1990-91

Table 8 Frequency of abnormal years (based on table 7)

Year	Frequency
1977-78	2
1978-79	0
1979-80	2
1980-81	1
1981-82	1
1982-83	1
1983-84	2
1984-85	3
1985-86	1
1986-87	2
1988-89	1
1989-90	4
1990-91	3
1991-92	1
1992-93	3

Table 9. Relation between compound growth rate and instability in potato production

District	Compound growth rate	Instability
Balasore	+	Un-favourable
Balangir	+	Un-favourable
Cuttack	+	Un-favourable
Dhenkanal	+	Un-favourable
Ganjam	+	Un-favourable
Kalahandi	+	Favourable
Keonjhar	+	Favourable
Koraput	+	Un-favourable
Mayurbhanj	+	Favourable
Phulbani	+	Un-favourable
Puri	+	Un-favourable
Sambalpur	+	Favourable
Sundergarh	+	Un-favourable
Orissa state	+	Un-favourable

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PERFORMANCE OF TPS FAMILIES FOR POTATO PRODUCTION AS TRANSPLANTED CROP

R.B. Verma and R.D. Singh[1]

ABSTRACT: The seedlings of seven TPS families were raised in nursery beds and 30 days old seedlings were transplanted in the field to see the performance of TPS genotypes on ware tuber production. Considering the overall performance it was found that the genotypes HPS7/67, HPS 1/13 and 83P 47 x TPS/B-57 were high yielder and economical than others.

INTRODUCTION

Raising of potato crop from seed tubers poses several problems such as storage of seed tubers, carry over of tuber borne diseases, bulk transport and major investment in procurement of seed constituting about 40-60% of total cost of raising the crop (3). In India, Central Potato Research Institute, Shimla, is able to meet. 25% of breeders' seed requirement of the country. The problem of seed has been partly solved by identification of aphid free periods and development of seed-plot technique. The crop, however, continues to be grown in large parts of our country using poor quality seed of new as well as old potato varieties, mainly because of short supply of good certified seed and its high cost. In the potato production using the true potato seed which has advantages of being disease free, low cost planting material and economical in storage and distribution of seed, is an alternate technology to solve these problems to a great extent. In the present study an experiment was conducted to see the performance of TPS genotypes and the crop raised by transplanting the seedlings for tuber production.

MATERIALS AND METHODS

The experiment was carried out at Main Experiment Station, (Vegetables) of N. D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) during 1991-92 and 1992-93 in randomised block design with three replications having net plot size of 2.25 x 1.5 m^2. Tuber production by transplanting seedlings involves two steps, viz: raising of seedlings in nursery bed and transplanting them in the field. The nursery bed (1 x 1 x 0.1 m) were prepared by mixing the surface soil and FYM in the ratio of 1 : 1. The top of the bed was covered with 1 cm thick layer of sieved FYM and moistened by sprinkling water. The following day, top of bed was hoed and levelled to break the crust to get proper texture. Pre-germinated TPS were evenly placed in 0.5 cm deep furrows at 10 cm apart on bed @ 2g/m^2 on 24th Nov. in the year 1991 and 1992 respectively. For pre-germination, TPS was soaked in water for 24 hrs, mixed with sieved FYM in the ratio of 1 : 2 and kept moist for next 3-4 days to stage when the radicles just start coming out. Seeds were covered with thin layer of sieved FYM and dry grass. The beds were

[1]Department of Vegetable Science, N.D. University of Agriculture and Technology, Kumarganj, Faizabad-224229 (U.P.)

sprinkled with water 2-3 times in a day for a week. On the day of seed sowing small quantity of B.H.C. dust was applied around the beds to discourage ants and other insects from damaging the seed. Mulch was removed when seedlings started germination. The seedlings were sprayed with 0.1% urea on alternate days after emergence of first true leaf. The field for transplanting the seedling was prepared and a basal dose of FYM @ 20 t/ha was applied. The trial was laid out in randomised block design with three replications having a net plot size of 2.25 x 1.5m^2. Half of nitrogen @ 50 kg/ha and full dose of phosphorus and potassium @ 80 kg/ha were applied as side placement. Furrows of about 20 cm deep and 45 cm apart were made and irrigated just before transplanting. Two healthy seedlings per hill were transplanted at 10 cm apart in afternoon, in such a way that roots get placed below the water mark. The furrows were kept moist till seedling establishment. After 40 days of transplanting the remaining half dose of nitrogen @ 50 kg/ha was applied at the time of earthing up. Harvesting was done on 5th April, 1992 and 11th March, 1993 at full maturity. The data were recorded on plant height (cm), number of tubers per plant, average tuber weight (g), yield of tubers (t/ha) and cost of tuber production (Rs./t). The data were analysed as per procedures of Panse and Sukhatme (4).

RESULTS AND DISCUSSION

The plant height differences among the TPS genotypes were found statistically significant at 30 DAT and 60 DAT stage during both the years except at 30th day stage during 1991-92 (Table 1). The overall performance for two years showed that the genotypes HPS 7/67 followed by HPS 1/13 produced tallest plants at 30th and 60th day after transplanting, whereas, minimum plant height was noted in HPS 1/67. The variation in plant height may be due to recover capacity of transplanting shock. Similar findings have also been reported by Bhatia *et al.* (2) and Batra *et al.* (1). The number of tubers per plant differed significantly among the genotypes. It ranged from 3.41 to 7.66 during 1991-92 and 4.41 to 5.51 in 1992-93. The maximum number of tubers was found

Table 1. Plant height of TPS genotypes under transplanted condition

TPS genotypes	Plant height (cm)			
	30 DAT		60 DAT	
	1991-92	1992-93	1991-92	1002-93
HPS 1/13	22.82	23.15	41.46	41.05
HPS 7/67	23.56	22.75	42.18	42.28
HPS 11/13	22.56	21.95	40.65	40.00
HPS 1/67	20.84	20.95	39.45	38.95
83P47 x TPS/B-57	21.64	21.72	40.00	42.05
TPS-C-3	21.46	20.05	38.95	39.95
MS 80-758 x TPS/B-57	21.56	22.00	39.00	40.10
SEm ±	0.634	0.584	0.716	0.644
LSD at (P = 0.05)	NS	1.80	2.20	2.00

in HPS 7/67 during both the years. The average tuber weight and tuber yields among the TPS genotypes were also statistically significant during both the years. The overall maximum tuber weights per plant for two years were recorded in TPS-3 (20.85 g) followed by 83 P 47 x TPS/B-57 (20.64 g) and HPS 11/13 (20.14 g) while, minimum in HPS 7/67 (18.56 g). The highest tuber yield was recorded in HPS 7/67 (21.92 t/ha) followed by HPS 1/13 (20.90 t/ha) and HPS 11/13 (17/42 t/ha) during 1991-1992. During 1992-93, it was also maximum in HPS 7/67 (21.62 t/ha) followed by 83P47 x TPS/B-57 (19.59 t/ha) and HPS 1/13 (18.96 t/ha) (Table 2). Data indicated that the overall performance of HPS 7/67 was the best (tuber yield of 21.77 t/ha) followed by HPS 1/13 (19.93 t/ha) and 83P47 x TPS/B-57 (18.29 t/ha). The data also indicates that the plant height has positive bearing on yield of the crop . The latter is the result of interaction of genotypes and environment. Steward *et al.* (5) have also opined that the general pattern of organisation of potato plant is modulated by the genotypes. However, the growth habit, anatomy, metabolism, tuber yield and quality differ with changes in environment.

Table 2. Performance of TPS genotypes on tuber production under transplanted condition

TPS genotypes	Number of tubers per plant		Average tuber weight (g)		Tuber yield (t/ha)	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
HPS 1./13	5.75	4.11	17.12	23.16	20.90	18.96
HPS 7/67	7.66	5.51	16.55	20.57	21.92	21.62
HPS 11/13	4.46	5.02	19.76	21.14	17.42	18.83
HPS 1/67	5.61	4.33	16.95	22.03	17.24	17.04
83P47 x TPS/B-57	3.41	4.29	19.13	22.14	16.98	19.59
TPS-C-3	4.82	4.18	18.75	22.95	16.56	17.65
MS 80-758 x TPS/B-57	4.72	4.98	17.78	21.52	16.11	18.29
SEm ±	0.746	0.164	0.588	0.438	1.201	0.729
LSD at (P = 0.05)	2.32	0.51	1.83	1.36	3.73	2.27

Table 3. Economics of tuber production from TPS under transplanted condition

TPS genotypes	Total cost of cultivation (Rs./ha)		Yield (t/ha)		Cost of production (Rs./tonne)	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
HPS 1/13	13,055.91	16,949.47	20.90	18.96	624.69	893.96
HPS 7/67	13,055.91	16,949.47	21.92	21.62	595.62	783.97
HPS 11/13	13,055.91	16,949.47	17.42	18.83	748.48	900.13
HPS 1/67	13,055.91	16,949.47	17.24	17.04	757.30	994.69
83P47 x TPS/B-57	13,055.91	16,949.47	16.98	19.54	768.90	865.21
TPSC-3	13,055.91	16,949.47	16.56	17.56	788.40	965.23
MS 80-758 x TPS/B-57	13,055.91	16,949.47	16.11	18.29	810.00	926.71

The total cost of cultivation of individual genotypes under seedling transplants including the cost of raising seedlings in nursery beds for transplanting was same, Rs. 13,055.91 and Rs. 16,949.47/ha during 1991-92 and 1992-93 respectively. The difference between two years was mainly due to increase in the cost of inputs like fertilizers, pesticides and labour wages etc during 1992-93. During 1991-92, the tuber production cost (Rs./t) of all TPS genotypes was in the range of Rs. 595.62 to Rs. 810 per tonnes with maximum in MS 80-758 x TPS/B-57 and minimum in HPS 7/67. However, during 1992-93 it was in the range of Rs. 783.97 to Rs. 994.69 per tonne with maximum in HPS 1/67 and minimum in HPS 7/67 (Table 3). The variation in production cost among the genotypes was primarily due to fluctuation in yield potential of TPS genotypes because cost of tuber production (Rs./t) was calculated by dividing the cost of cultivation (Rs./ha) by total yield (t/ha).

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SHORT NOTE

A SIMPLE SCHEME TO MEASURE RESPIRATION RATE OF POTATO TUBERS WITH CO_2 GAS ANALYSER*

J.P Singh, Ashiv Mehta and H. N. Kaul[1]

Commercially available `Gas Analysers' can measure increase in the concentration of CO_2 emitted by respiring tubers in a closed chamber maintained at room temperature. However, the calculation of respiration rate takes into account the varying free volume of gases in the chamber with each sample of potato tubers. Further, the measured respiration rate needs to be converted to mg CO_2/kg potato tubers/hour or some such temperature and pressure insensitive units to make comparisons meaningful. A low cost apparatus connected to a CO_2 gas analyser and a simple calculation procedure is given here for rapid and precise measurement of respiration rate of potato tubers. The possible sources of error are also discussed.

Apparatus : An ordinary pressure filtering apparatus (2L capacity) was modified to make an inexpensive, easy to operate, sample chamber to be attached with CO_2 gas analyser (CI-301, CID Inc., USA) in a closed loop (Fig. 1).

Procedure : Suitable samples of potato tubers (300-500 g) were kept in a chamber and the lid sealed with a small amount of grease applied uniformly on the ground glass fins of the lid and sample chamber. The initial reading of CO_2 concentration was recorded 2 minutes after closing the chamber in order to obtain uniform concentration of CO_2 in the whole system (connecting tubes, sample chamber and the CO_2 analyser). This step was essential to minimize intra sample variations in respiration rate. After recording initial (0 second) concentration, the increase in concentration of CO_2 was measured exactly after 300 seconds (5 minutes).

Calculation : Respiration rate at the given temperature was calculated by equation (1), modified formula of Schippers (2).

$$\text{Respiration rate } (\text{mg } CO_2 \text{ kg}^{-1} \text{ hr}^{-1}) = \frac{V_1 - V_2}{g} \times \frac{\wedge C}{\wedge T} \times \frac{273}{(273 + R^0C)} \times \frac{P}{1.013} \times \frac{1}{22.41} \times 1000 \times 0.044 \times 3600 \quad \ldots\ldots\ldots (1)$$

where

V_1 = volume of the sample chamber (L)

V_2 = volume occupied by potato tubers (L) [weight of potato tubers in g x 1.108 x

* Publication No. 1342, CPRI, Shimla.

[1] Central Potato Research Station, Jalandhar - 144003 (Panjab).

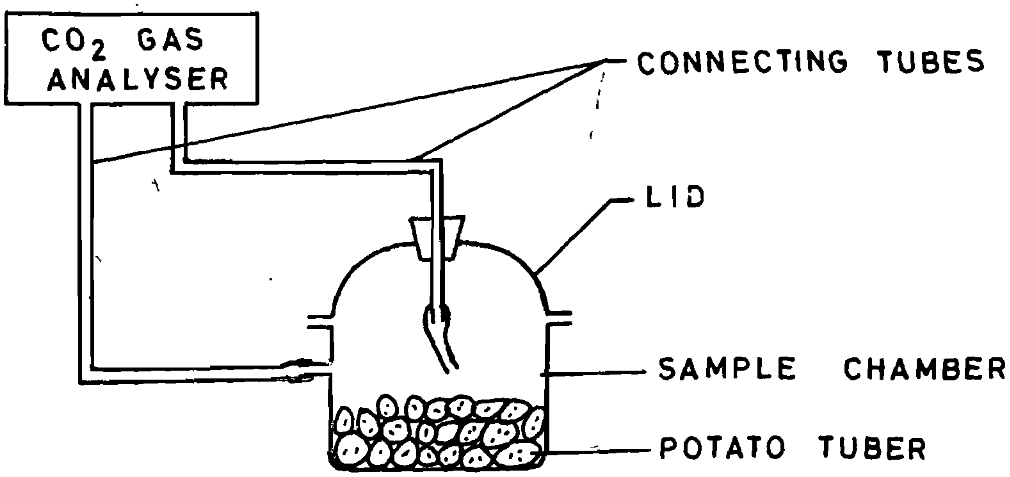

Fig. 1. Schematic arrangement for measurements of respiration rate of potato tubers

1/1000; Marwaha and Raj Kumar (1) reported the mean specific gravity of potato tubers of Indian cultivars as 1.08]

g = weight of potato tubers (g)

^C = increase in concentration of CO_2 (micro mol mol^{-1} or volumetric ppm)

^T = time lapse between initial and final reading of CO_2 concentration (seconds)

R = room temperature (°C)

P = atmospheric pressure (bars)

Explanation for different factors of the equation are :

273/(273 + R°C) = factor for conversion to normal temperature of 273°K

P/1.013 = factor for conversion to normal pressure of 1 bar atmospheric pressure

1/22.41 = factor to account for gas volume (22.41 L) at (L/mole) normal.pressure and temperature to convert concentration of CO_2 (ppm) into absolute volume of CO_2 in the sample chamber.

1000 (g/kg) = factor for respiration rate per kg of tuber.

Table 1. Respiration rate of dormant and sprouted potato tubers of some Indian cultivars

Cultivars	Respiration rate (mg CO_2/kg/ha)	
	dormant	sprouted
Kufri Chandramukhi	5.75	26.67
Kufri Bahar	5.76	26.58
Kufri Lauvkar	6.36	26.18
Kufri Jyoti	5.32	22.81
Kufri Badshah	9.74	25.69

Measurements of respiration rate were made for dormant tubers at 18°C and sprouted tubers at 35°C room temperature.

0.044 (kg/mole) = factor for conversion of concentration of CO_2 gas (ppm) into mg CO_2.

3600 (s/hr) = factor for respiration rate per hour.

The terms of the above formula can be simplified as under:

$$\text{Respiration rate } (\text{mg } CO_2 \text{ kg}^{-1} \text{ hr}^{-1}) \approx \frac{V_1 - V_2}{g} \times \frac{\wedge C}{\wedge T} \times \frac{1}{(273 + R^{o}C)} \times 1904875.2 \times P$$

Precautions : A sampling rate (frequency of sampling) and air flow (volume of sampling) of 3 seconds and 1.0 L per minute, respectively, was found most satisfactory. Automatic gas analysers are programmed for a range of these parameters. However, the precise recording of CO_2 concentration and ^T is crucial. A potential source of error is the presence of water vapour in the air inside the sample chamber, released by the respiring tubers. Water vapour has a dilution effect in which the partial pressure of CO_2 is decreased. *Secondly, Infra Red (IR) gas analysers are sensitive to water vapour,* particularly at higher CO_2 concentrations in excess of 300 ppm, which is the common case during respiration measurements. The problem could be effectively overcome by providing a dessicant upstream of the analyser. Most IR gas analysers are provided with effective in-built dessicant device in the system. However, the dessicant has to be regularly checked for efficiency of moisture absorbance and changed if needed.

With precautions cited above, the tuber respiration rate of some Indian potato cultivars harvested at full maturity were measured and the coefficient of variation for 10 replicates of several potato tuber samples was < 3%. The respiration rate of dormant potato tubers 3 weeks after harvest and sprouted tubers stored for 18 weeks at ambient temperatures (17.5-35.0°C) ranged from 5.32 to 9.74 and 22.81 to 26.67 mg CO_2 /kg/hr, respectively (Table 1). Respiration rate of tubers is reported to vary from 1.5 to 12.5 mg CO_2/kg/hr at storage temperatures of 2.5 to 15.0°C (2).

ACKNOWLEDGEMENTS

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SHORT NOTE

COMPARATIVE EFFECT OF DIFFERENT HERBICIDES IN POTATO CV. KUFRI BADSHAH

N.M. Patel, P.M. Shah, P.T. Patel[1]

Earlier studies have indicated that application of Fluchloralin (0.75 and 1.0 kg/ha) as preplant incorporation, and Pendimethalin (0.75 and 1.0 kg/ha) as pre-emergence were effective in controlling weeds during initial growth of potato. The present study was carried out to evaluate efficacy of certain other herbicides in potato.

The experiment was carried out on loamy sand soil at Horticultural Research Farm, Gujarat Agricultural University, Anand during 1990-91 *rabi.* The experiment consisted of 15 treatments repeated three times in the randomized block design. The details regarding the treatments are given alongwith the counts of weeds in table 1. Popular high yielding variety Kufri Badshah was planted on 22nd November 1990 at 45.0 x 15.0 cm spacing. The crop was fertilized with 220 : 110 : 220 kg NPK/ha. Total twelve irrigations were applied during the crop life. The herbicides were sprayed by Knapsack sprayer fitted with a flat fan nozzle using 500 litres water. Weeds were removed at 20, 30, 40, 50, 70 and 85 days after planting in the weed free treatment. The weed population was recorded at 40th and 65th day after planting and at harvest of the crop. The other observations, viz. tuber yield, were recorded at harvest.

Weed flora : The weed flora observed in the experimental field was comprised of *Chenopodium album* L, *Digera arvensis* Forsk, *Chenopodium murale* L, *Phyllanthus niruri* L, *Tribulus terrestris* L, *Portulaca oleracea* L, *Melilotus alba* Lunk, *Cyperus rotundus* L, *Cynodon dactylon* Pears.

Dry weight of weeds : The dry weight of weeds recorded from unweeded control was 7.01, 15.69 and 32.40 g/ha at 40 DAP, 65 DAP and at harvest respectively (Table 1). All the treatments significantly reduced the dry weight of weeds as compared to unweeded control at all the growth stages. Significantly minimum dry weight of weeds was recorded under Pendimethalin @ 1.00 kg/ha at 40 DAP, 65 DAP and at harvest but the same was at par with Pendimethalin @ 0.75 kg/ha at 40 DAP. The reduction in dry weight of total weeds under Pendimethalin 1.0 kg/ha was 6.16, 13.86 and 28.77 g/ha at 40 DAP, 65 DAP and at harvest respectively over unweeded control.

All three hand weeding treatments (30, 45 and 65 DAP) significantly reduced the dry weight of weeds over UWC recorded at 40, 65 DAP and at harvest. Thus one handweeding at 30 DAP was found as good as that of weed free treatment.

[1] Gujarat Agricultural University, Anand Campus, Anand - 388110 (Gujarat).

Table 1. Effect of weed control treatments on dry weight of weeds, total tuber yield and weed control efficiency

Treatments (kg/ha)		Dry weight of weeds (q/ha)			Total tuber	Weed control
		40 DAP	65 DAP	At harvest	yield q/ha	efficiency (%)
Fluchloralin	@ 0.75 kg/ha. PPI	1.71	4.26	10.23	309.08	68.42
-"-	@ 1.00 kg/ha PPI	1.52	3.83	8.90	311.29	72.53
Pendimethalin	@ 0.75 kg/ha PE	1.02	2.56	5.50	322.90	83.02
-"-	@ 1.00 kg/ha PE	0.85	1.83	3.43	353.76	89.41
Alachlor	@ 0.75 kg/ha PE	2.30	4.97	12.72	290.42	60.74
-"-	@ 1.00 kg/ha PE	1.81	4.48	11.67	295.86	63.98
Oxyfluorfen	@ 0.1 kg/ha PE	2.45	7.16	15.30	290.42	52.78
-"-	@ 0.15 kg/ha. PE	2.17	6.09	13.52	291.15	58.27
Paraquat	@ 0.75 kg/ha EPE	1.41	3.18	7.68	328.34	76.30
-"-	@ 1.00 kg/ha EPE	1.26	2.78	7.22	318.20	77.72
One hand weeding	at 30 DAP	0.00	2.74	6.77	333.33	79.10
-"-	at 45 DAP	6.01	2.31	6.42	289.98	80.02
-"-	at 60 DAP	6.18	0.00	6.08	256.47	81.23
Weed free check		0.00	0.00	0.00	360.30	-
Un-weeded check		7.01	15.69	32.40	239.56	-
SEM		0.08	0.14	0.14	11.03	-
CD at 5%		0.23	0.41	0.28	31.95	-
CV%		5.98	5.98	2.58	6.24	-

PPI = Pre plant incorporation, PE = Pre emergence, EPE = Early post emergence, DAP = Days after planting

Among the herbicidal treatments Pendimethalin @ 1.00 kg/ha was found significantly superior over rest of the treatments. Since Pendimethalin is less susceptible to degradation in soil system, its efficacy in suppressing the weed growth could be continued for a longer time during the growth period.

Effect on tuber yield : All manual and herbicidal weed control treatments significantly increased the tuber yield as compared to unweeded control (Table 1). The weed free control produced maximum tuber yield (360.30 q/ha).

Among the herbicidal treatments, Paraquat 0.75 kg/ha and both the levels of Pendimethalin achieved the highest tuber yield but remained at par with that of HW 30 DAP. On an average weed free, Pendimethalin @ 1.00 and 0.75 kg/ha, Paraquat 0.75 kg/ha and one hand weeding at 30 DAP increased the tuber yield to the tune of 50.4, 47.67, 34.78, 37.06, 39.06 and 39.14% respectively over unweeded control.

The lower yield observed in Oxyfluorfen and Alachlor was due to decrease in plant population at harvest and number of tubers per plant. Among hand weeding treatments, one hand weeding at 45 DAP and 60 DAP significantly reduced the dry weight of weeds over unweeded check which helped to increase the tuber yield of potato. The increase in the tuber yield was significant only in hand weeding once at 30 DAP. It is clearly seen from the results that removal of weeds later than 30 DAP reduced the tuber yield. Thus the period of 30-40 DAP was found the most critical for crop weed competition in potato.

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SHORT NOTE

HYBRID PJ-376 IS HAVING FIELD TOLERANCE AGAINST FOUR POTATO VIRUSES*

Shiv Kumar[1], R.P. Rai[2] and Sarjeet Singh[1]

Availability of a minimum quantity of 80 q of disease free stocks of any advanced hybrid is one of the basic requirement before it is released as a notified variety. Therefore, it is imperative to produce disease free stocks of early maturing hybrid PJ-376 recommended for release in 1993 by AICPIP workshop. With this objective, tuber indexing of this hybrid alongwith Kufri Chandramukhi and Kufri Sindhuri was undertaken in two consecutive seasons by using polyvalent and specific das-ELISA to know the status of four potato viruses X,S,Y & M by testing individual sprout/plant and in a group of four plants. Comparative results on detection of PVX, PVS, PVY & PVM in three cultures are reported here.

A total of 550 single eyes received from CPRS, Patna in October, 1993 were allowed to sprout at room temperature in Shimla. After 15 days, individual sprout from each eye was removed and crushed in polythene bag in 1:10 (w/v) dilution of phosphate buffer pH 7.0. These samples were tested by polyvalent penicillinase das-ELISA for PVX, PVS, PVY, PVA & PLRV following standard procedure of penicillinase ELISA (3) using Inotech microtitre plate. Polyvalent IgG was prepared by mixing 0.13, 0.14, 0.13, 0.15 and 0.16 mg specific IgG of PVX, PVS, PVY, PVA & PLRV respectively in 1 ml phosphate buffer saline in similar way as prepared by Perez de San Roman et al. (2). A part of this physical mixture was conjugated with 0.04 mg/ml penicillinase enzyme (Sarjeet Singh, 1989, unpublished). Single wells were used for detection of all the five viruses. The specific positive control for each virus was kept to check the effectiveness of polyvalent IgG and conjugate. The plate was measured in Dynatech ELISA Reader M-710 at 570 nm after 45 minutes. The absorbance values of diseased samples half and less than half of healthy were taken as positive.

Single eyes were planted in glasshouse in May, 94 and plants emerging from single eyes were tested individually and in a group of four by specific alkaline phosphatase das-ELISA (1) in Inotech microtitre plates. The absorbance values of diseased and healthy samples were measured at 410 nm in Dynatech ELISA Reader M-710. Absorbance values twice and more than twice in comparison to healthy samples were taken as positive (diseased) and less than twice as healthy.

Based on these determinants the usefulness of single and four plant group testing of different viruses either singly or in combination was calculated to know their status in three cultivars.

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[1]Central Potato Research Institute, Shimla-171 001 (H.P.).
[2]Central Potato Research Station, Patna-801 506 (Bihar).

Table 1. Detection of potato viruses X, S, Y, A and LR by polyvalent penicillinase das-ELISA

Cultivar	No. of plants tested	Per cent diseased	Percent healthy
PJ-376	469	71.0	29.00
Kufri Chandramukhi	90	100	0.0
Kufri Sindhuri	90	88.5	11.5

Table 2. Detection of potato viruses X, S, M and Y by alkaline phosphatase das-ELISA

Cultivar	No. of samples	% Infection				% Healthy in	
		PVX	PVS	PVY	PV	single plant test	four plant group test
Kufri Sindhuri	52	*15.4*	*80.0*	*7.7*	-	*11.5*	*0.0*
Kufri Chandramukhi	40	65.0	85.0	0.0	-	0.0	0.0
PJ-376 (A)	93	4.2	38.7	19.4	-	55.9	21.8
(B)	93	4.2	38.7	19.4	54.8	19.4	-

-= Not tested,.A = tested for X,S,Y, B = tested for X,S,Y & M.

The polyvalent detection of viruses (PVX, S, Y, A & LR) through sprout ELISA showed 71.0% infection in PJ-376, 100.0% in Kufri Chandramukhi and 88.1% in Kufri Sindhuri in first testing (Table 1). However, even on planting `healthy' tubers in field (Stage I) still virus-like symptoms were observed in plants of PJ-376.

In subsequent testing with specific alkaline phosphatase das-ELISA of individual plantlets of PJ-376, 1.1, 12.8, 1.1 and 36.5% incidence of PVX, PVS, PVY and PVM respectively was recorded. The combined incidence of these viruses in combinations of two (i.e. SX, XM, XY, MY, SY and MS) was 0.0, 2.2, 0.0, 1.1, 10.1, 0.0 and 7.5% respectively and of triple combination (XMS and SYM only) it was 1.1 and 6.5% respectively. In Kufri Chandramukhi, the incidence of X, S and Y alone was 5.0, 30.0 and 5.0% respectively. The combined infection of XS alone was recorded to the tune of 50%. In Kufri Sindhuri, the incidence of individual viruses alone (PVX, S, Y) was 0.0, 61.5 and 7.8% and of combined infection (XS and SY alone) was 15.4 and 3.9% respectively. In single plant test of PJ-376, 55.9% plantlets were found healthy in comparison to 11.5% in Kufri Sindhuri and 0.0% in Kufri Chandramukhi (Table 2). While in four plant group testing only 19.4% plantlets were found healthy in PJ-376 and none in two commercial cultivars.

The appearance of visible virus like symptoms under field condition in stage I in penicillinase-poly-ELISA tested plants was due to PVM infection as 54.8% incidence was confirmed by alkaline phosphatase das-ELISA. The results indicated that this hybrid has a field tolerance to four viruses in comparison to other two cultivars and single plant test gave more number of disease free plants than four plant group testing.

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SHORT NOTE

TUBER YIELD AND UPTAKE OF N, P AND K IN THE LEAVES, STEMS AND TUBERS AS AFFECTED BY NITROGEN LEVELS AND HAULMS CUTTING IN POTATO CV. KUFRI BAHAR

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

Fertilizer is one of the most important constituent for higher yield of potato. Among fertilizers, nitrogen is second most important nutrient after potassium which increases the vegetative growth, crop duration and also the quality of tuber. In general, the growing period is shortened by harvesting the crop at immature stage for early marketing. In such condition, nitrogen may play an important role in enhancing the crop duration and also for more bulking. Therefore, the present experiment was conducted to judge the effect of nitrogen levels and haulms cutting on N, P and K content and uptake in the leaves, stems and tubers.

The experiment was conducted at Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during 1986-87 and 1987-88 to study the effect of four levels of nitrogen (0, 50, 100 and 150 kg/ha) and five dates of haulms cutting (80, 90, 100, 110, and 120 DAP) in a randomised block design with three replications. The soils of the experimental field was sandy loam having pH 7.65 and 7.68, electrical conductivity 0.168 and 0.167 dsm^{-1}, available N 128 and 130 ppm, available P 8.20 and 8.10 ppm and available K 6.40 and 6.60 ppm in 1986-87 and 1987-88 respectively. The soil was fertilized with N, P and K in the form of urea, single super phosphate and muriate of potash. Full dose of phosphorus (50 kg/ha) and potassium (80 kg/ha) to all the plots and 1/2 dose of nitrogen were applied as per treatments. Rest half dose of nitrogen was top dressed at 30 DAP (at the time of earthing). Tubers weighing 25-30 g were planted at 60 x 20 cm inter and intra row spacing on 29th October (1986) and 1st November (1987). N, P and K content in the leaves, stems and tubers were determined by the method of 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 weight.

It is clearly evident from average data of two years (Table 1) that tuber yield and uptake of N, P and K in the leaves stems and tubers increased significantly with the increase in the level of nitrogen application. The maximum tuber yield (240.30 q/ha) was recorded at 150 kg N/ha and minimum in the control. The higher yield at 150 kg N/ha

[1] Project Directorate of Vegetable Research, 1, Gandhi Nagar (Naria) Sunderpur, Varanasi - 221005.
[2] Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi - 221005 (U.P.).

Table 1. Tuber yield and uptake of N, P and K in the leaves, stems and tubers as affected by application on N levels and haulms cutting

Nitrogen	tuber	Uptake of Nitrogen (kg/ha)			Uptake of Phosphorus (kg/ha)			Uptake of Potassium (kg/ha)		
levels	(q/ha)	Leaves	Stems	Tubers	Leaves	Stems	Tubers	Leaves	Stems	Tubers
N_0	114.04	15.11	1.09	24.40	0.77	0.10	3.71	12.45	3.30	42.80
N_1	188.64	21.03	1.83	47.13	1.38	0.13	6.53	13.98	4.01	65.78
N_2	231.80	27.41	2.56	61.92	1.70	0.17	8.20	15.85	4.63	75.16
N_3	240.30	31.75	3.48	66.99	2.07	0.22	8.94	16.36	4.91	73.90
C.D. at 5%	69.62	3.16	0.46	4.09	2.01	1.97	1.76	3.34	0.61	4.25
Haulms cutting (DAP)										
80	168.30	27.96	2.58	44.18	1.78	0.18	6.17	18.65	4.92	58.52
90	179.73	28.99	2.78	47.22	1.82	0.19	6.63	18.44	5.52	62.96
100	192.04	22.57	2.13	49.90	1.43	0.17	6.77	14.31	3.91	63.73
110	207.26	22.09	1.87	53.67	1.33	0.12	7.17	12.39	3.44	67.01
120	221.61	17.52	1.86	55.43	1.04	0.11	7.48	9.51	3.65	69.57
C.D. at 5%	77.84	3.53	0.52	4.57	2.25	2.20	1.79	3.74	0.68	4.75

application was due to a better vegetative growth, because nitrogen is an important constituent of chlorophyll which increases the photosynthesis, resulting in assimilation of more carbohydrates and their translocation to the tubers (5). The uptake on N, P and K in the leaves, stems and tubers was higher at 150 kg N/ha except K in tubers. The increase in the uptake of N, P and K was due to the fact that nitrogen is an important constituent of protein, chlorophyll and helps in the utilization of P and K and other elements. The uptake of these nutrients was due to the higher yield, higher dry matter and higher nutrient content in different parts of the plants (4). The increase in the uptake of K in the leaves, stems and tubers was also noted by Jackson and Haddock (3). Contrary to this, the tuber yield and uptake of N, P and K in the tubers increased significantly and decreased in the leaves and stems, with the delay in the haulms cuttings. The highest yield of tubers (221.61 q/ha) and N, P, K, uptake in the tubers i.e. 55.43, 7.48 and 69.57 respectively were recorded at 120 DAP, while the highest N, P and K in the leaves and stems were recorded at 90 DAP except K in stems (Table 1). The higher yield at 120 DAP was due to continuous translocation of photo-synthates over a long period of time which increased the size and weight of the individual tubers (7). The decrease of N, P and K uptake in leaves and stems and increase in the tubers were due to the translocation of nitrogen from the aerial parts to the tubers. The above view was also expressed by Grewal *et al.* (1) and Sharma and Verma (8). The increase in the uptake of N and P in the leaves and stems up to 90 DAP and decrease later on upto 120 DAP was also reported by Jackson and Haddock (3) and Sharma *et al.* (6).

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SHORT NOTE

EFFECT OF DIFFERENT FERTILITY LEVELS ON DRY MATTER PRODUCTION AT DIFFERENT STAGES OF GROWTH AND NUTRIENT UPTAKE OF POTATO*

N.T. Sujatha and K.S. Krishnappa[1]

With increasing cost of fertilizers, organic manure like farm yard manure (FYM) as a renewable energy source is applied to potato for not only raising the yield but maintaining soil fertility (5). However, little information is available in Karnataka State on the integrated use of fertilizers and FYM on the dry matter production and nutrient uptake by potato. The present study was therefore carried out to study the effect of fertilizer levels and FYM on the dry matter production at different stages of growth and nutrient uptake by cv. Kufri Jyoti.

Field trial was carried out at the Agricultural Research Station, Chintamani (University of Agricultural Sciences, Bangalore) during *Kharif* 1993-94, to study the effect of different fertility levels on the dry matter production and nutrient uptake in Kufri Jyoti. The soil of the experimental field was red sandy loam, having pH 7.5, organic carbon 0.50%, available P_2O_5 and K_2O were 14.5 and 240.0 kg/ha respectively. Nine treatments (Table 1) were distributed in a randomized block design with three replications. Well decomposed FYM as per treatments was applied 15 days before planting and incorporated in the soil. Half of N, full P_2O_5 and K_2O in the form of urea, diammonium phosphate and muriate of potash as per treatments were applied at the time of planting and remaining half of N was applied 4 weeks after planting. Tubers were planted at 50 cm x 20 cm. The crop was raised under rainfed conditions with protective irrigation by adopting recommended package of practices. Five plants were selected at random from each treatment for dry matter estimation at 50, 75 days after planting and at harvest. The nutrient uptake was estimated by standard procedures as out-lined by Jackson (1)

Dry matter production : Fertility levels significantly increased the dry matter production at all stages of plant growth studied (Table 1). The plant continued the dry matter accumulation till maturity and this was influenced by different fertilizer levels as well as growth stage of plant. In haulms, there was a decline in dry matter towards maturity which may be due to translocation of carbohydrates from haulms to tubers and also senescence of leaves. Similar results have been reported by other workers (2). Haulms accounted for 25.2 to 26.8% of the total dry matter production at harvest in

*Part of the M.Sc (Hort.) thesis of the senior author to the University of Agricultural Sciences, Bangalore.

[1] Division of Horticulture, University of Agril. Sciences, GKVK Campus Bangalore-560 065 (Karnataka).

Table 1. Dry matter production at different stages of growth and nutrient uptake, as influenced by different fertility levels

Treatments ($N : P_2O_5 : K_2O$ kg/ha)	Dry matter production (kg/ha)						Nutrient uptake (kg/ha) at harvest		
	Days after planting		At harvest						
	55	75	Haulms	Roots	Tubers	Total	N	P_2O_5	K_2O
Control (No fertilizer and FYM)	6080	7535	1984.0	46.2	5850.0	7880.2	117	14	108
120 : 100 : 120 without FYM	7127	8148	2215.7	58.9	6348.7	8623.3	148	17	131
60 : 50 : 60 without FYM	6631	8025	2214.3	56.7	6344.3	8615.3	143	17	133
120 : 100 : 120 + 25 t FYM/ha	7932	8673	2505.3	63.7	6651.7	9220.7	169	18	184
60 : 50 : 60 + 25 t FYM/ha	7315	8395	2392.7	61.7	6563.3	9017.7	160	18	139
120 : 100 : 120 + 50 t FYM/ha	8806	9352	2717.3	66.8	7359.0	10143.1	213	28	207
60 : 50 : 60 + 50 t FYM/ha	8200	8920	2543.3	66.7	6969.3	9579.3	184	19	193
0 : 0 : 0 + 25 t FYM/ha	6356	7805	2071.3	53.2	5974.0	8098.5	134	14	125
0 : 0 : 0 + 50 t FYM/ha	6442	7883	2103.7	54.7	6083.7	8242.1	139	14	128
CD ($P = 0.05$)	834	785	201.3	6.9	369.0	390.9	11	3	29

different fertility levels. Roots formed very meagre part. At harvest tubers constituted 72.6 to 74.2% of the total dry matter in different fertility levels. Highest dry matter production was in the fertility level of 120 kg N + 100 kg P_2O_5 + 120 kg K_2O + 50 t FYM/ha with an increase of 28.0% over the control. The increased dry matter production can be attributed to more synthesis and translocation of photosynthates due to application of fertilizers and organic manure (2, 3).

Nutrient uptake : Fertility levels significantly increased the nutrient uptake. Application of 120 kg N + 100 kg P_2O_5 + 120 kg K_2O + 50 t FYM/ha increased the nutrient uptake by almost two-folds. Tubers constituted more than 62 per cent of the total uptake. These results are in agreement with the findings of earlier workers (4,5). The increased nutrient uptake can be attributed to fertilizer and FYM application by which more nutrients were made available and they also promoted the growth of roots, thus leading to more absorption of nutrients.

The results revealed that the fertility levels influence the dry matter production and nutrient uptake and these in turn significantly affected the yields.

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SHORT NOTE

INSECT PESTS OF POTATO IN LAHAUL & SPITI REGION OF HIMACHAL PRADESH

S.B.S. Parihar, K.D. Verma[1] and V.K. Chandla[2]

Potato growing valleys of Lahaul & Spiti are situated at an altitude ranging from 9000 to 11,000 feet above the mean sea level in the North-East of Himachal Pradesh, providing unique agro-climatic conditions for potato cultivation. The high quality seed potato grown in this region is distributed to other states of the country. Information on various insect pests damaging this valuable crop in this region is scanty, hence surveys were undertaken for recording various insect pests damaging potato crop at different stages during 1987.

As many as 31 insects were observed to damage the potato crop during July-September (Table 1). Amongst these, two aphid species, viz. *Myzus persicae* (Sulzer) and *Aphis gossypii* (Glover) are known to be the potential vector of important potato viruses and need special mention. *M. persicae* crossed the critical level of 20 aphids/100 compound leaves by the third week of August. Besides these, six species of leaf hoppers were also recorded and *Amrasca biguttula biguttula* (Ishida) was the predominent one. Its population in Pattan and Bhaga valleys was 9 and 6 hoppers/plant respectively.

Among other sucking insects, *Lygus* spp. need special mention as these caused speckling of leaves with rusty patches. In some of the severely infested fields, up-to 17% yield losses were recorded.

Two species of cutworms, viz. *Agrotis ipsilon* (Hfn.) and *Agrotis segetum* (Schiff.) were found damaging this crop. The former was relatively more common and caused up to 5% tuber damage. Rajendran and Chandla (1986) also recorded the same species of cutworm from Lahaul & Spiti. Wireworm (*Agrotis* sp.) was the most common causing potato tuber damage upto 14.5% at Pattan and Bhaga valley. *Empoasca punjabensis* (Pruthi), *Macrosteles sexnotatus* (Fallen), *Leptocentrus* sp., *Lygus* spp., *Athetis* sp., *Acherontia atropos* (L.) *Astycus lateralis* (Fabricius), *Strophosmides* sp. and *Haltica* sp.

[1]Central Potato Research Station, Modipuram - 250 110, Meerut (U.P.).
[2]Central Potato Research Institute, Shimla - 171 001 (H.P.).

Table 1. Insect-pests damaging potato crop in Lahaul & Spiti region of Himachal Pradesh

Insect-Pest	Order/Family	Period of Activity
	Orthoptera	
Acrida exaltata (Walker)	Acrididae	July-September
Oxya velox (Fabricius)	"	"
Chrotogonus trachypterus (Blanchard)	"	"
	Hemiptera	
Amrasca biguttula biguttula (Ishida)	Cicadellidae	August-September
Aphis gossypii (Glover)	Aphididae	"
Bagrada sp.	Pentatomidae	"
Cletus sp.	Coreidae	July-August
Creontiades pallidus	"	"
Dysdercus cingulatus (Fabricius)	Pyrrhocorridae	August
Empoasca spp.	Cicadellidae	August-September
Empoasca punjabensis (Pruthi)	"	"
Leptocentrus sp.	Membracidae	"
Lygus spp.	Miridae	July-September
Macrosteles sexnotatus (Fallen)	Cicadellidae	August-September
Myzus persicae (Sulzer)	Aphididae	"
Nezara viridula (Lin)	Pentatomidae	
Nisia nervosa	Membracidae	
	Lepidoptera	
Acherontia artopos (Lin)	Sphingidae	August
Agrotis ipsilon (Hufnagel)	Noctuidae	August-September
Agrotis segetum (Schiffer)	"	"
Athetis sp.	"	September
Dasychira mendosa (Hubner)	Lymantriidae	August
Diacrisia obliqua (Walker)	Arctiidae	August September
Exigua sp.	Noctuidae	"
Plusia sp.	"	September
Mythimna separata (Walker)	"	August-September
Spodoptera exigua (Hubner)	"	"
Agriotis sp.		
	Coleoptera	
Astycus lateralis (Fabricius)	Elateridae	August-September
Haltica sp.	Ourculionidae	July September
Strophosmides sp.	Chrysomelidae	"
Strophosmides sp.	"	"

seem to be the first record from Lahaul & Spiti region of Himachal Pradesh.

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SHORT NOTE

STUDIES ON INTERCROPPING WITH POTATO IN EASTERN UTTAR PRADESH

M.V. Singh and A.P. Singh[1]

Potato is an important *rabi* crop grown as pure as well as intercrop with *rabi* oil seed and cereal crops like, mustard, linseed and wheat. The cost of cultivation of potato is much higher (approximately Rs. 16000/ha) and as a result the net returns from the crop are not more. In this situation some intercrop, viz. mustard, linseed, etc. grown with potato 3 : 1 and 3 : 3 rows ratio produced more net returns. The present experiment was conducted to observe the feasibility of the mustard, linseed as intercrop with potato and to calculate the net returns from each intercropping systems.

The experiment was carried out at Vegetable Research Station, N.D. University of Agriculture and Technology, Kumarganj, Faizabad in *rabi* season of 1990-91 and 1991-92. The soil was silty clay loam in texture and medium in NPK and alkaline in reaction. Five treatments (Table 1) were replicated four times in randomized block design. The cultivars used were Kufri Badshah (potato), Narendra Rai (mustard) and Neelam (linseed). Sowing of all the crops was done in the first fortnight of November during both the years. Potato, mustard and linseed (pure) were fertilized with recommended dose of NPK while in intercropping with mustard and linseed, varied the fertilizers equal to pure row to that given in their pure cropping. Other agricultural operations, viz. earthing, weeding, plant protection measures were done as per needs of the crops. The economics and potato equivalent were calculated on current market price @ Rs. 100, 800, 700 and Rs. 150, 1200, 1000 per quintal potato tubers, mustard and linseed in 1990-91 and 1991-92, respectively.

Effects of cropping system on yield : The data pertaining to yield equivalent given in table 1 showed that higher potato equivalent was observed (290.0 q/ha) under potato + mustard intercropping followed by pure potato (276.0 q/ha). Minimum yield of potato yield equivalent of 138.0 q/ha was recorded under pure linseed crop. The tuber yield of potato with mustard was reduced (51.0 q/ha) i.e. 18.47% only while additional mustard yield was 8.1 q/ha (28.47%) of its pure stand. The yield of mustard in intercropping increased due to availability of more space for growth of the plants. Similar results were reported by Rathi and Verma (1) and Singh and Rathi (2).

Economics of the cropping systems : The maximum net returns were received (Rs. 23858/ha) from potato + mustard intercropping system followed by the pure mustard crop (Rs. 21500/ha). Similar results have also been reported by Singh and Verma (3).

[1] Department of Vegetable Science, N.D. University of Agriculture and Technology, Kumarganj, Faizabad-224229 (U.P.).

Table 1. Yield of potato, mustard , linseed as sole and intercrops with economics of different treatments (pooled data of 1990-91 and 1991-92)

Treatments	Potato Tuber yield (q/ha)	Mustard-linseed intercrop yield (q/ha)	Yield of sole mustard and linseed crop (q/ha)	Yield equivalent to potato (q/ha)	Cost of cultivation (Rs/ha)	Cost of produce (Rs/ha)	Net returns (Rs/ha)
Potato	276.00	-	-	276.00	15350.00	34491.50	19141.50
Mustard	-	-	28.45	228.00	7000.00	28500.00	21500.00
Potato + Mustard	225.0	8.10	-	290.46	12450.00	36308.00	23858.00
Potato + Linseed	227.00	5.510	-	265.00	12287.50	33064.00	20776.50
Linseed	-		-20.30	138.26	4500.00	17283 00	12783.00

The minimum net profit (Rs. 12783/ha) was received from pure linseed crop. Net profit from the potato + mustard was always higher than all cropping patterns. The profits from the sole potato crop (Rs. 19145/ha) was lower than pure mustard. The maximum cost of cultivation (Rs. 15350/ha) was involved with pure potato crop which was higher than pure mustard, pure linseed, potato + mustard, and potato + linseed.

It is concluded that the potato + mustard cropping system is more profitable and feasible for cultivators than other cropping systems.

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SHORT NOTE

REACTION OF POTATO VARIETIES/HYBRIDS TO TUBER-MOTH *PHTHORIMAEA OPERCULELLA*

S.B. S. Parihar[1] and V.K. Chandla[2]

Potato tuber moth, *Phthorimaea operculella* (Zeller), is the most destructive pest of potato in India (4). In the plateau region of Maharashtra its field infestation varied from 30 to 70 and 3 to 40 per cent in *kharif* and *rabi* respectively (1). The losses in the country stores range from 30 to 70 per cent in Uttar Pradesh and Bihar. The use of insecticides has shown varying degree of success in the management of tuber moth (2,3). In recent years, the use of resistant cultivars has been established as a primary method of pest control as an adjunct to other pest management components. Keeping this in consideration nineteen varieties/hybrids of potato were screened against this pest under glass house conditions at Central Potato Research Institute, Shimla during 1981 and 1982. Different varieties/hybrids under test were planted in the plastic pots (6 x 6 cm) on 26th June in 1981 and 15th June, 1982. One month after planting, a pot of each variety/hybrid was randomly kept at equidistance in a large circular plastic tray. The space between these pots was filled with soil. Five sets represented five replications. In the centre of each tray, 220 first instar larvae of the PTM were released and a musline cloth cage was kept over it. Observations on foliar damage was recorded 20 days after release of the larvae. The per cent of foliar damage was assessed by visual observation. On the basis of foliar damage, potato varieties/hybrids were classified as tolerant (< 2%), less tolerant (2-5%), moderately susceptible (5-15%), susceptible (15-25%) and highly susceptible (above 25%).

Results indicated that none of the varieties/hybrids was free from the pest attack. The reaction of different cultivars to PTM was similar during both the test years except Kufri Sheetman and ON-1645 which behaved differently. These observations indicated that three cultivars viz. Kufri Sindhuri, Kufri Dewa and Kufri Badshah were less tolerant while Kufri Shakti, G-2524, Ultimus and Kufri Jeevan were moderately susceptible with 8.2 to 14.4% foliar damages. Kufri Sheetman, Gulmarg Special, F-5242, PS-4904 and Great Scot were graded susceptible in foliage damage ranging 20.3 to 24.6% and remaining cultivars were found to be highly susceptible with damage level ranging from 29.1 to 91.2% (Table 1).

[1]Central Potato Research Station, Modipuram, Meerut - 250 110 (U.P.).
[2]Central Potato Research Institute, Shimla - 171 001 (H.P.).

Table 1. Reaction of potato varieties/hybrids against tuber moth

Reaction Category		Variety/hybrid
Tolerant	:	Nil
Less tolerant	:	Kufri Sindhuri*, Kufri Dewa, Kufri Badshah
Moderately susceptible	:	Kufri Shakti, G-2524, Ultimus, Kufri Jeevan
Susceptible	:	Kufri Sheetman, Gulmarg Special, Great Scot
Highly susceptible	:	ON-1645, Up-to-date, SLB/Z-405, Graige defiance, SLB/A-569, President, BSC/C-1753, Magnum Bonum, Kufri Kuber

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