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J. Indian Potato Assoc. 22 (3-4) : 92-94 (1995)

FERTILIZER REQUIREMENT OF RICE GROWN AFTER POTATO IN POTATO-RICE ROTATION*

V.S. Kushwah[1] and J.S. Grewal[2]

ABSTRACT : Field studies were conducted from 1984 to 1987 to study the residual effect of NPK applied to potato on the manurial requirement of rice at the Central Potato Research Station, Patna. Recommended dose of 150 kg N, 60 kg P_2O_5 and 100 kg K_2O/ha was applied to potato cv. Kufri Sindhuri and differential doses of NPK were given to rice cv. Sita. The results revealed that NPK applied to potato reduced the PK dose for rice by 50% in the first year and 100% in the second year of the rotation but there was no reduction in N dose. In the third year, significantly higher grain yield was obtained with the recommended dose of 80 kg N, 40 kg P_2O_5 and 20 kg K_2O/ha, compared to all the other treatments. It is concluded that rice grown after potato may be supplied with 80 kg N, 20 kg P_2O_5 and 10 kg K_2O/ha in the first year, only 80 kg N/ha in the second year and 80 kg N, 40 kg P_2O_5 and 20 kg K_2O/ha in the third year of potato-rice rotation.

INTRODUCTION

Direct as well as residual effect of FYM, PK and P are less pronounced on wheat, maize and rice than potato in rotations and the residual effect of these manures/ fertilizers was sufficient to meet P and K needs of cereals but not of potato(3).Fertilizers applied to potato leave some residual effect on succeeding crops (2). Upadhyay & Grewal (4) found that the effect of PK fertilizers and FYM was significant on the yield of large size tubers only and the residual effect of PK fertilizers and FYM was quite pronounced on the succeeding wheat crop in potato - wheat rotation. Potato responds well to NPK fertilizers and large increases in tuber yields have been reported with increased doses of fertilizers. Information on the fertilizer requirement of rice grown after potato, necessitated the present study which was aimed at quantifying the NPK doses for rice grown after potato with the recommended doses of NPK fertilizers in potato - rice rotation.

MATERIALS AND METHODS

A field experiment was conducted for three consecutive years (1984-85) to (1986-87) at the Central Potato Research Station,Patna (Bihar) to find out the fertilizer requirement of rice grown after potato in potato -rice rotation. The soil of experimental site was silty clay loam type, having pH 7.8, organic carbon, 0.85%, available phosphorus 17.2 kg and availble potassium 175kg/ha. The recommended dose of NPK (150 kg N, 60 kg P_2O_5 and 100 kg K_2O/ha) was applied to potato and differential

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doses of NPK (50%and 100% of the recommended dose -80kg N, 40kg P_2O_5 and 20kg K_2O/ha)were applied to rice crop each year. The experiment was laid out with seven fertilizer treatments, each having a gross plot size of 7.2 x 2.4m in randomized block design with three replicates. Well sprouted 35-40 g tubers were planted at 60 x 20 cm spacing on 17.11.84, 30.11.85 and 17.11.86 and harvested on 8.3.85, 14.3.86 and 11.3.87 in the first, second and third years of study, respectively. After the harvest of potato crop, field remained vacant and transplanting of rice cv. Sita was done at 15 x15 cm spacing each year on 16.7.85, 19.7.86 , 28.7.87 and harvesting on 11.11.85, 21.10.86 and 6.11.87 respectively. Sowing of rice nursery was done on 11.6.85, 18.6.86 and 2.7.87 in the first, second and third years of experimentation, respectively.

Half the dose of N and full dose of P and K as per treatment were applied at planting in potato and at transplanting in rice. NPK doses were applied through *suphala* (20:20:0), ammonium sulphate and muriate of potash in first year and through calcium ammonium nitrate (CAN), single super phosphate and muriate of potash in second and third year of study. Top dressing of 50% N was done through CAN in 1985-86 and 1986-87 in potato at 25 days after planting at the time of earthing up. Top dressing of 25% N through urea, in all the three years of study, in rice crop, was done each at 40 and 75 days after transplanting.

RESULTS AND DISCUSSION

Grain yield : Average grain yields of rice were 30.8, 23.8 and 38.4 q/ha in the first, second and third years of study. Lower yield in the second year (1985-86) was becuse of severe damage caused by *Gandhi* bug at the time of grain filling stage. Differential application of NPK showed that the highest yield of rice (35.8 q/ha) was obtained by applying 80 kg N, 20 kg P_2O_5 and 10 kg K_2O/ha in the first year and only 80 kg N/ha in the second year (29.3 q/ha). The above yield in first year was also found to be at par statistically with 40 kg N, 20 kg P_2O_5 and 10 kg K_2O/ha (32.4 q/ha). however, keeping in view the heavy losses due to leaching and volatilization and low recovery of N during rainy season in rice crop, former differential dose (80 kg N, 20 kg P_2O_5 and10 kg K_2O/ha) may prove better than the latter dose (40 kg N, 20 kg P_2O_5 and 10 kg K_2O/ha).

The results indicate that residual effect of NPK applied to potato reduced the PK dose of rice by 50% in the first year and 100% in the second year of potato - rice rotation. There was no reduction in N dose. However, in the third year of rotation (1986-87), the highest grain yield (52.4 q/ha) was obtained with 80 kg N, 40 kg P_2O_5 and 20 kg K_2O/ha which was significantly higher than the rest of the treatments. It indicated that in the third year of rotation, NPK applied to potato did not leave sufficient residual effect of P and K which could meet the requirement of rice partly or wholly. Hence, the dose of P and K alongwith the N @ 80 kg/ha need to be applied @ 40 kg P_2O_5 and 20 kg K_2O/ha (Table 1). Chatterjee & Mondal (1) found that the subsequent crops following potato, viz. jute, mung (green gram), rice, maize etc.

Table 1. Residual effect of NPK applied to potato on the manurial requirement of paddy in potato - rice rotation

Fertilizer (kg / ha)			Paddy grain yield (q/ha)			
N	P_2O_5	K_2O	84-85	85-86	86-87	Mean
0	0	0	28.6	18.1	28.8	25.2
40	0	0	27.3	22.1	34.5	28.0
40	20	10	32.4	22.7	37.9	31.0
40	40	20	27.8	24.2	40.4	30.8
80	0	0	30.3	29.3	37.5	32.4
80	20	10	35.8	24.0	37.0	32.3
80	40	20	33.1	26.5	52.4	37.3
Mean			30.8	23.8	38.4	
SEm ±			1.7	1.8	2.9	
CD(0.05)			5.2	5.5	8.9	

need not be fertilized with P and K except the application of recommended doses of N to the individual crops in the system. The contrary findings may be due to higher yields of potato (275 to 386 q/ha)in the present study which might have resulted in more removal of PK nutrients as compared to the study carried out by Chatterjee & Mondal (1) where potato yield levels were in the range of only 160 to 180 q/ha. In the present study, the average tuber yield in 1984-85, 85-86 and 86-87 obtained was 386, 275 and 275 q/ha, respectively. Higher tuber yield in first year may be owing to better soil conditions at the time of planting compared to second and third year of experimentation. Tuber yields with all the fertilizer treatments in all the three years were at par statistically.

Thus, from the present study it may be concluded that in potato-rice rotation, potato cv. Kufri Sindhuri planted at 60 x 20 cm may be supplied each year with 150 kg N,60 kg P_2O_5 and 100 kg K_2O/ha. The succeeding rice crop may be fertilized with 80 kg N, 20 kg P_2O_5 and 10 kg K_2O in the first year, only 80 kg N in the second year and 80 kg N, 40 kg P_2O_5 and 20 kg K_2O/ha in the third year of potato - rice rotation.

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EFFECT OF FERTILIZER N RATE AND NITRIFICATION INHIBITOR ON THE NUTRIENT UPTAKE OF POTATO -1. *MICRONUTRIENTS*

P. Stalin* and J. Enzmann[1]

ABSTRACT : Field experiments comprising four levels of N(0,80, 160 and 240 kg/ha), alone and in combination with a nitrification inhibitor CMP, revealed that the uptake of B, Zn, Mn and Fe by potato plant increased with the advancement of crop growth. The N application had a positive effect on the micronutrient uptake during the growth period. In the presence of CMP, the B and Zn uptake were increased, on the other hand, the Mn and Fe uptake were decreased. A crop of 100 q fresh tubers inclusive of its haulms on an average removed 37 g B, 88 g Zn, 134 g Mn and 749 g Fe/ha.

INTRODUCTION

One of the ways to increase the fertilizer N use efficiency is the use of nitrification inhibitor which can induce a dominated ammonium nutrition in plants and thereby minimize losses of N through leaching, volatilization and denitrification. It is not yet clear whether the dominated ammonium nutrition is beneficial to all plant species. The past studies with maize (6), winter wheat (4) and potato (8) showed a change in the uptake pattern of nutrients particularly micronutrients through application of ammonium sulphate when compared with CAN. Since those studies were made without use of nitrification inhibitor, the effect observed may be due to SO_4^{2} action. There is paucity of information on the response of N nutrition under field conditions on the uptake of micronutrients at different growth stages. Moreover, the recent developments in agriculture compel the farmers to concentrate on the problem of optimal supply of micronutrients to the high yielders. Therefore the present study was undertaken to find out the effect on N fertilization and nitrification inhibitor, CMP (1- Carbamoyl - 3(5) - methyl pyrazole) on the uptake pattern of micronutrients during the growth period of potato crop.

MATERIALS AND METHODS

Field experiments were conducted during 1982 and 1983 on sandy loam leached soil at the Probstheida Experimental Station of the Institute of Tropical Agriculture, University of Leipzig, Germany. Some chemical properties of the experimantal soil are given in table 1.

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Table 1. Chemical properties of the experimental soil (0-20 cm depth)

Properties	1982	1983
pH (N/10 KG 1)	6.15	5.61
Humus (%)	2.04	-
CEC (m.e/100g soil)	8.50	7.85
Total - N (mg N/100 g soil)	84.01	105.47
P (mg P/100 g soil)	21.80	12.70
K (mg K/100 g soil)	20.50	14.63
$Ca^{++)}$ (m. e/100 g soil)	6.02	5.88
$Mg^{++)}$ (m. e./100 g soil)	0.51	0.45
B (ppm)	1.52	1.01
Cu (ppm)	*8.00*	5.25
Zn (ppm)	7.12	5.02
Mn (ppm)	32.00	45.00
Fe (ppm)	65.00	51.00

+) exchangeable.

The treatments were arranged in a factorial experiment design and replicated four times. There were eight treatments comprising four levels of N viz., 0, 80, 160, and 240 kg/ha as urea alone, and in combination with nitrification inhibitor 'CMP' (4 kg/ha substance). CMP dissoloved in water directly sprayed and worked immediately 10 cm depth into the soil prior to urea application. All plots reveived a basal dose of 47.2 kg P/ha as superphosphate and 200 kg/ha as muriate of potash. Seeds of potato cv. Adretta, a medium duration variety commonly grown in the former GDR, was planted in plots measuring 6m x 4.8 m.

During the crop period, plant samples (foliage and tubers) were taken at four different growth stages (tuber initiation, flowering, tuber bulking phase and physiological maturity). The samples collected at different periods were estimated for dry matter weight (foliage and tubers) and the contents of micronutrients. B content was estimated following the method of Brown (2), while Zn, Mn and Fe were determined with atomic absorption spectrophotometer. The uptake of various micro nutrients was calculated by multiplying the concentration of micronutrients in haulms and tubers with dry matter yield at different stages of growth.

RESULTS AND DISCUSSION

The pooled data pertaining to the uptake of micronutrients (B, Zn, Mn and Fe) during the growth period are presented in tables 2-5.

Boron : The results in table 2 reveal that B uptake by the tops increased steadily and reached its maximum at tuber bulking phase, while the B uptake by tubers continued to increase till physiological maturity.

Table 2. B uptake (g/ha) during the growth period at different N levels

N levels/ (Kg/ha)	B uptake (g/ha)						
	Tops				Tubers		
Days*	21	35	65	100	35	65	100
Without CMP							
0	17	47	70	44	9	24	41
80	24	43	76	73	11	25	43
160	27	47	102	99	11	26	50
240	23	51	109	55	12	27	55
Mean	23	47	89	68	11	26	47
With CMP							
0	14	49	74	46	10	28	44
80	28	47	79	57	13	30	45
160	27	76	137	87	13	35	50
240	27	67	137	78	10	35	53
Mean	24	60	107	67	12	32	48
CD (0.05)				11.07			N.S.
N levels				N.S.			N.S.
CMP				N.S			N.S.
N x CMP							

* after emergence

The results revealed further that the amount of boron already taken up by the flowering period (on 35th day) accounted for 50 - 62% of the total B requirement of potato at physiological maturity. From that, nearly 10% B was transported to the tubers at the same period (flowering). According to Bergmann and Neubert (1) the potato plant has a high demand for boron in the period of intensive foliage growth and flowering.

It can be seen that the different N levels tried promoted the B uptake during the growth period (Table 2). The positive effect of the B uptake was more pronounced in tops than that in tubers. These values are in consonance with Katalymow (5). In the presence of CMP, the B uptake by the tops and tubers during the growth period was considerably higher than in its absence. At the time of highest B uptake (65th day) the differences were distinct. It is of interest to note that the actual value of uptake at physiological maturity for a crop of 100 q fresh tubers inclusive of its haulms, was 37 g of boron/ha from the soil.

Zinc : The Zn uptake by the tops and tubers continued to increase steadily till physiological maturity (Table 3). The quantity of zinc already taken up by the crop until the flowering period amounted to nearly 49-53% of the total Zn requirement of potato at physiological maturity. From that, 16% Zn was transported to the tubers

Table 3. Zn uptake (g/ha) during the growth period at different N levels

N levels/ (Kg/ha)	*Zn uptake (g/ha)*						
	Tops				*Tubers*		
Days*	21	35	65	100	35	65	100
Without CMP							
0	50	72	84	81	40	86	128
80	88	83	138	99	45	99	128
160	65	90	109	160	40	95	144
240	53	98	116	152	40	101	145
Mean	64	86	112	123	41	95	136
With CMP							
0	76	92	100	93	49	106	155
80	107	101	122	134	48	104	120
160	95	131	126	180	50	111	136
240	53	100	126	193	42	116	138
Mean	83	106	119	150	47	109	137
CD (0.05)							
N Levels				30.5			N.S.
CMP				15.1			N.S.
N xCMP				21.3			N.S.

* after emergence

at the same period (flowering). Furthermore, the accumulation of Zn in tubers makes out 51% of the total Zn uptake at maturity. The different levels of N tried led to a general increase in Zn uptake by the tops and tubers during the growth period. The use of nitrification inhibitor, CMP increased the Zn uptake by the whole plant during the growth period. At the time of physiological maturity, the increase in Zn uptake by the whole plant accounted for averagely 11% due to use of CMP. On an average, 88 g of zinc/ha was removed from the soil by a crop of 100 q tubers inclusive of its haulms.

Manganese : The Mn uptake by tops and tubers increased with the advancement of crop growth (Table 4). In the flowering period, on an average, 47-61% of the total requirement of Mn at the physiological maturity was met by the crop. From that, only 4% was transported to the tubers during the same period (flowering). Fritz (3) reported high demand for manganese at the time of flowering in potato crop. The different N levels increased Mn uptake by the tops and tubers during the growth period. The increase in the total Mn uptake at physiological maturity was found to be between 76 and 80% at 240 kg N/ha with and without CMP, respectively over control. An increase in Mn uptake by N application in crops other other than potato has been reported (4, 6, 7). The use of CMP led to reduction in Mn uptake by the tops and tubers during the growth period particularly at the highest N levels, 240 kg/ha tried. The reason for the general reduction of Mn uptake may be the antagonistic relationship of nutrient ions. The data show that a crop of 100 q tubers inclusive of

Table 4. Mn uptake (g/ha) during the growth period at different N levels

N levels/ (Kg/ha)	*Mn uptake (g/ha)*						
	Tops				Tubers		
Days*	21	35	65	100	35	65	100
Without CMP							
0	33	136	216	169	13	45	68
80	49	167	319	344	15	53	83
160	49	188	226	567	16	55	84
240	58	259	351	335	19	49	92
Mean	47	188	278	354	16	51	82
With CMP							
0	30	148	239	194	14	43	68
80	42	255	175	213	14	63	68
160	33	279	425	440	19	68	110
240	32	201	279	378	12	54	83
Mean	34	221	280	306	15	57	82
CD(0.05)							
N Levels				34.2		N.S	
CMP				17.5		N.S	
N.CMP				24.3		N.S	

*after emergence.

Table 5. Fe uptake (g/ha) during the growth period at different N levels

N levels s/(Kg/ha)	*Fe uptake (g/ha)*						
	Tops				Tubers		
Days*	21	35	65	100	35	65	100
Without CMP							
o	473	794	1250	1235	128	453	458
80	631	833	1311	2199	159	449	638
160	583	1536	1407	2818	176	529	659
240	511	1985	1330	1272	193	560	710
Mean	550	1287	1330	1872	164	498	616
With CMP							
0	350	850	1109	1254	135	467	534
80	633	1336	1021	1474	150	460	580
160	525	1534	1710	1930	212	572	670
240	402	1095	1420	1215	180	522	659
Mean	478	1204	1315	1468	169	505	
CD (0.05)							
N Levels				53.2			28.5
CMP				26.5			N.S.
N x CMP				38.3			N.S.

* after emergence

its haulms removed on an average 134 g of manganese/ha from the soil which can give a guideline for deriving the Mn requirement of potato crop.

Iron : Like Mn uptake, the Fe uptake by the tops and tubers showed a steady increase during the growth periods (Table 5). The total uptake increased till physiological maturity. The high demand at the maturity period was also observed in the previous study with potato (8). The results reveal further that the amount of Fe already taken up by the crop accounted for 58-66% of the total Fe requirement of the crop. From that, nearly 7-8% Fe was transported to the tubers at flowering. The different N levels promoted the Fe uptake by the tops and tubers during the growth period. Similar results were also obtained in winter wheat (4). The data relating to the Fe uptake by the tubers show that the application of 240 kg N/ha with and without inhibitor recorded an increase in Fe uptake of 23-55% at physiological maturity when compared to the control. The use of CMP caused a decrease in Fe uptake during the growth period. From the present study, it is noteworthy that the Fe removal by 100 q tubers/ha inclusive of its foliage amounted to 749 g/ha.

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NITROGEN NEEDS OF POTATO WHEN PLANTED ON DIFFERENT DATES

M.V. SINGH[1]

ABSTRACT : Two years' data showed significant improvement towards tuber yield due to different dates of planting, nitrogen levels and their interaction. November 1st planting proved to be beneficial than later dates and highest tuber yield (500 q/ha) was recorded in case of 200 kg N/ha and 1st November planting with maximum net return as well.

INTRODUCTION

The time of planting determines the length of the growing period of a potato crop which influences the yield and tuber size of the produce. Planting time also influences the yield in ware crop of potatoes (2, 3, 4). The increase in yield with applied nitrogen has earlier been reported by Ghose and Gupta (1). The present expriment was therefore conducted to study the response of nitrogen for different dates of planting of potato.

MATERIALS AND METHODS

Field experiments were conducted in completely randomized block design at Narendra Dev Agricultural University Vegetable Farm, during 1991-92 and 1992-93. The combinations of four dates of planting (1st, 10th, 20th and 30th November) and four levels of nitrogen (80, 120, 160, 200 kg/ha) were randomy allocated. The soil of the experimental plot was sandy loam in texture and alkaline in reaction (pH 7.8). It was poor in organic carbon (0.25, 0.30%) available phosphorus (14.5 and 16.5 kg/ha) and available postassium (100 and 120 kg/ha) in 1991-92 and 1992-93 respectively. Phosphorus and potash were applied @ 80 kg and 100 kg/ha respectively through single superphosphate, and muriate of postash. Medium sized tubers (50 g) of Kufri Badshah were planted at 60 × 20 cm spacing in plots measuring 3.6 m × 3.0 m. All the cultural operations were done as and when required. The growth characters, viz. germination, plant height, number of leaves/plant and number of stems were recorded at 30, and 60 days after planting. The crop was harvested at 90 days of planting for each date of planting in both the years.

RESULTS AND DISCUSSION

Vegetative growth : The results pertaining to vegetative characters (Table revealed that the plant height, number of stems/m^2 and number of leaves/pla

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Table 1. Effect of nitrogen levels x dates of planting on vegetative growth of the potato crop

Treatments	Gemination % at 30 days of planting		Plant height in cm at 60th day of crop		Number of leaves/plant 60th day of crop		Number of stems/m2 at 60th day of crop	
	1992-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
T_1 1st Nov-80 kg N	99.0	97.0	30.6	30.7	54.0	52.25	30.3	29.6
T_2 1st Nov-120 kg N	98.0	97.0	42.6	42.0	61.0	59.75	34.6	34.2
T_3 1st Nov-160 kg N	96.0	96.0	51.3	51.4	64.66	62.75	38.5	38.1
T_4 1st Nov-200 kg N	97.0	97.0	52.4	52.8	70.33	69.0	40.7	40.1
T_5 10th Nov-80 kg N	96.0	96.0	28.3	28.3	53.0	51.25	28.9	29.2
T_6 10th Nov-120 kg N	97.0	97.0	40.5	40.8	58.33	57.5	33.4	33.4
T_7 10th Nov-160 kg N	98.0	95.0	48.7	48.5	63.66	61.5	37.3	37.5
T_8 10th Nov-200 kg N	97.0	96.0	50.5	50.4	68.0	66.25	38.3	38.7
T_9 20th Nov-80 kg N	*99.0*	*96.0*	*27.7*	*27.5*	*47.0*	*46.5*	28.3	28.1
T_{10} 20th Nov-120 kg N	97.0	96.0	40.1	39.2	55.0	54.0	32.8	32.5
T_{11} 20th Nov-160 kg N	99.0	97.0	47.4	47.4	62.33	58.75	36.06	36.5
T_{12} 20th Nov-200 kg N	100.0	96.0	48.5	48.5	66.0	66.75	36.9	37.1
T_{13} 30th Nov-80 kg N	96.0	95.0	27.3	27.4	43.66	42.75	26.7	26.4
T_{14} 30th Nov-120 kg N	95.0	96.0	38.2	38.3	50.33	48.5	30.7	31.3
T_{15} 30th Nov-160 kg N	97.0	96.0	46.6	46.1	56.33	56.0	33.3	32.2
T_{16} 30th Nov-200 kg N	99.0	97.0	47.5	47.4	62.66	61.25	34.3	38.8
SE± m for D×N	1.26	0.851	0.493	0.21	0.72	0.61	0.450	0.26
C.D. at 5 % for D×N	N.S.	N.S.	1.42	0.60	2.08	1.74	1.30	0.74

Table 2. Effect of N × dates of planting on tuber yield

Treatments	Yield q/ha		A grade tubers q/ha		B grade tubers q/ha		C grade tubers q/ha	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
T_1 1st Nov-80 kg N	289.0	282.0	80.0	76.0	180.0	181.0	29.0	25.0
T_2 1st Nov-120 kg N	333.0	325.0	100.0	95.0	207.0	210.0	27.0	20.0
T_3 1st Nov-160kg N	478.0	442.0	120.0	125.0	320.0	296.0	38.0	21.0
T_4 1st Nov-200kg N	500.0	500.0	135.0	140.0	341.0	336.0	22.0	24.0
T_5 10th Nov-80 kg N	267.0	262.0	70.0	70.0	170.0	165.0	27.0	26.0
T_6 10th Nov-120 kg N	322.0	315.0	90.0	95.0	192.0	190.0	41.0	30.0
T_7 10th Nov-160 kg N	444.0	431.0	110.0	130.0	304.0	295.0	30.0	30.0
T_8 10th Nov-200 kg N	466.0	458.0	120.0	125.0	318.0	310.0	28.0	23.0
T_9 20th Nov-80 kg N	244.0	231.0	63.0	75.0	146.0	129.0	35.0	28.0
T_{10} 20th Nov-120 kg N	311.0	306.0	72.0	88.0	218.0	183.0	21.0	36.0
T_{11} 20th Nov-160 kg N	411.0	403.0	95.0	95.0	283.0	280.0	33.0	28.0
T_{12} 20th Nov-200 kg N	433.0	425.0	112.0	111.0	301.0	295.0	21.0	19.0
T_{13} 30th Nov-80 kg N	222.0	215.0	58.0	63.0	132.0	119.0	32.0	34.0
T_{14} 30th Nov-120 kg N	256.0	247.0	67.0	69.0	160.0	145.0	28.0	32.0
T_{15} 30th Nov-160 kg N	356.0	347.0	86.0	81.0	238.0	244.0	32.0	22.0
T_{16} 30th Nov-200 kg N	378.0	372.0	100.0	106.0	250.0	250.0	28.0	27.0
S. E. ± m for dates × Nitrogen	4.31	2.60	2.52	2.17	3.26	2.5	5.45	3.70
C. D. at 5 % for dates × Nitrogen	12.45	7.35	7.26	6.16	9.43	7.06	15.74	10.48

varied significantly under the influence of treatments. The maximum height of plant, number of leaves and stems/plant were recorded in crop planted on 1st Nov. and applied with 200 kg N ha which was significantly more than the rest of the treatments in both the years.

Tuber yield : The yield of potato was significatly higher in first November planting than subsequent dates of plantings in both the years of investigation. The application of nitrogen increased the yield signicantly with increasing doses upto 200 kg N/ha in both the years, which may be attributed to significant increase in tuber germination, increase in plant height, number of leaves/plant and number of stem/m^2.

Gradewise yield : As regards the production of different grades of tubers, the first November planting was found most effective over other dates. Similarly the highest dose of 200 kg N/ha effectively increased the A and B grade tubers in both the years. There was least production of C grade tubers with the maximum dose of N (200 kg) in both the years. The dates of plantings and nitrogen levels interacted significantly in different grades of tubers. The first November plantings in presence of 200 kg N/ha brought about the maximum production of A and B grade tubers.

Economics of treatments : It is clear from the results that the highest returns over 80 kg N/ha was recorded with 200 kg nitrogen /ha on first November planted crop followed by 10th November planted crop with the same nitrogen level (i.e. 200 kg N/ha). The application of 200 kg N/ha showed the maximum benefit in different dates of planting from 1st to 20th November while in 30th November planting, the trend was reversed, maximum benefit being derived from the application of 200 kg N/ha.

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KEEPING QUALITY IN ADVANCED POTATO SELECTIONS DURING NON-REFRIGERATED STORAGE

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ABSTRACT : Storability of advanced potato selections, viz. MS/79-10, MS/78-46, JI-5857, JI-1857, PJ-376, QB/A9-120, JN-1758 and cv. Kufri Chandramukhi (control) was studied from March to June in evaporatively (passive) cooled potato store-ECPS. The intensity of sprouts (g/kg tuber) was lowest in MS/79-10 and MS/78-46 in ECPS as well as at room temperature. Loss in weight of tubers was also low in these two selections both at 60 and 90 days of storage. Keeping quality in general was better in ECPS than at room temperature.

INTRODUCTION

Cold storage facilities in India are not adequate to store the required quantity of potatoes (1). Huge quantity of potatoes are stored in country stores especially during March- June (3). These months in North Indian plains are characterised by high ambient temperatures and low relative humidity which are highly unfavourable for potato storage (2). Good storability of potato genotype is indispensable for its wider acceptability and greater utilization. The present paper outlines the storage behaviour of advanced potato selections in comparison with a well known good-keeper cv. Kufri Chandramukhi in two non-refrigerated storage regimes, viz. ordinary room and evaporatively (passive) cooled potato store (ECPS).

MATERIALS AND METHODS

Storage studies with different advanced selections of potato *(Solanum tuberosum L.)* were carried out at Central Potato Research Station, Modipuram, Meerut during 1991 and 1992. Healthy, cured and clean tubers of uniform size (40-50 g) were selected for cv. Kufri Chandramukhi (Control) and advanced potato selection, viz. MS/79-10, MS/78-46, JI-5857, JI-1857, QBA/9-120, PJ-376 and JN-1758. Selected tubers were stored from mid-March to mid-June in four replications of 100 tubers each in hessian bags in ordinary room (21.0-35.9°C, RH 55-88%) and in ECPS (17.2-30.9° C, RH 72-91%). ECPS is a simple potato store developed by CPRI, Shimla in which microclimate is kept cool on the basis of passive evaporation of water (2).

Ten randomly selected and marked tubers in each bag were weighed at 15 days interval for measuring the loss in weight of tuber. The percentage of sprouting (as

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number of sprouted tubers), rottage and sprouting intensity (weight of sprouts per unit weight of tuber) were recorded fortnightly throughout the storage period. The temperature and relative humidity were recorded daily at 8.0 a.m. and 2.0 p.m. in ECPS, at room temperature and ambient. Results obtained during two years under investigation were pooled and are reported here.

RESULTS AND DISCUSSION

Storage behaviour: Weekly average of temperature and RH at ambient, room temperature and inside ECPS are presented in table 1.

Table 1. Temperature and relative humidity (weekly average) at ambient, room temperature and in ECPS during storage (mean of 1991 and 1992)

Time		Ambient (A)	Room (R)		ECPS (E)		
		A	R	± Over A	E	± Over A	±Over R
				1. TEMPERATURE (°C)			
8.0 a.m.	Max.	28.1	32.7	+4.6	28.4	+0.3	-4.3
	Min.	17.7	21.0	+3.8	17.2	-0.5	-3.8
2.0 p.m.	Max.	40.5	35.9	+4.6	30.9	-9.6	-5.0
	Min.	25.8	24.6	-1.2	23.3	-3.5	-2.3
				2. RELATIVE HUMIDITY (%)			
8.0 a.m.	Max.	77	88	+11	90	+13	+2
	Min.	42	69	+27	76	+34	+7
2.0 p.m.	Max.	48	80	+32	91	+43	+11
	Min.	25	55	+30	72	+47	+17

ECPS vs ordinary room : Sprouting (percentage and intensity) in all the selections and control was invariably higher in ECPS than in the room both at 60 and 90 days after storage (DAS) (Table 2). Higher RH and moderate temperature, observed mostly in ECPS, have been reported to encourage sprouting in potatoes (4). The rotting and loss in weight of tubers in all the stored material remained markedly lower in ECPS after 60 and 90 DAS. Magnitude of weight loss in ECPS have earlier been reported to be only about half of that in potatoes stored in ordinary room (5).

Control vs selections : Three selections namely MS/79-10, MS/78-46 and JI-5857 showed moderate weight loss (5.9-8.1%) at 60 DAS in ECPS, which was comparable to control (6%) and significantly lower than the other selections (Table 2). These three selections also performed better at 90 DAS in ECPS, particularly MS/79-10, and MS/78-46 which showed minimum weight loss (11.5 and 11.6% respectively) as against control (12. 3%) and other selections (15.5 and 20.1%) (Table 2). Although rottage of tubers in MS/79-10 and MS/78-46 was marginally higher than control yet the significantly lower intensity of sprouts helped minimize the weight loss in these two selections both at 60 and 90 DAS in ECPS. The superiority

Table 2. Performance of advanced potato selections after 60 and 90 days of non-refrigerated storage

Cultivar/Selection	ECPS*				ROOM			
	Srouting		Rotting	Weight	Sprouting		Rotting	Wt. Loss
	(%)	Intensity (g/kg tuber wt.)	(%)	Loss (%)	(%)	Intensity (g/kg tuber wt.)	(%)	(%)
(A)			(a) At 60 days after storage					
Kufri Chandramukhi	93	3.0	0.1	6.2	31	1.7	4.2	13.6
MS/79-10	82	2.7	0.4	8.1	38	0.9	1.2	8.4
MS/78-46	99	2.6	0.6	5.9	37	1.5	2.1	9.8
JI/5857	98	6.8	0.1	8.0	46	2.2	0.9	16.7
JI/1857	98	5.6	0.2	9.6	50	2.7	2.1	15.1
QBA/9-120	98	7.3	0.7	9.3	54	2.8	0.8	13.5
PJ-376	95	3.8	0.3	10.6	46	1.8	2.0	13.2
JN-1758	99	3.7	0.7	13.1	51	1.3	0.8	18.2
C.D. at 5%	6.4	0.2	0.1	1.6	9.2	0.2	0.1	1.5
(B)			(b) At 90 days after storage					
Kufri Chandramukhi	100	7.7	0.3	12.3	61	2.4	4.7	18.7
MS/79-10	100	6.8	1.6	11.5	100	2.6	3.3	16.1
MS/78-46	100	6.0	3.1	11.6	72	2.2	3.1	16.2
JI-5857	100	12.7	1.3	15.2	94	4.2	3.9	20.8
JI-1857	100	13.2	3.0	15.5	100	4.6	3.9	24.2
QBA/9-120	100	12.9	3.1	17.2	100	4.3	2.9	19.9
PJ-376	100	7.8	1.0	20.1	87	3.1	2.9	22.3
JN-1758	100	7.8	2.1	19.5	100	3.6	2.2	23.5
C.D. at 5%	N.S	0.34	0.3	1.9	10	0.12	1.3	1.2

* ECPS - Evaporatively (Passive) cooled potato store.

in keeping quality parameters in selections MS/79-10 and MS/78-46 in ECPS was also maintained in room temperature storage. Sprouting and rottage of tubers were markedly lower than control which resulted in the minimum weight loss (8.4-9%) in the two selections as against control (13.6%) at 60 DAS and (16.1-16.2%) against control (18.7%) at 90 DAS at room temperature. In general, all the selections showed higher sprouting and lesser rottage than the control at room temperature.

These results indicate that among all the selections tested, the keeping quality of selection MS/79-10 and MS/78-46 was superior in both the non-refrigerated storage conditions, Storage performance of these two selections was significantly better than the control cultivar Kufri Chandramukhi at room temperature.

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TUBER PRODUCTION IN RELATION TO WEATHER PARAMETERS AND AGROMETEOROLOGICAL INDICES PREVAILING DURING DIFFERENT PHENOLOGICAL STAGES OF POTATO CROP*

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ABSTRACT : Significant negative correlation of tuber yield with maximum, minimum and mean air temperatures in the stage R_1 (vegetative and tuber initiation phase) and with mean soil temperatures in the stages R_1 and $R_1 + R_2$ (vegetative phase and tuber development phase) indicated the favourable effect of low soil and air temperatures during these stages in contributing towards the higher tuber yield. A high positive correlation between accumulated absorbed photosynthetically active radiation (accu. APAR) in the stages R_1, $R_1 + R_2$ and R_3 (tuber bulking stage) + R_4 (physiological maturity stage) and tuber yield at physiological maturity was noticed. The fact that tuber yield was positively correlated with thermal regimes i.e. accumulated growing degree days (accu. GDD), accumulated heliothermal unit (accu. HTU) and accumulated soil temperature (accu. ST) indicated the indirect positive contribution of these agrometeorological indices to the tuber yield. The path coefficient analysis revealed three important parameters, viz. min. T in the stage R_1, accu. APAR in the stage (R_1+R_2) and accu. GDD in the stage R_3 which could be used efficiently in predicting the tuber yield.

INTRODUCTION

Despite the fact that it is very difficult to separate direct effects of environmental factors from those that are interrelated, much research on potato growth environment relationships has been directed towards specific phases of development or a single environmental variable. Potato is a weather sensitive crop and for the yield improvement in this crop, it is imperative to know the relative contribution of different weather parameters/agrometeorological indices. The interdependence and interrelationship of different weather parameters/agrometeorological indices which could contribute to the potato production are very important. The studies with respect to correlation and path analysis of potato tuber yield with weather parameters and agrometeorological indices are limited and so to say, virtually not available in literature. To understand this, the correlation and path-coefficient of different weather parameters/agrometeorological indices with potato tuber yield were worked out.

MATERIALS AND METHODS

The investigation on potato crop (cv. Kufri Badshah) was undertaken 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,

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Anand (Lat. 22 ° 35', Longi. 72 ° 55' and 45.1 meters A.M.S.L.). Investigations comprised field experimentation laid out in split plot design replicated six times with three dates of planting (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 and with four irrigations with the levels (as sub-plot treatments) viz. irrigation when the available soil moisture (ASM) reached a value of 75% of the total ASM (I_1), irrigation when the 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). Canopy-air temperature differential were measured with the help of infrared thermometer (AG-42) daily at 1430 hours. The plot size was 2.7 × 3.4 m with a spacing of 45 cm inter-row and 20 cm intra-row. The seed size was approximately 25 to 35 g per tuber. A total dose of 220: 110: 220 N:P: K kg ha^{-1} was applied in the form of urea, diammonium phosphate and muriate of potash. The entire quantity of phosphorus and potash and half the quantity of nitrogen were applied as basal dose at the time of planting. The remaining quantity of nitrogen was given as top dressing during the earthing up operation. Tuber yield was examined in relation to weather parameters as recorded at the agrometeorological observatorry on a regular routine basis and agrometeorological indices were derived from the weather parameters. Soil temperatures at 15 cm depth were visually observed and recorded on daily basis at 0830, 1430 and 1730 hours of treatments D_1 I_1, D_2 I_2 and D_3 I_3. The daily value of evaporation was taken from open pan evaporimeter. The base temperature employed in the computation of growing degree days (GDD) was 4.4°C. The same value of the base temperature i.e. 4.4°C was used by Benoit and Grant (3). The important bio-metric observations were recorded as per the chronology of the crop phenology. Their specific characteristics and durations are described herewith (1).

R_1 - From emergence to 50% of plants having at least one tuber > 1 cm diameter (vegetative phase and tuber initiation)

R_2 - 20 days after R_1 (vegetative phase and tuber development)

R_3 - 20 days after R_2 (tuber bulking stage)

R_4 - Green canopy reaches 20% of the maximum achieved (physiological maturity)

(R_1+ R_2) = From vegetative phase and tuber initiation to the end of tuber bulking

(R_2+R_3) = From vegetative phase and tuber initiation to the end of tuber bulking

(R_3+R_4) = From vegetative phase and tuber development to physiological maturity.

The performance of the tuber yield in relation to weather parameter and agrometeorological indices in the respective phenological phases viz. mean hours of bright sunshine (BSS), mean maximum air temperature (Max. T.), mean minimum air temperature (Min.T), mean of mean air temperature (Mean.T), mean of temperature range (TR), mean of morning vapour pressure (MeanVP_1), mean of afternoon vapour pressure (MeanVP_2), mean of mean vapour pressure (Mean VP), accumulated evaporation (accu.EP), accu. absorbed photosythetically active radiation (accu. APAR), accumulated growing degree days (accu. GDD), accumulated soil temperature (accu.ST), accumulated heliothermal units (accu.HTU i.e., GDD×BSS) and accumulated thermal interception rate (accu.TIR i.e., dry matter/GDD×SR) was assessed one by one in terms of the stage-wise correlations of the tuber yield with weather parameters and agrometeorological indices. The photosynthetically active radiation was measured periodically with the help of Licor Datalogger (Model LI-1000) and line quantum sensor (Model LI-191 SA).

RESULTS AND DISCUSSION

The correlation coefficients between tuber yield and weather parameters/ agrometeorological indices are shown in table 1. It was observed that the correlations between tuber yield and mean maximum air temperature, mean minimum air temperature and mean of air temperature were significantly negative in the stage R_1 but high positive correlation with mean temperture were found in the stage R_3 of the crop. This indicated that low temperatures during vegetative and tuber initiation stage (R_1) were beneficial to the crop. Likewise, higher temperatures were also required in the tuber bulking stage of the crop (R_3).

Negative significant correlation was found between the tuber yield and mean soil temperature in stages R_2 and (R_1+R_2) indicating that low soil temperatures were better for vegetative stage to tuber development of the crop (R_1+R_2). The same type of influence of high soil and air temperatures on tuber initiation and number of tubers per plant have been reported by Borah and Milthorpe (4), Epstein (5), Marinus (10) and Gawronska *et al.* (6). These temperatures directly affect photosynthetic rate which may also be mediated through its negative effect on tuberization. Other expermental data (8, 11, 12) also indicated that temperatures in the range of 16°-25°C were better for good vegetative growth and tuber initiation under non-limiting conditions of irradiance and net photosynthesis rates. However, the positive correlation of tuber yield with maximum and mean air temperatures in the stage R_3 of the crop indicated that higher temperatures prevailing during this stage favoured tuber yield. In the present study, the lower yield was produced in an early planting date which coincided with low temperatures (< 20°C) during the bulking stage (R_3) and *vice versa*, i.e. higher yields were produced in late planting where temperatures were higher during tuber bulking stage as compared with those during the same stage in case of early planting.

Amongst the agrometeorological indices, the accu. APAR exhibited significant positive correlation with tuber yield in the stages R_1 and (R_1 + R_2) and high positive correlation in the stage (R_3 + R_4) (i. e. throughout the growing period of the crop). A high positive relationship between IPAR (Intercepted photosynthetically active radiation) and both total and tuber dry matter has been shown by Allen and Scott

Table 1. Correlation coefficients between tuber yield and weather parameters/agrometeorological indices prevailed during different phenological stages of potato crop

Weather Parameters/ agrometeorological indices	Phenological stages						
	R_1	R_2	R_3	R_4	(R_1+R_2)	(R_2+R_3)	(R_3+R_4)
BSS	0.119	-0.055	-0.357	0.744	-0.053	-0.303	0.431
Max.T	-0.838*	-0.391	0.931**	-0.007	-0.726	0.518	0.665
Min.T	-0.818*	-0.607	0.685	-0.633	-0.732	-0.009	0.587
Mean T	-0.863*	-0.588	0.861*	-0.310	-0.734	0.025	0.731
Mean ST	-0.792	-0.847*	0.006	-0.523	-0.824*	-0.789	-0.709
TR	-0.539	0.379	0.213	0.442	0.099	0.543	0.521
VP1	-0.663	-0.558	0.429	-0.597	-0.678	-0.105	-0.391
VP2	-0.242	-0.515	0.192	-0.546	-0.450	-0.254	-0.126
Mean VP	-0.440	-0.542	0.302	-0.559	-0.553	-0.200	-0.214
Accu. EP	0.765	0.245	0.348	0.281	0.836*	0.397	0.642
Accu.APAR	0.821*	0.441	0.612	0.520	0.844*	0.607	0.946**
Accu. GDD	0.900*	-0.210	0.861*	-0.464	0.809	0.561	-0.068
Accu. ST	0.891*	-0.847*	0.00	0.441	0.821*	-0.826*	-0.462
Accu.HTU	0.891*	-0.182	0.091	-0.257	0.832*	-0.048	0.101
Accu. TIR	0.624	-0.048	0.394	-0.659	0.399	0.202	0.158

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

R_1 =From emergence to 50 % of plants having at least one tuber > 1 cm in diameter (vegetative phase and tuber initiation)
R_2 =20 days after R_1 (vegetative phase and tuber development)
R_3 =20 days after R_2 (tuber bulking stage)
R_4 =Green canopy reaches 20% of the maximum achieved (physiological maturity)
(R_1+R_2) =From emergence to the of vegetative phase and tuber development
(R_2+R_3) =From vegetative phase and tuber initiation to the end of tuber bulking
(R_3+R_4) =From vegetative phase and tuber development to physiological maturity.

(2). Likewise, the crop growth rate and tuber yield have been reported by Khurana and McLaren (7) and also by Manzel (9) to be linearly related to PAR intercepted by the crop over the whole season. In the present study, the APAR in the early vegetative phase to tuber initiation (R_1) as also in early vegetative phase to tuber development (R_1 + R_2) were found to have positive correlation with tuber yield. It was because, tuber initiation and growth during these stages i.e. R_1 and (R_1 + R_2) were stimulated by high level of radiation. In growth chambers, tuber initiation has been reported to start earlier at high irradiance (4). The accumulated APAR during bulking stage upto maturity (R_3 + R_4), showed highly significant positive correlation with tuber yield, the significant positive correlation exhibited by accu. EP in stage (R_1 + R_2) with tuber yield was well explainable on the basis of the fact that higher evaporation rates during tuber initiation and tuber development stage of the crop played an indirect role by lowering the temperature in this stage. This was also reflected in negative assoiciation of stress degree days with tuber yield. The accumulated GDD, HTU and ST are representative of the thermal regimes of air and soil that prevailed during the period for which they are considered. The fact that tuber yield was positively correlated with these agrometeorological indices in the stages R_1 and (R_1 + R_2) were in contrast with the negative correlation of tuber yield with the maximum, minimum and mean temperatures that prevailed during the same stages. In contrast to the negative correlation with temperature means of different stages, the accumulated thermal/ heat indices were related positively with tuber yield. This is due to fact that different treatments required varying durations for tuber initiation and development. Since the mean temperature for each duration varied only in small measure, the length of period would greatly affect the respected accumulated values. Further observations showed that the thermal regimes as expressed by accumulated totals were associated with longer period of tuber initiation due to prevailing lower temperature (Fig. 1). It is clear from fig. 1 that the third date of sowing in 1991-92 encountered lower temperature during tuber initiation and development. Accumulated soil temperatures were negatively correlated with tuber yield in stages R_2 and (R_2 + R_3) of the crop. This was also due to shorter period of prevailing higher temperatures in these stages.

The path-coefficient analysis (cause and effect analysis) which permits the partitioning of correlation coefficients into those indicating direct and indirect effects, gives a better picture of the influence of different weather parameters/agrometeological indices on tuber yield. The results are presented in table 2. It was revealed that the direct and indirect effects of max. T in the stages R_1 and R_3, accu. GDD in the stage R_1 and accu. ST in the stages R_2, (R_1 + R_2) and (R_2 + R_3) were either negligible or very low signifying thereby that the contribution of these variables on tuber yield (through significant association) was of low order.

Maximum temperature in the stage R_1 having negative association with tuber yield had high positive indirect effect through accu. ST in the stage R_1, whereas its indirect effect through min. T in the stage R_1 was high and negative. The effect of max. T in the stage R_1 was moderate, indirect and negative on the tuber yield

Table 2. Path-coefficient analysis showing direct (diagonal) and indirect (off diagonal) effects of different weather parameters/ agrometeorogical indices in important crop phenophases on tuber yield of potato

Weather parameters/ agrometeoro-logical indices	Stages	Max. T		Min.T	Accu. APAR		Accu. GDD		Accu. ST				Correlation with tuber yield
		R_1	R_3	R_1	R_1	(R_1+R_2)	R_1	R_3	R_1	R_2	(R_1+R_2)	(R_2+R_3)	
Max. T	R_1	**0.00**	0.110	-0.612	-0.342	-0.492	0.00	-0.455	0.808	0.094	0.159	-0.108	-0.838*
	R_3	0.00	**-0.145**	0.497	0.472	0.714	0.00	0.536	-0.935	-0.081	-0.225	0.100	0.931**
Min.T	R_1	0.00	0.099	**-0.727**	-0.364	-0.477	0.00	-0.340	0.827	0.071	0.181	-0.087	-0.818*
Accu. APAR	R_1	0.00	-0.096	0.373	**0.710**	0.910	0.00	0.377	-1.140	-0.047	-03327	-0.062	0.821*
	(R_1+R_2)	0.00	-0.110	0.368	0.685	**0.943**	0.00	0.460	-1.182	-0.054	-0.325	-0.059	0.844*
Accu. GDD	R_1	0.00	-0.118	0.384	0.642	0.828	**0.00**	0.437	-1.019	-0.068	-0.283	0.098	0.900*
	R_3	0.00	-0.134	0.426	0.461	0.747	0.00	**0.581**	-0.993	-0.084	-0.226	0.084	0.861*
Accu. ST	R_1	0.00	-0.111	0.492	0.663	0.913	0.00	0.472	**-1.221**	-0.063	-0.319	0.065	0.861*
	R_2	0.00	0.122	-0.530	-0.346	-0.527	0.00	-0.504	0.795	**0.097**	0.158	-0.112	-0.847*
	(R_1+R_2)	0.00	-0.098	0.397	0.701	0.924	0.00	0.396	-1.176	-0.046	**-0.331**	0.054	0.822*
	(R_2+R_3)	0.00	0.115	-0.500	-0.350	-0.440	0.00	-0.385	0.632	0.086	0.142	**-0.126**	-0.826*

R^2 = 1.00, Residual =0.003*, Significant at 5% level, ** Significant at 1% level

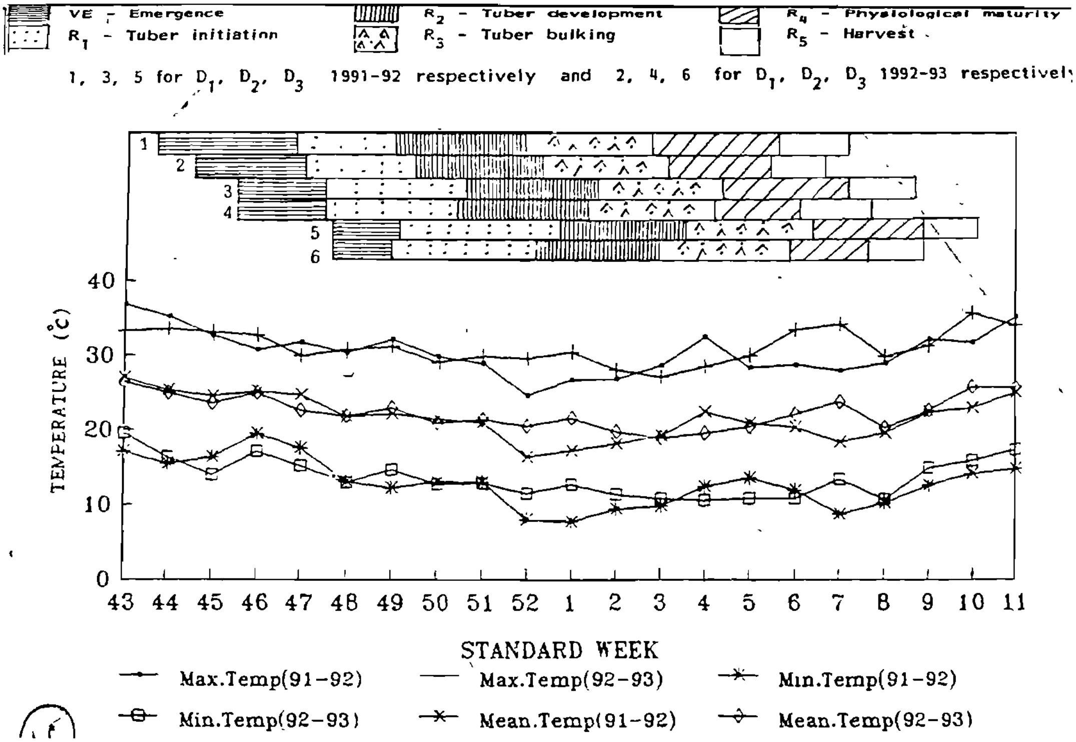

Fig. 1.

through accu. APAR in the stages R_1 and (R_1 + R_2). Accumulated ST is a result of max. and min. temperatures. The positive effect of maximum T in the stage R_1 was balanced out by the negative effect via min. T and accu. APAR in the stage R_1. This phenomenon was observed for all variables indicated in the path analysis (Table 2) i.e. the effect of variable through accu. ST in the stage R_1 on tuber yield was balanced out by the effect of variable through min. T and accu. APAR in the stage R_1.

Max. T in the stage R_3 had high positive correlation with tuber yield. Its indirect effect through accu. APAR in the stage (R_1 + R_2) and accumulated GDD in the stage R_3 was positively high and moderate respectively on tuber yield.

Minimum temperature in the stage R_1 having high negative association with tuber yield showed high direct negative effect and moderate indirect negative effect through accu. APAR in the stage (R_1 + R_2).

Accumulated APAR in the stage R_1 having high significant association with tuber yield showed high positive direct effect and also high positive indirect effect through accu. APAR in the stage (R_1 + R_2). Similar trend was observed for accu. APAR in the stage (R_1 + R_2).

Accumulated GDD in the stage R_1 contributed positively through accu. APAR in the stage (R_1 + R_2). Accumulated GDD in the stage R_3 had positive moderate direct effect on tuber yield, whereas its indirect effect through Accu. APAR in the stage (R_1 + R_2) was high and positive.

Accumulated ST in the stage R_1 having high positive correlation with tuber yield exerted very high negative direct effect. But its indirect influences through accu. APAR in the stages R_1 and (R_1 + R_2) were high and positive.

In general, the effect (direct or indirect) of variable through accu. APAR and accu. GDD was moderate to high on tuber yield and the effect was similar to total correlation.

The results revealed that among all the variables included in the path analysis (Table 2), accu. ST in the stage R_1 exerted very high effect on tuber yield but its influence was balanced out by the effect of min. T and of accu. APAR in the stage R_1. Recording of min. T is easier than measuring ST (i.e. accu. ST) and also accu APAR. Similarly, accu. APAR in the stage (R_1 + R_2) and accu. GDD in the stage R_3 showed moderate to high direct as well as via effect. Thus, three parameters viz. min. T in the stage R_1, accu. APAR in the stage (R_1 + R_2) and accu. GDD in the stage R_3 could be used efficiently in predicting the tuber yield. Partial regression models using the above three parameters were derived and are as under :

1. $$Y=1.201 - 0.239\,(\text{Min. T})_{R1} + 0.021 \sum_{ds}^{dE} (\text{APAR})_{(R_1+R_2)} \quad (R^2 = 0.78)$$

2. $$Y= -7.006 + 0.02 \sum_{ds}^{dE} (\text{APAR})\,(R1+R2) + 0.017 \sum_{ds}^{dE} (\text{GDD})_{R3} \quad (R^2 = 0.91)$$

3. $$Y= -9.876 + 0.097\,(\text{Min. T})\,R_1 + 0.023 \sum_{ds}^{dE} (\text{APAR})\,(R_1+R_2) + 0.020 \sum_{ds}^{dE} (\text{GDD})\,R_3 \quad (R^2 =0.91)$$

Where,

Y = Predicated tuber yield (kg m^{-2}) dE

and ds = Summation from starting date of the phaseds indicated as (ds) to the ending date of the phase indicated as (dE) in the equation

(Min. T) R_1 = Average daily minimum temperature (°C) during early vegetative and tuber initiation stage (R_1)

APAR (R_1+R_2) = Absorbed photosynthetically active radiation (MJ mx^{-2}) from emergence stage to the end of late vegetative phase and tuber development stage

$(GDD)R_3$ = Growing degree days during tuber bulking stages (R_3)

Looking at the performance of the above models in predicting yields, it could be said that models 2 and 3 could predict more acurately ((R^2=0.91) tuber yield of the crop at the end of tuber bulking stage which was at about 20 to 30 days before maturity. However, if further advance prediction is desired, the model no. 1 could be used with R^2=0.78. The model could predict the tuber yield of the crop when the crop was about to complete vegetative phase and tuber development stage which was about 40 to 50 days before maturity.

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EFFECT OF LEVELS AND METHODS OF POTASSIUM APPLICATION ON VEGETATIVE GROWTH AND YIELD OF POTATO CV. KUFRI BADSHAH

V.N. Singh* and S.P. Singh[1]

ABSTRACT : Application of 200 kg K_2O ha^{-1} gave significantly higher yield (250 and 224 q/ha^{1}) and also increased average plant height (73.0 cm) compared to control during 1990-91 and 1991-92. The split application of potassium was found to be most effective than its full basal application.

INTRODUCTION

Among short duration crops, potato needs moderate to optimum level of potassic fertilizers, in addition to oraganic manure (1). However, when applied at the time of planting, danger of leaching of soluble potash below the root zone by frequent irrigations during the growing season of the crop increases. Significant potato responses to N and K application have been reported by a number of workers in differrent agroclimatic regions of the country and optimum N and K dose varied with soil and potato variety (1 ,2, 4-8). Present investigation was, therefore, an attempt to study the effect of levels and methods of potassium application to potato on its growth and yield.

MATERIALS AND METHODS

The experiment was carried out in sandy loam, deep and well drained soil with pH 7.6 and 7.7, available N, P and K 125.0-123.0, 8.2-8.1 and 6.4- 6.6 ppm respectively. Organic carbon (%) and EC were 0.36 - 0.37 and 1.65 - 1.62 mmhos/cm in both the years, respectively. Well sprouted tubers of Kufri Badshah (25-30g) were planted at 60×60 cm spacing. Potassium was applied @ 50 (K_1), 100 (K_2), 150 (K_3) and 200 (K_4) kg K_2O ha^{-1} as full basal (M_1) , 3/4 basal +¼ top dressing at 30 days after planting (DAP-M_2), ½ basal +½ top dressing at 30 DAP(M_3), ½ basal +½ top dressing at 50 DAP (M_4), 1/3 basal +1/3 top dressing at 30 DAP +1/3 top dressing at 50 DAP (M_5) and no basal +½ top dressing at 30 DAP +½ top dressing at 50 DAP (M_6) along with control (K_0). Nitrogen was applied in the form of urea @ 120 kg N ha^{-1} in two split doses i.e. ½ as basal and rest half at 30 DAP.

Phosphorus in the from of single super phosphate was given @ 80 kg P_2O_5 ha^{-1} as basal dose. Potassium was applied through potassium chloride. The experiment was

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Table 1. Response of potato cv. Kufri Badshah to K application at different stages of growth (mean of two years)

Treatments	Plant height (cm)				Fresh wt.(g) of leaves hill⁻¹		
	30 DAP	45 DAP	60 DAP	75 DAP	30 DAP	50 DAP	70 DAP
*Levels of K_2O (kg/ha)**							
K_0	13.1	35.9	46.0	54.2	10.4	42.0	59.3
K_1	18.4	50.2	57.9	62.3	14.4	63.4	58.9
K_2	23.2	56.4	61.1	65.6	22.8	75.8	72.6
K_3	29.0	62.2	65.3	71.1	26.9	83.3	82.9
K_4	33.3	64.1	67.3	73.0	28.6	87.6	73.5
CD(0.05) Treatment	1.5	1.7	1.9	1.9	2.0	3.6	3.0
CD(0.05) K_0 Vs. Treatment	10.7	12.2	13.2	13.5	14.2	25.1	20.8
*Methods of Application**							
M_1	30.8	56.7	61.5	66.6	36.7	74.2	67.1
M_2	29.3	57.9	64.1	69.3	31.2	85.9	84.7
M_3	28.4	59.4	65.9	71.0	20.9	92.2	93.2
M_4	27.6	57.7	62.2	67.7	19.6	68.8	59.3
M_5	27.0	61.6	63.0	68.2	17.5	77.9	75.6
M_6	12.9	56.1	60.7	65.6	13.2	65.6	51.9
CD (0.05)	1.5	1.7	1.9	1.9	2.0	3.5	2.9

* As per details in the Meterials & Methods

conducted under randomised complete block design with three replications. The recommended cultural practices were followed for growing the crop. Various observations were recorded periodically adopting standard procedure. The association of different parameters with one another was worked out (3).

RESULTS AND DISCUSSION

Plant height : A perusal of data presented in table 1 revealed that there were significant effects of potassium levels and methods of application on height of plant. However, their interactions were non significant. The rate of increase was rapid upto 45 DAP but thereafter it slowed down. The K_4 treatment was significantly superior to K_3, K_2, K_1, and K_0. The maximum mean height of the plant was recorded under M_1 at 30 DAP (30.8 cm), M_5 at 45 DAP (61.6 cm) and M_3 at 60 DAP (65.9 cm) and 75 DAP (71.0 cm).

Fresh weight of leaves : It is evident from table 1 that the levels of potassium significantly increased fresh weight of leaves hill⁻¹. However, the increase was observed upto 50 days. Thereafter the fresh weight of leaves decreased. The maximum fresh weight of leaves i.e., 28.6 g at 30 DAP and 87.6 g at 50 DAP with K_4 and 82.9 g with K_3 at 70 DAP was recorded.

Table 2. Response of potato cv. Kufri Badashah to K application for fresh weight of stem/hill^{-1} (mean of two years) and yield

Treatments	Fresh weight (g) of stem hill^{-1}			Yield (q ha^{-1})	
	30 DAP	50 DAP	70 DAP	1990-91	1991-92
Levels of K_2O					
K_0	8.1	31.7	29.4	154.0	148.8
K_1	30.3	52.5	44.7	207.9	177.2
K_2	15.2	57.8	51.4	232.6	209.1
K_3	16.8	60.4	55.0	241.4	220.9
K_4	18.5	61.7	54.7	250.0	224.0
CD (0.05) Treatment	N.S.	2.1	2.5	5.5	5.3
CD (0.05) K_0 Vs. Treatment	15.0	16.2	17.9	37.7	39.1
Methods of Application					
M_1	20.8	54.4	47.8	230.4	205.6
M_2	16.4	39.2	60.6	234.4	208.7
M_3	15.8	69.0	61.4	238.7	212.4
M_4	14.2	52.7	46.6	231.2	205.5
M_5	14.3	57.5	50.6	238.5	211.2
M_6	12.8	49.3	43.8	225.1	203.4
C.D.(0.05)	2.1	2.3	2.5	5.4	5.5

N.S. = Non significant

The methods of application also had a significant effect on fresh weight of leaves, 36.7 g at 30 DAP with M_1, 92.2 g at 50 DAP and 93.2 g at 70 DAP with M_3 were obtained.

Fresh weight of stems : Data pertaining to fresh weight of stem hill^{-1} are presented in table 2. The levels of potassium imparted a significant effect on fresh weight of stem hill^{-1} at each successive stage of crop growth except 30 DAP. In the beginning the increase in fresh weight was more but it declined from 50 DAP to rest of the period. The maximum fresh weight of stem hill^{-1} was recorded with K_4 i.e. 61.7 g and 54.7 g.

The fresh weight of stem hill^{-1} was significantly affected by methods of application. The highest fresh weight of stem hill^{-1} was observed under M_1 at 30 DAP (20.8 g) and M_3 at 50 DAP (69.0 g) and 70 DAP (61.4 g).

The increase in the height of plant, fresh weight of leaves and stem by potassium application is due to its association with the efficiency of leaf as an assimilator of carbon dioxide and builder of plant substances. It also enhances the metabolic activities of the plant and brings about its better growth. The slow increase in plant growth (45 DAP) and decrease in fresh weight of leaves and stems (50 DAP) may be due to translocation of nutrients into tuber (2). The rapid increase in height of plant, fresh weight of leaves and stems in early stages of plant growth was due to availability of more nutrients for sustaining the plant (7).

Tuber yield: It is evident from table-2 that the various levels of potassium significantly increased the yield of tubers. The highest yield (250 and 224 q ha $^{-1}$) was recorded with K_4 and which was significantly higher than control (K_0). All the methods of K application also significantly increased the tuber yield. The interaction effect of levels and methods was non significant. The increase in yield due to potassium application has also been reported by Sharma and Arora (4). The increase in yield by split application of potassium might be due to minimum loss of potassium through leaching and maximum availability during the crop period (5).

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COMPARISON OF ANDIGENA AND TUBEROSUM FOR ENHANCING TPS PRODUCTION*

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ABSTRACT : Large variation with generally more duration of flowering, number of inflorescences/ plant, number of flowers/ inflorescence and pollen fertility was observed in *andigena* than the *tuberosum* cultures studied. No relationship between number of inflorescence/plant and number of flowers / inflorescence was observed indicating that selection of parents for high values of both the characters was possible and the *andigena* genotypes would better serve as male parents in hybrid TPS production. High variability was also observed for berry formation, number of seeds per berry and seed weight. There did not appear to be any difference in berry setting in *andigena* and *tuberosum* when used as females, However, *andigena* cultures gave higher berry set when used as males.

INTRODUCTION

The use of true potato seed (TPS) for raising commercial potato crop can greatly reduce the dependence of farmers on disease free seed tubers of standard varieties which is expensive and also in short supply. However, to establish TPS as an alternative and effective propagule for raising the commercial crop, it is imperative to develop high yielding TPS populations whose seed in large quantities can be produced economically and with sufficient ease. A high yielding TPS population with poor flowering has no chance of acceptance in the trade. Flowering, pollen fertility and the extent of berry and seed set are, therefore, important criteria determining the economics of large scale TPS production. Though information on flowering behavior and pollen fertility etc., is available for group *Tuberosum* and *Andigena* in general (5), yet very limited information is available on these aspects in the Indian varieties and the advanced hybrids. Keeping this in view, the characteristics of parents, important in determining their suitability for TPS production were studied in 15 parents selected on the basis of genetic divergence. The information on % berry set, number of seeds per berry and seed weight was collected in all possible 105 crosses of the above parents and reported here.

MATERIALS AND METHODS

The 15 genotypes, selected on the basis of genetic diversity, were studied for their flowering behaviour. These represented different clusters and exhibited genetic divergence. Among these, nine genotypes belonged to ssp. *tuberosum*, four to ssp. *andigena*, and two were hybrids between ssp. *tuberosum* and ssp. *andigena*. The genotypes were as follows :

* Part of the Ph. D. thesis (1993) of Sr. author.

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S. tuberosum ssp. *tuberosum*		ssp. *andigena*	
i)	Kufri Jyoti	i)	EX/ A-680-16
ii)	Kufri Jeevan	ii)	EX/ A-679-10
iii)	Dekama	iii)	EX/ B-723
iv)	Katahdin	iv)	EX/ B-687
v)	Kufri Badshah		
vi)	Kufri Bahar	ssp. *andigena* × ssp. *tuberosum*	
vii)	JF- 246		
viii)	SLB/M-70	i)	Kufri Kuber
xi)	VB-8	ii)	Kufri Sheetman

The experiment was conducted at Central Potato Research Station, Kufri, HP (30° N 75° E; 2501 m above MSL) during the summer of 1989. Sixty tubers (4 rows of 15 tubers each) of each of 15 selected genotypes were planted in the hybridization block. A distance of 50 cm was kept between rows and 30 cms from tuber to tuber within the row. The data were recorded on 10 randomly selected competitive plants of each genotype. The remaining plants were utilized in crossing programme. The observations were recorded for the following characters.

i) **Duration of flowering** : The character was measured in number of days starting from appearance of first floral primodia in a genotype to the end of flowering.

ii) **Inflorescences per plant** : The character was recorded by counting periodically the number of emerging flowering bunches in a plant.

iii) **Flowers per inflorescence** : The number of buds producing flowers were counted in 10 random inflorescences for each of 10 plants.

iv) **Pollen stainability** : The character was measured by staining pollens from different inflorescences and staining them with 2% solution of acetocarmine.

v) **Per cent berry set** : Berry setting was calculated from the number of flowers pollinated in a cross and the number of berries formed.

vi) **Seeds per berry** : The seeds were extracted from 5 equal size berries randomly taken from each cross combination and counted.

vii) **One hundred seed weight** : Three samples of 100 seeds from each cross were counted and weighed (mg) on an electronic balance.

The analysis of variance was done and Duncan's multiple range test was applied to find significant differences between 15 parents studied for characters i) to iv). The average values for characters v) to vii) recorded on 105 cross combinations were used for studying variability.

RESULTS AND DISCUSSION

The analysis of variance for duration of flowering, number of inflorescences per plant, number of flowers per inflorescence and pollen stainability is presented in table 1. The results showed significant differences among the genotypes for all the four characters studied.

Table 1. Analysis of variance for flowering characters

Source	df	Duration of flowering (days)	Inflorscences per plant	Flowers per plant	Pollen stainability
Replication	9	41.54	3.96	1.28	14.06
Genotypes	14	1466.18**	392.65**	61.76**	2656.38**
Error	126	18.26	3.27	0.73	13.85

**Significant at 1% levels

The data (Table 2) showed that the duration of flowering in general was more in *andigena* genotypes (9 to 10 weeks; Av. 9.7 weeks) as compared to the varieties and hybrids, derived from *tuberosum* (duration 4.1 to 9.8 weeks; Av. 7.7 weeks) indicating that *andigena* need to be exploited in TPS programme. This will enable extension of hybridization period resulting in production of more TPS. The variability of flowering duration in *tuberosum* varieties showed that it was also possible to select *tuberosum* parents with longer duration of flowering (eg. Kufri Jyoti and SLB/M-70) for use in TPS production. A large variation among genotypes was observed for number of inflorescences per plant, flowers per inflorescence, and pollen fertility (Table 2). The

Table 2. Performance of genotypes for flowering behaviour

Genotype	Duration of flowering (Days)	Av. No. of inflorescence	Av. No. of flowers/ inflorescence	% pollen stainability
EX/B-723	71.9A	22.9 D	3.9 G	68.2E
Kufri Sheetman	71.0 A	32.9 A	8.1 CD	47.6 H
EX/A-680-16	69.7 A	22.0 D	7.6 D	92.7 A
Kufri Jyoti	68.7 AB	30.4 B	6.6 E	64.9 EF
EX/A-679-10	68.5 AB	20.2 E	6.0 EF	79.0 C
SLB/M-70	65.5 BC	30.5 B	7.6 D	64.0 F
EX/B-687	62.1 CD	16.6 F	6.0 EF	87.3 B
Dekama	60.7 D	29.9 B	7.8 D	63.0 F
Kufri Jeevan	60.6 D	21.9 D	4.4 G	41.0 I
Kufri Kuber	56.7 E	19.3 E	11.6 B	54.7G
Kufri Bahar	55.9 EF	23.3 D	5.6 F	52.0 G
JF-246	52.1 G	26.2 C	8.7 C	66.3 EF
Kufri Badshah	52.1 FF	15.5 FG	5.4 F	43.0 I
Katahdin	34.5 H	14.0 G	5.8 EF	74.7 D
VB-8	33.0 H	13.5 G	13.0 A	88.0 B
LSD (0.05)	3.78	1.60	0.76	3.29

genotypes derived from *tuberosum* showed greater variation than *andigena* genotypes. The number of inflorescences per plant was much larger in Kufri Sheetman which also has longer duration of flowering. The extent of variability available for this character in *tuberosum* varieties/hybrids indicated that selections for high number of inflorescences per plant would be effective when used as parents in TPS production. Thus Kufri Jyoti, Dekama and SLB/M-70 with about 30 inflorescences per plant would be useful as parents in TPS production. The *tuberosum* varieties/ hybrids and the *andigena* genotypes showed sufficient variability for flowers/inflorescence indicating the possibility of selecting genotypes with higher number of flowers per inflorescence. There did not appear to be any relationship between number of inflorescences per plant and number of flowers per inflorescence indicating that selection of parents for high values of both these characters is possible. A large variation (6 to 26 flowers/inflorescence) for this character has also been observed by Upadhya (8). Considering that only about six flowers per bunch are ideal (9) for getting synchronous berry development and also to reduce pollination time between the first and the last flower in a bunch, all the parents except Kufri Jeevan and EX/ B-723 appear promising.

The estimates of pollen fertility (Table 2) in general revealed that *S. tuberosum* ssp. *andigena* genotypes showed higher pollen stainability than the *tuberosum* genotypes. Howard (5) observed that *andigena* genotypes generally exhibited higher pollen fertility in contrast to *tuberosum* where pollen sterility was common. This, therefore, indicates that *andigena* in general will be more suitable for use as male parents for TPS production, though selected *tuberosum* genotypes could also be used. In the present investigations all the *andigena* genotypes except EX/B-723 and the *tuberosum* hybrid VB-8, appeared promising as male parents.

The extent of berry set (Table 3) in various crosses ranged from 20.7% (EX/B-723 × CP-1406) to 72.7% (Kufri Jyoti × EX/A -680-16 and Kufri Jyoti × VB-8). In general, the extent of berry setting was more in the crosses where either *tuberosum* varieties Kufri Jyoti, Katahdin or *andigena* clone EX/A-680-16 were used as female parents. Among male parents, all *andigena* genotypes (except EX/B-723) and *tuberosum* variety/hybrid Katahdin and VB-8 gave high berry set. There did not appear to be any difference with regard to berry setting in *andigena* and *tuberosum* female parents. When used as male parents, *andigena* cultures essentially gave a higher berry set. A large variation was also observed for seeds per berry in the crosses studied. The 100 seed weight in the crosses varied from 49.6 to 108.2 mg (Table 3). Similar variation in seed weight has also been observed in *tuberosum* and *andigena* genotypes (3,8).

The present study supports the earlier conclusions made by Chadha (1), who suggested that genotypes for TPS production should be selected on the basis of profuse blooming, and high berry and seed set. The male parents should also produce abundant fertile pollen. However, the present results do not support the

Table 3. Variation in crosses for TPS attributes

S. No	Cross			% Berry setting	No. of seeds per berry	Seed wt. (mg)
1.	Kufri Jyoti	×	Kufri Jeevan	42.59	211	71.20
2.	Kufri Jyoti	×	Kufri Sheetman	38.78	172	69.80
3.	Kufri Jyoti	×	Kufri Kuber	31.25	139	69.50
4.	Kufri Jyoti	×	Katahdin	63.16	286	70.70
5.	Kufri Jyoti	×	EX/A 679-10	67.86	306	67.70
6.	Kufri Jyoti	×	EX/A 680-16	72.72	344	56.30
7.	Kufri Jyoti	×	EX/B-723	53.85	289	58.20
8.	Kufri Jyoti	×	EX/B-687	66.66	386	65.90
9.	Kufri Jyoti	×	JF-246	51.85	276	69.40
10.	Kufri Jyoti	×	Kufri Badshah	33.33	201	56.90
11.	Kufri Jyoti	×	Kufri Bahar	37.50	189	67.90
12.	Kufri Jyoti	×	V.B. -8	72.72	289	91.30
13.	Kufri Jyoti	×	Dekama	66.66	246	81.90
14.	Kufri Jyoti	×	SLB/M-70	63.33	254	69.10
15.	Kufri Jeevan	×	Sheetman	28.57	154	59.70
16.	Kufri Jeevan	×	Kufri Kuber	30.76	132	78.50
17.	Kufri Jeevan	×	Katahdin	43.47	202	67.00
18.	Kufri Jeevan	×	EX/A 679-10	52.38	264	71.10
19.	Kufri Jeevan	×	EX/A 680-16	54.54	286	49.60
20.	Kufri Jeevan	×	EX/B-723	47.62	300	78.50
21.	Kufri Jeevan	×	EX/B-687	52.38	212	83.60
22.	Kufri Jeevan	×	JF-246	38.09	178	71.30
23.	Kufri Jeevan	×	K. Badshah	36.00	199	58.10
24.	Kufri Jeevan	×	K. Bahar	32.50	186	47.90
25.	Kufri Jeevan	×	V.B.-8	44.12	254	79.40
26.	Kufri Jeevan	×	Dekama	29.17	233	84.50
27.	Kufri Jeevan	×	SLB/M-70	33.46	212	64.40
28.	Kufri Sheetman	×	Kufri Kuber	23.52	89	69.50
29.	Kufri Sheetman	×	Katahdin	43.47	180	65.00
30.	Kufri Sheetman	×	EX/A 679-10	44.12	198	65.00
31.	Kufri Sheetman	×	EX/A 680-16	42.42	214	60.30
32.	Kufri Sheetman	×	EX/B-723	28.57	167	60.90
33.	Kufri Sheetman	×	EX/B-687	34.38	200	69.00
34.	Kufri Sheetman	×	JF-246	30.56	135	78.00
35.	Kufri Sheetman	×	Kufri Badshah	30.00	142	48.90
36.	Kufri Sheetman	×	Kufri Bahar	26.66	149	78.90
37.	Kufri Sheetman	×	V. B. -8	42.10	189	79.00
38.	Kufri Sheetman	×	Dekama	33.33	104	71.70
39.	Kufri Sheetman	×	SLB/M-70	34.38	123	78.50
40.	Kufri Kuber	×	Katahdin	46.15	280	90.50
41.	Kufri Kuber	×	EX/A 679-10	49.09	304	70.60
42.	Kufri Kuber	×	EX/A 680-16	52.63	334	75.60
43.	Kufri Kuber	×	EX/B-723	36.11	301	82.30
44.	Kufri Kuber	×	EX/B-687	46.43	346	82.90
45.	Kufri Kuber	×	JF-246	27.50	189	98.70
46.	Kufri Kuber	×	Kufri Badshah	31.82	195	72.10
47.	Kufri Kuber	×	Kufri Bahar	34.09	207	73.20
48.	Kufri Kuber	×	V.B.-8	41.18	284	83.10
49.	Kufri Kuber	×	Dekama	29.16	194	80.40
50.	Kufri Kuber	×	SLB/M-70	31.11	201	65.40
51.	Katahadin	×	EX/A679-10	65.00	304	95.20
52.	Katahadin	×	EX/A 680-16	68.42	380	105.30
53.	Katahadin	×	EX/B -723	58.33	364	85.10

Table 3 (Contd.)

S. No	Cross			% Berry setting	No. of seeds per berry	Seed wt. (mg)
54.	Katahadin	×	EX/ B-687	68.42	388	67.90
55.	Katahadin	×	JF-246	52.38	212	91.30
56.	Katahadin	×	Kufri Bashah	54.55	202	76.70
57.	Katahadin	×	Kufri Bahar	44.44	198	67.70
58.	Katahadin	×	V. B.- 8	62.50	298	87.80
59.	Katahadin	×	Dekama	34.29	189	72.70
60.	Katahadin	×	SLB/ M-70	44.44	241	68.10
61.	EX/A 679-10	×	EX/A 680-16	51.72	305	101.60
62.	EX/A 679-10	×	EX/B-723	41.38	248	63.20
63.	EX/A 679-10	×	EX/B-687	55.17	348	83.80
64.	EX/A 679-10	×	JF- 246	30.30	222	68.70
65.	EX/A 679-10	×	Kufri Badshah	28.12	185	58.40
66.	EX/A 679-10	×	Kufri Bahar	26.47	192	69.70
67.	EX/A 679-10	×	VB-8	51.72	364	83.30
68.	EX/A 679-10	×	Dekama	29.17	227	88.90
69.	EX/A 679-10	×	SLB/M-70	34.29	222	68.50
70.	EX/A 680-16	×	EX/B-723	61.11	282	91.50
71.	EX/A 680-16	×	EX/B-687	67.56	354	88.10
72.	EX/A 680-16	×	JF-246	12.85	239	50.40
73.	EX/A 680-16	×	Kufri Badshah	38.46	202	95.60
74.	EX/A 680-16	×	Kufri Bahar	42.85	218	67.60
75.	EX/A 680-16	×	V.B.-8	63.63	305	77.40
76.	EX/A 680-16	×	Dekama	51.85	272	64.60
77.	EX/A 680-16	×	SLB/M-70	52.00	264	74.20
78.	EX/B 723	×	EX/B-687	46.15	186	54.20
79.	EX/B 723	×	JF-246	21.74	104	57.20
80.	EX/B 723	×	Kufri Badshah	30.77	98	61:20
81.	EX/B 723	×	Kufri Bahar	37.50	78	65.80
82.	EX/B 723	×	V.B.-8	40.00	138	83.70
83.	EX/B 723	×	Dekama	20.69	102	65.90
84.	EX/B 723	×	SLB/M-70	23.33	106	82.60
85.	EX/B 687	×	JF-246	56.25	282	61.50
86.	EX/B 687	×	Kufri Badshah	65.00	292	85.60
87.	EX/B 687	×	Kufri Bahar	57.89	261	71.30
88.	EX/B 687	×	V.B.-8	72.22	330	88.90
89.	EX/B 687	×	Dekama	52.17	298	77.10
90.	EX/B 687	×	SLB/M-70	56.00	264	68.10
91.	JF-246	×	Kufri Badshah	33.60	232	65.30
92.	JF-246	×	Kufri Bahar	36.73	214	83.00
93.	JF-246	×	V.B.-8	46.51	281	76.10
94.	JF-246	×	Dekama	40.43	264	55.40
95.	JF-246	×	SLB/M-70	28.20	198	98.40
96.	Kufri Badshah	×	Kufri Bahar	34.21	266	98.60
97.	Kufri Badshah	×	V.B.-8	45.45	288	88.40
98.	Kufri Badshah	×	Dekama	39.22	231	71.90
99.	Kufri Badshah	×	SLB/M-70	42.11	228	73.30
100.	Kufri Bahar	×	V.B.-8	58.33	304	89.10
101.	Kufri Bahar	×	Dekama	43.48	254	67.60
102.	Kufri Bahar	×	SLB/M-70	40.74	267	58.70
103.	V.B.-8	×	Dekama	68.42	256	108.20
104.	V.B.-8	×	SLB/M-70	66.66	215	76.40
105.	Dekama	×	SLB/M-70	45.95	202	75.20

recommendation that female parent should be male sterile so that large quantity of seed can be produced conveniently. On the contrary our results support Upadhya and Thakur (9), who suggested that both male and female parental lines should have male and female fertiliy as the male sterile genotypes had low berry and poor seed setting (Table 2) when used as females in hybridization.

Considering that for TPS production long duration of flowering, more flowers per plant and high berry and seed set are important criteria for the female parent, the genotypes Kufri Jyoti, Katahdin and EX/A-680-16 will be the ideal female parents. Similarly, for male parents, high pollen fertility and pollen abundance are important criteria hence use of *andigena* genotypes EX/ A-679-10, and EX/B-687 will be useful. The involvement of above *tuberosum* and *andigena* parents in the crosses would help in exploiting herterosis for tuber yield as has been observed by many workers (2, 3, 4, 6,).

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RESPONSE OF NITROGEN LEVELS AND PLANTING DATES ON POTATO YIELD AND ECONOMICS IN MADHYA PRADESH

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ABSTRACT : An experiment consisting of combination of four each of planting dates and nitrogen levels was conducted during *rabi* of 1991-92 and 1992-93 to find their effects on yield and economics of potato Cultivation in Satpura region of M.P. Significant yield differences were obtained with diffrent dates and nitrogen levels. Nitrogen levels of 160 kg/ha on 25th Oct. of planting gave highest average yield (252.86q/ha) and net return (Rs 40, 825/ha) with cost benefit ratio of 14.71 closely followed by 15th Oct. at same levels of nitrogen. From nitrogen 120kg./ha with planting date of 4th Nov. obtained average yield of 240.31q/ha with net-return of Rs 38,920/ha but cost benifit ratio was higher 15.44 than the other combinations.

INTRODUCTION

Nutrient requirement of potato is quite high, and judicious use of fertilizer and organic manure is essential to obtain optimum yield. Since different doses of nitrogen application on different dates of planting markedly affect potato yield and its economics, therefore present study was undertaken with an objective to find out the nitrogen needs of potato when planted at different dates for getting maximum yield as well as net returns.

MATERIALS AND METHODS

Field experiments were carried out at Zonal Agricultural Research Station, Chhindawara under AICPIP, during *rabi* seasons of 1991-92 and 1992-93. The soil was clay loam and contained 383,16, and 600 kg. available nitrogen, phoshporus and potassium respectively with a pH of 7.2. The treatment included all combinations of planting dates (15th, 25th Oct. 4th and 14th Nov.) with nitrogen levels (80,120,160 and 200 kg/ha). The experiment was laid out in randomized block design with three replications having plot size of 3.6×3.0 m^2. Well sprouted tubers of JH-222 were planted at different dates at 60×20 cm. inter & intra row spacings. A uniform dose of phoshporus and potassium (100kg/ha each) applied with 2/3 dose of nitrogen was applied as basal dose and the remaining 1/3 nitrogen was applied after 35 days of planting as per treatments. The crop was adequately protected against insect pests and diseases. Harvesting was done 100 days after planting and tuber yield, economics and cost benifit ratio were calculated as per treatment.

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Table 1. Effect of potato planting dates and nitrogen levels on economics of JH-222 (Kufri Jawahar)

Treatments date xN/ ha		Germination %			Yield q/ha		Average of two year i.e. 1991-92 & 1992-93		
		91-92	92-93	Av.	91-92	92-93	Av.	Net return	C.B. Ratio Rs./ha
15th Oct. + 80 Kg.	:	94.82	88.86	91.84	222.68	170.81	196.75	31594	13.94
15th Oct. + 120 Kg.	:	92.22	88.51	90.37	247.68	180.99	214.34	34348	13.60
15th Oct. + 160 Kg.	:	93.70	86.29	89.99	283.61	210.12	246.87	39694	14.30
15th Oct. + 200 Kg.	:	93.33	82.18	87.76	281.48	209.60	245.54	39214	12.94
25th Oct. + 80 Kg.	:	93.69	94.43	94.06	204.62	204.62	204.60	33010	14.56
25th Oct. +120 Kg.	:	93.69	96.63	95.16	214.35	225.08	219.72	35375	14.03
25th Oct. + 160 Kg.	:	94.06	94.81	94.44	252.12	253.60	252.86	40825	14.71
25th Oct. + 200 Kg.	:	92.22	93.40	92.81	251.94	250.99	251.67	40327	13.31
04th Nov. + 80 Kg.	:	99.25	100.00	99.63	176.38	204.11	190.25	30572	13.49
04th Nov. + 120 Kg.	:	97.40	97.77	97.59	237.49	243.12	240.31	38920	15.44
04th Nov. + 160 Kg.	:	95.55	97.74	96.65	229.16	240.96	235.06	37770	13.61
04th Nov. + 200 Kg.	:	98.51	99.62	99.07	227.77	242.04	234.91	37492	12.37
14th Nov. + 80 Kg.	:	97.03	98.68	97.86	174.35	172.20	173.28	27609	12.18
14th Nov. + 120 Kg.	:	96.66	97.77	97.22	229.25	215.06	222.16	35765	14.19
14th Nov. + 160 Kg.	:	94.81	95.18	94.99	217.59	210.09	213.84	34085	12.28
14th Nov. + 200 Kg.	:	96.66	91.47	94.07	215.27	209.97	212.62	33624	11.10
CD at 5%		NS	7.65	-	24.14	23.71	--	--	--

Note :- (1) The price of potato was Rs. 170/175 per q. for the year 91-92 & 92-93 respectively.

RESULTS AND DISCUSSION

Percentage germination of tubers was counted at 25 days after planting. In the year 1991-92, germination varied from 92.22 to 99.25% and the differences were found non-significant. However, in 1992-93 treatments differed significantly, The lower (82.18%) germination was recorded in early date of planting with higher dose of nitrogen and highest with potato planted on 4th Oct. with lower dose of nitrogen. On an average germination varied from 87.76 to 99.63% (Table 1).

Out of four dates of planting, tuber yield on second date (25th Oct.) reesulted in the highest average yield (232.22 q/ha) closely followed by first date (15th Oct.) but third date (4th Nov.) resulted in lowest yield (205.48 q/ha). The lower yield might be due to high temperatures prevailing during the time of maturity causing moisture stress. Similar decrease in yield with delayed planting has been reported by Gupta(1), Lal and Sahota (2) and Perumal (4).

Tuber yield increased significantly with increase in the levels of nitrogen up to 160 kg/ha., however, maximum yield (237.51 q/ha) was recorded with 160 kg N/ha. closely followed by 200 kg N/ha. i.e. 236.18 q/ha. and lowest 191.22 q/ha. with 80 kg N/ha. The yield increase of potato with increase in nitrogen application has been reported earlier (3).

Interaction effect of planting dates and nitrogen doses significantly affected tuber yield. Planting on 25th Oct. with 160 kg N/ha. showed higher potato yield (252.86 q/ha.) closely followed by planting on 4th Oct. with 160 kg N/ha. while 120 kg N/ha gave higher yield on late planting i.e. 4th Nov. (240.31 q/ha) and 14th Nov. (222.16 q/ha). The lowest yield of 173.28 q/ha. was recorded with lower dose of nitrogen (80 kg N/ha at last date of planting i.e. 14th Nov. Thus early planting of potato required higher levels of nitrogen than that of late planting. This could be ascribed to maximum utilization of nitrogen fertilizer because of sufficient time avilable for crop maturity.

Planting on 25th Oct. with 160 kg N/ha gave higher net return (Rs. 40, 825/ha) closely followed by the same date of planting with higher dose of nitrogen. Lowest net return (Rs. 27,609) was obtained with planting on 14 Nov. at lower dose of nitrogen (Table 1).

Cost benifit ratio was calculated on the basis of rupee invested on nitrogen doses (all other inputs being same in all treatments). A higher gain of 15.44 was obtained from 120 kg N/ha with planting date of 4th Nov. and lowest (11.10) at planting date 14th Nov. with higher dose of nitrogen (Table 1). On the other hand the gain was 13.54,14.31 and 12.36 per rupee invested on nitrogen dose of 80, 120, 160 and 200 kg/ ha respectively.

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OPINION SURVEY ON PRODUCTION AND MARKETING OF IRRIGATED POTATO IN CHIKKABALLAPUR TALUK, KARNATAKA*

K.P. Aswatha Reddy, C. Nanja Reddy and Lalith Achoth[1]

ABSTRACT : The major problems faced by the producers was nonavailability of quality seed tubers at reasonable prices, lack of adequate capital, high cost of fertilizers and plant protection chemicals and high incidence of pests and diseases. In marketing aspects the major problems faced were fear of price fall, spoilages and immediate need for cash. Lack of improved storage facilities, high cost of transportation and high commission charges, violent price fluctuation and absence of price support programme.

INTRODUCTION

The economic performance of a crop is assessed based on the cost of production and net return obtained per unit area. The empirical data on physical inputs and net returns per unit area would be extremely useful to the farmer as well as for policy-maker to augment the productivity and production of any crop enterprise. Such studies are also useful to commercial banks and other credit institutions in estimating the financial requirements in cultivation and formulating their lending policies. Keeping this in view it was decided to study the economic performance of irrigated potato.

MATERIALS AND METHODS

Kolar district was purposely selected for the study as it has a relatively large area under potato crop and ranks third in production in Karnataka.Chikkaballapur taluk alone accounted for nearly 74.83 per cent of the total area under this crop in the district. There are hoblis in Chikkaballapur taluk namely Nandi, Kasaba and Mandikal: To give a better representation, two hoblis (area having minimum of 100 villages) Nandi and Kasaba were selected for the study. Again five villages which had the relatively large area under potato were selected from each hobli. Thus 10 villages were selected for the study.

From this list, nine farmers form each village were randomly selected. From these sample villages a sample of 90 farmers was drawn. Accodingly the actual area under potato of the 45th respondent was 0.80 hectare. The frist 45 respondents were classified as small producers and the remaining 45 respondents as large producers.

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* Part of senior author's M.Sc. (Agri.) Thesis.

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Opinions of the farmers regarding the problems of production and marketing of potato were collected and tabular analysis was done using the percentages to arive at the conclusions.

RESULTS AND DISCUSSION

The problems faced by the producers in the production and marketing of irrigated potato are presented in table 1. It could be seen from the table that the major problems were non-availability of quality seed tubers at reasonable prices, high cost of fertilizers and pesticides, high incidence of pests and diseases and lack of adequate capital.

Nearly 95% of the farmers were of the opinion that the cost of seed (Rs. 2, 375. 66/acre) was very high and the quality of seed tubers was also low. Hence, to safeguard the interest of the producers, Government and co-operative institutions must make suitable arrangements for the supply of good quality seed tubers at reasonable rates.

Almost all the farmers expressed that prices of fertilizers were high. On an average each farmer spent Rs. 629.41 per acre on fertilizers. Hence, the State Department of Horticulture should educate farmers on the importance of soil test and educate the farmers on the application of fertilizers based on the soil test results. This would help in the economic use of fertilizers. Majority of tthe sample

Table 1. Opinion of respondents on the problems of production and marketing of irrigated potato (percentage)

	Particulars	Small producer	Large producer	Pooled category
A	*Production*			
1.	Nonavailability of quality seed tubers	93.16	96.13	94.64
2.	Lack of adequate capital	87.23	81.13	84.18
3.	Lack o quality of plant protection chemecals	43.16	61.01	52.08
4.	High cost of fertilizer	100.00	100.00	100.00
5.	High inidence of pests and diseases	63.01	64.05	63.53
6.	Lack of extension education facility	51.09	49.03	50.06
B	*Marketing*			
1.	Fear of price fall	04.92	73.39	69.15
2.	High storage losses	89.16	86.32	87.74
3.	Lack of imprved storage facility	79.63	83.09	81.36
4.	High cost of storage	55.01	48.0.8	51.54
5.	Immediate need for cash	73.30	68.01	70.65
6.	High cost of transportation	100.00	100.00	100.00
7.	High commission charges	94.16	89.67	91.91
8.	Voilent price fluctuations	100.00	100.00	100.00
9.	Absence of price support programmes	84.13	79.78	81.95

farmers (80%) felt that improved and adequate storage facilities were lacking. So, proper and adequate storage facility would help the producers to avoid possible losses due to storing in unscientific manner. Cold storages would help the farmers to protect both quantity and quality of potato and also distress selling.

Almost all the potato producers expressed that the cost of transporting potato to distant market was very high. The cost of transport alone accounted for 26.22 per cent of total marketing cost. Hence transport facilities at reasonable charges may be provided by the Government or co-operative institutions.

The producers of potato (nearly 95%) were of the opinion that the present commission charge of four per cent was too high as compared to the service rendered by them. However, the recent government policy direct the commission agents to collect the commission charges from the buyers. The above discussion indicated that potato production was faced with the numerous problems in production and marketing. Therefore, every effort should be made by the Government and State Departments like Horticulture, Marketing and Co-operatives to protect the interest of the potato producers.

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EFFECT OF PHOTOSYNTH, GROWTH REGULATOR AND IRRIGATION FREQUENCY ON POTATO YIELD

A.M. Puste[1] and A.L. Kundu[2]

ABSTRACT : Two years field study was conducted at the University Research Farm, to visualise the performance of irrigation levels (I_1 to I_4, respectively at stolon initiation, tuber initiation, early bulking and late bulking stage) and agro-chemicals (Paras, a photosynth contains Mixtalol and Planofix, a growth regulator) on the tuber yield of potato. It was revealed from the experiment that the yield characteristics and tuber yield of potato were influenced significantly by the irrigation levels and sprayed materials. Number of tuber/hill, weight/tuber and tuber yield was increased significantly with the irrigation level and was maximum at 4-irrigation levels (19.3 t/ha) which was 61.8% more than that of single irrigation given at stolon initiation stage. The effect of agro-chemicals on both the yield and yield characteristics were more predominant over without spray during the period of experimentation. Maximum tuber yield of potato (17.9 t/ha) was obtained when standing crop was sprayed two times with Paras and two times with Planofix @ 5.0 and 0.25 ml/lit of water at 30,50 and 40, 60 DAS and the increment was 18.5% more than that of control (15.1 t/ha).

INTRODUCTION

In the recent years, the area, production and productivity of potato crop have shown remarkable progress in West Bengal. Potato (*Solanum tuberosum* L.) is grown as an important tuber crop during the winter months on highly productive soils in West Bengal. When irrigation water is a scarce and costly imput, success of the crop production depends largely on the irrigation at proper stages and appropriate quantity (3, 5, 6, 8). Growth of crop plants can be altered in beneficial ways using plant growth substances (9). Significant yield increase was observed due to foliar application of agro-chemicals (Planofix) during the growth period of turmeric (2), ginger (4), groundnut (7) and also in potato (1) which prompted to undertake a field experiment to assess the effect of irrigation, photosynth (Paras contains Mixtalol) and growth regulator (Planofix) on the tuber yield of potato in the alluvial soils of West Bengal.

MATERIALS AND METHODS

The experiment was laid out in split plot design with three replications at the University Research Farm (23.5°N, 89°E and 9.5 m above mean sea level) in the Gangetic plains of upland soil having pH 7.1, sandy loam in texture (Entisol soil-sub order udent and great fleuvudent) with good drainage having moderate status of nitrogen (0.7%). The available P_2O_5 and K_2O were 17.2 and 110 kg/ha respectively,

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while CEC was 19.5 m.e./100 gm. Levels of irrigations were put in the main plot while agro-chemicals constituted the sub-plot treatments. Potato (Kufri Chandramukhi) was planted 50 cm apart during 1st week of December in the years 1989 and 1990.

Following are the details of the treatments :

Main plot :

I_1 – Irrigation at stolon initiation

I_2 – Irrigation at stolon initiation + at early bulking stage

I_3 – Irrigation at stolon initiation + at tuber initiation + early bulking stage

I_4 – Irrigation at stolon initiation + at tuber initiation + early bulking + late bulking stage

Sub-plot :

T_1 – No spray

T_2 – Paras sprayed @ 2.5 ml/lit at 30 DAS

T_3 – Paras sprayed @ 5.0 ml/lit at 30 DAS

T_4 – Paras sprayed @2.5 and 5.0 ml/lit at 90 DAS and 50 DAS

T_5 – Paras sprayed @5.0 ml/lit at 30 and 50 DAS

T_6 – Paras sprayed @ 2.5 ml/lit at 30 and 50 DAS and Planofix sprayed @ 0.25 ml/lit at 40 and 60 DAS

T_7 – Paras sprayed @ 5.0 ml/lit at 30 and 50 DAS and Planofix sprayed @ 0.25 ml/lit at 40 and 60 DAS

At land preparation, entire dose of phosphate (100 kg P_2O_5/ha) and potash (100 kg K_2O/ha) were applied coupled with 50% N (75 kg N/ha) as basal while the rest (75 kg N/ha) of nitrogen was applied in two equal splits, one at tuber initiation and the second at bulking stage.

RESULTS AND DISCUSSION

Irrigation : Application of irrigation water remarkably influenced the yield characteristics of potato like number of tuber/hill and weight of individual tuber as well as tuber yield of potato (Table 1). Maximum number of tuber/hill and highest individual tuber yield was obtained at 4-irrigations level which was at par with 3-irrigations level and these were significantly different from single (I_1–irrigation at stolon initiation) and double irrigation (I_2–irrigation at stolon + early bulking stage). The same trend was observed with respect to tuber yield. Highest tuber yield (19.35 t/ha) was obtained when irrigation was applied at stolon, tuber initiation, early and late bulking stage (I_4) which was 61.85% more than that of having received single irrigation at stolon initiation stage (12 t/ha).

Levels of agro-chemicals : Spraying of photosynth and growth regulator significantly increased the yield attributing characters and tuber yield over unsprayed control (Table 1). Significant variation in yield characters like number of tuber/hill, weight/tuber was noticed due to different agro-chemical uses except tuber weight during 1989-90. Frequent sprayings of chemicals with higher doses might have advantages over control. Maximum number of tuber/plant, tuber weight and tuber yield (17.91 t/ha) were obtained when standing crop was sprayed twice with Paras and twice with planofix @ 5.0 and 0.25 ml/lit of water respectively at 30, 50 and 40, 60 DAS and the increment was 18.5% than that of control (11.1 t/ha).

Table 1. Effect of irrigation and agro-chemicals on the yield characteristics and yield of potato

	Tuber/hill		Weight/tuber (g)		Tuber yield (t/ha)		
Treatment	1989-90	1990-91	1989-90	1990-91	1989-90	1990-91	Pooled
Irrigation							
I_1	4.80	4.11	17.4	15.9	12.7	11.3	12.0
I_2	6.71	5.80	23.6	21.4	17.4	15.2	16.3
I_3	8.20	6.91	27.1	24.0	19.7	17.0	18.35
I_4	8.61	7.40	28.4	25.2	20.3	18.4	19.35
S.Em ±	0.22	0.14	0.505	0.44	0.38	0.69	0.49
CD (0.05)	0.77	0.5	1.75	1.53	1.33	2.39	1.70
Levels of Agro-chemicals :							
T_1	6.17	5.40	22.5	19.4	16.2	14.0	15.11
T_2	6.44	5.20	22.9	20.1	16.5	14.5	15.52
T_3	6.75	5.85	2.3	20.7	17.1	15.0	16.03
T_4	7.08	6.06	24.2	21.5	17.4	15.5	16.47
T_5	7.40	6.28	25.1	22.6	18.0	16.0	16.99
T_6	7.71	6.47	25.3	23.2	18.5	16.4	17.46
T_7	7.97	6.67	25.6	23.7	18.9	16.9	17.91
S.Em ±	031	0.25	0.97	0.59	0.62	0.64	0.46
C.D. (0.05)	0.88	0.71	Ns	1.69	*1.76	*1.82	1.32

*Significant at 0.05 level only : N. S. = Not significant

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INTERCROPPING OF ONION AND FENNEL WITH POTATO

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ABSTRACT : Onion and fennel were grown as intercrops in potato. Tuber yield was not reduced by the intercrop when Kufri Badshah was the variety, however, cv. JH-222 recorded a reduction of about 21% due to onion (seed crop) and 8% due to fennel. When intercrop was grown with Kufri Badshah, yield of intercrop (onion seed crop) was reduced by 55-87% while with JH-222 its yield was reduced by 30-36% only. Net return increased when onion or fennel was grown as intercrop in potato compared with sole crop of potato. Net return increased further when recommended dose for intercrop was also added to the intercropped plots. Return from potato + onion was higher than crops of potato + fennel.

INTRODUCTION

Potato is heavily fertilized. When one main crop and another intercrop are made to grow simultaneously then there is complete utilization of surplus nutrients from the main crop, better utilization of solar energy and higher income per unit area. Singh and Rathi (3) obtained higher net return by growing potato in association with mustard. Potato + mustard was the most remunerative intercropping system followed by potato + methi, potato + pea, potato + raya, potato + lentil and potato + wheat (1). Intercropping of potato with wheat did not affect potato yield and increased net return over potato (2). Fennel is gaining popularity in Haryana and its sowing time coincide with potato, however, its growth is picked up in later part of winter. Planting time of onion bulb for seed production is also same as for potato and have not much growth until middle of December. Therefore, it was decided to grow fennel and onion as intercrops in potato.

MATERIAL AND METHODS

Studies on intercropping were undertaken during 1987-88, 88-89, 89-90, 91-92 and 92-93. Soil of the experimental field was sandy loam, nutrient status of the field over various years ranged from 19-25 Kg P/ha, 720-750 Kg K/ka, 0.41-0.47% organic carbon and 8.0-8.1 pH. Well sprouted tubers of Kufri Badshah during 1987-88 and 1988-89 and of JH-222 during 1989-90, 1991-92 and 1992-93 were planted at a spacing of 60 × 20 cm. Onion bulb (Hisar-2) and fennel seed (Local) as per treatment were planted in between two potato ridges at a spacing of 15 and 10 cm, respectively. When raised as sole crop, onion was planted at 50 × 20 cm and fennel at 30 × 20 cm spacings. Potato was fertilized with N : P_2O_5 : K_2O ; 150 : 60 : 60 kg/ha

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during 1987-88 and 1988-89 and 120 : 60 : 60 kg/ha during 1989-90, 1991-92 and 1992-93. Onion and fennel was fertilized with N : P_2O_5 ; 120 : 60 and 50 : 25 Kg/ha, respectively. Intercrop was grown without giving any additional fertilizer during 1987-88, 1988-89 and 1989-90. However, during 1991-92 and 1992-93, there were two treatments for each intercrop (onion as well as fennel), one, with fertilizer recommended for main crop only and in other, fertilizer recommended for main as well as intercrop was applied. Information regarding date of planting and harvesting are given in Table 1. Plot size was 16.2 sq. m. (5.4 × 3.0m) during 1987-88, 1988-89 and 1989-90 and 10.08 sq.m (3.6 × 2.8 m) during 1991-92 and 1992-93. Treatments were replicated four times and arranged in randomised block design.

Table 1. Details of planting and harvesting

Name of crop	Date of planting		Date of harvesting
	Sole crop	Intercrop	
Potato	10 Oct. 87	10 Oct. 87	10 Feb. 88
Onion	11 Oct. 87	18 Oct. 87	10 May to June 88
Potato	17 Oct. 87	17 Oct. 88	16 Feb. 89
Onion	30 Oct. 88	23 Oct. 88	15-30 May, 89
Potato	12 Oct. 89	12 Oct. 89	14 Feb. 90
Onion	27 Oct. 89	27 Oct. 89	May 90
Potato	16 Oct. 91	16 Oct. 91	31 Jan. 92
Onion	16 Oct. 91	16 Oct. 91	May, 92
Fennel	12 Nov. 91	12 Nov. 91	May, 92
Potato	23 Oct. 92	23 Oct. 92	5 Feb. 93
Onion	23 Oct. 92	23 Oct. 92	May, 93
Fennel	23.Oct. 92	23 Oct. 92	May, 93

RESULTS AND DISCUSSION

Yield of potato, onion and fennel are given in Table 2. There was no reduction in tuber yield due to intercrop (onion seed crop) during 1987-88 and 1988-89, when Kufri Badshah was the variety. However, during remaining three years when JH 222 was the variety, reduction in tuber yield due to onion seed crop (intercrop) was about 21% and due to fennel 8%. This reduction in tuber yield came down to 16% due to onion seed crop and 1% due to fennel when fertilizer dose recommended for intercrop was also applied. Singh and Rathi (3) also reported reduction in tuber yield by 6% when mustard was grown as intercrop. Compared with sole crop yield of onion, in intercrop it was reduced by 55-87% during 1987-88 and 1988-89 and 30-36% during remaining three years. Fennel was grown as intercrop during 1989-90, 1991-92 and 1992-93 only. Reduction in fennel yield ranged from 11-53% compared with sole crop of fennel. When fertilizer recommended for intercrop was also applied to the intercrop treatments during 1991-92 and 1992-93 there was improvement in the yield of onion as well as fennel and this reduction in onion and

Table 2. Yield of potato and intercrops (q/ha)

Treatment	1987-88		1988-89		1989-90		1991-92		1992-93	
	Potato	Onion seed	Potato	Onion seed	Potato	Onion seed	Potato	Onion seed	Potato	Onion seed
Potato Pure	357.6	—	384.6	—	316.1	—	272.8	—	286.7	—
Potato + Onion	360.7	6.126	379.1	1.582	250.7	5.6	220.0	8.36	222.2	7.912
Potato + Fennel	—	—	—	—	301.0	16.8	255.0	13.02	252.0	14.831
Potato + Onion, with additional fertilizer for intercrop	—	—	—	—	—	—	225.9	11.19	244.3	10.913
Potato + Fennel, with additional fertilizer for intercrop	—	—	—	—	—	—	272.8	14.14	280.3	16.964
Onion pure	—	13.710	—	11.736	—	8.7	—	13.12	—	11.359
Fennel pure	—	—	—	—	—	18.9	—	21.70	—	31.30
C.D. (5%)	N.S.	1.340	N.S	0.915	16.8	N.S. (O) N.S. (F)	30.0	3.27(O) 2.16 (F)	21.0	1.73 (O) 3.33 (F)

(O) = For Onion,(F) = for Fennel

Table 3. Land equivalent ratio and crop equivalent, (q/ha) of intercrop treatments

Treatment	Land equivalent ratio*					Crop equivalent, q/ha*				
	1987-88	1988-89	1988-90	1991-92	1992-93	1987-88	1988-89	1989-90	1991-92	1992-93
Potato + Onion	1.455	1.120	1.436	1.444	1.472	605.7	442.38	425.7	638.0	617.8
Potato + Fennel	—	—	1.841	1.535	1.353	—	—	448.0	352.7	363.2
Potato + Onion, with additional fertilizer for intercrop	—	—	—	1.681	1.813	—	—	—	785.4	790.0
Potato + Fennel with additional fertilizer for intercrop	—	—	—	1.652	1.520	—	—	—	378.9	407.5

*Land equivalent ratio = (Yield of main crop in intercropping system/yield of main crop in sole crop system) + (yield of intercrop in intercropping system/yield of intercrop in sole crop system)

Crop equivalent, q/ha = [(Yield of main crop in intercropping system × rate per q of main crop) + (yield of intercrop in intercropping system × rate per q of intercrops)] / rate per q of main crop.

fennel yield in intercrop compared with sole crop came down to 15 and 35% from 36 and 40% during 1991-92 and 4 and 46% from 30 and 53% during 1992-93, respectively.

From the fore-going para it is clear that Kufri Badshah is much better competetor than JH 222 as reduction in onion yield was much higher when it was grown with Kufri Badshah as compared to JH 222. Further yield of Kufri Badshah in sole as well as intercrop was same. It may be because Kufri Badshah is a tall growing variety and thus it suppressed the growth of onion. Out of the two intercrops tested, onion seed crop proved better competetor (Table 2) than fennel. It may be due to the fact that onion seed crop got initial boost in the growth from the reserve food present in onion bulb.

Land equivalent ratio (LER) of all intercrop treatments was more than unity during all the years. Crop equivalent (CE) was also improved by all the intercrop treatments (Table 3). There was further improvement in LER and CE when fertilizer recommended for main as well as intercrop was applied to the intercrop treatments. Net return during all the years increased (Table 4) with the growing of intercrop in

Table 4. Comparative net return in Rs/ha

Treatment	1987-88	1988-89	1989-90	1991-92	1992-93
Potato pure	37135	40515	44966	42751	45467
P + O	61464	41047	56002	107791	103687
P + F	—	—	65820	58421	60473
P + O (F)	—	—	—	136086	136868
P + F (F)	—	—	—	63167	68813
O	61859	51989	36309	122015	129151
F	—	—	25922	31714	46130

*Net return has been calculated by deducting the cost of fertilizers and seed from the gross income. Potato sold at Rs. 125/q during 1987-88 and 1988-89, Rs. 160/q during 1989-90 and Rs. 200/q during 1991-92 and 1992-93.

Onion seed sold at Rs. 5000/q, during 1987-88, 1988-89, 1989-90 and Rs. 10,000/q during 1991-92 and 1992-93.

Fennel seed sold at Rs, 1400/q, during 1989-90 and Rs. 1500/q during 1991-92, 1992-93.

Potato seed purchased at Rs. 225/q, during 1987-88 and 1988-89, Rs. 240/q during 1989-90, Rs. 350/q during 1991-92 and 1992-93.

Onion bulb purchased at Rs. 300/q during 1987-88 and 1988-89, Rs. 325/q during 1989-90 and Rs. 400/q during 1991-92 and 1992-93.

Fennel seed purchased at Rs. 2500/q during 1989-90 and Rs. 3000/q during 1991-92 and 1992-93.

** P = Potato, O = Onion, F = Fennel, (F) = With additional fertilizer for intercrop.

potato compared with sole crop of potato. When the recommended dose of fertilizer for intercrop was also added in the intercropped plots, net return increased further. During 1991-92 and 1992-93 net return was higher when onion was grown as intercrop in potato compared with potato + fennel. However, during 1989-90, onion crop was affected by purple blotch and thus its yield was reduced considerably and therefore, during this year potato + fennel performed better than potato + onion. When in intercropped plots fertilizers recommended for only main crop was given, onion sole crop resulted in higher net return compared with potato + onion. However, when recommended fertilizers for intercrop as well as main crop were applied to the intercropped plots, net return from potato + onion was higher than the sole onion crop.

It may be concluded that it is possible to grow fennel or onion as intercrop in early maturing varieties of potato like JH 222 for higher net return but it is not possible to grow intercrop in tall growing and late varieties of potato like Kurfi Badshah.

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FERTILIZER MANAGEMENT IN POTATO BASED CROPPING SYSTEMS-III. EFFECT OF RESIDUAL AND APPLIED FERTILITY ON SECOND SUCCEEDING CROPS OF OKRA AND PALAK

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ABSTRACT : Okra and *palak* (spinach) were grown as second succeeding crops in sequence with potato-tomato and potato-okra, respectively to study the residual effect of fertilizer doses. Fertility levels given to second succeeding crops were no fertilizer, 25, 50 and 75% of the recommended dose of N without P and K and recommended dose of NPK. Higher dose of NPK (33% higher than the recommended) applied previously to potato increased fruit yield and NPK content of foliage in okra. However, in *palak*, improvement in yield and NPK content was recorded only during the second year while zinc applied to potato had no effect on any of these parameters. Application of the recommended nitrogen without P and K to the second succeeding crops of okra and *palak* was enough to obtain yield statistically at par with the recommended dose of NPK. Nitrogen content of the foliage increased in both the crops with increase in the dose of nitrogen, however, P and K content of the foliage was not influenced by the N application.

INTRODUCTION

The potato has highest potential of providing *bio-mass* per unit area and time. Heavy doses of fertilizers are recommended for this crop. Under such a situation, residual effect of fertilizer can always be expected and should be considered while applying fertilizers to the succeeding crops. Being a short duration crop, potato provides opportunity for growing many *kharif* and spring crops in the sequence.

The effect of fertility (NPK) levels and zinc on growth and yield of potato and yield of 1st succeeding crops of tomato and okra have already been reported (6,7). The present investigation has been carried out to study the effect of residual and applied fertility on growth and yield of second succeeding crops of okra and *palak* in two potato based cropping systems, viz. (1) Potato-tomato-okra and (11) Potato-okra-*palak*.

MATERIALS AND METHODS

After the harvest of first succeeding crops of tomato and okra, the already laid plots were prepared by manual labour with spade. Before sowing of the second succeeding crops, soil samples were taken from each treatment and analysed for N,P and K status of soil (Table 1). As in case of first succeeding crops (7), there were 20

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Table 1. Soil status for NPK after harvest of first succeeding crops (Tomato and Okra)

Treatment	N kg/ha		P_2O_5 kg/ha		K_2O kg/ha	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
F I						
N_0	140.6	146.4	38.5	41.0	305.0	325.0
N_1	140.9	147.0	--	--	--	--
N_2	142.0	150.0	--	--	--	--
N_3	143.2	152.6	--	--	--	--
NPK	144.8	152.4	43.4	47.0	337.0	356.0
F II						
N_0	142.0	151.4	40.5	43.0	326.0	337.0
N_1	143.6	153.6	--	--	--	--
N_2	143.8	155.0	--	--	--	--
N_3	145.0	156.0	--	--	--	--
NPK	147.0	160.0	47.5	50.6	354.0	369.0

treatment combinations of four fertility levels applied to potato crop and five to the second succeeding crops. Four fertility levels applied to potato crop were combinations of two levels each of NPK recommended i.e. 150 kg N, 50 kg P_2O_5 and 100 kg K_2O/ha (F.I.) and 33% higher than the recommended dose (F.II) and zinc 0 (Z_0) and 25 kg Zn SO_4 (Z_1). Fertility levels for second succeeding crops were, no fertilizer application (N_0), 25 (N_1), 50 (N_2) and 75% (N_3) of the recommended dose of nitrogen, without P and K and recommended dose of NPK i.e. 100 kg N, 50 kg each of P_2O_5 and K_2O for okra and 80 kg N, 40 kg each of P_2O_5 and K_2O/ha for *palak* (NPK). The layout, crop rotation and fertility treatment in a plot remained the same during both the succeeding crops and the years of experimentation (1991-92 and 1992-93).

Second succeeding crop, okra cv. Varsha Uphar (in first cropping sequence) was sown on 22 and 20 June during 1992-93, respectively. The seeds were sown at 45 × 20 cm by dibbling method. Three seeds were sown at one place and when the plants were of 10-12 cm height the crop was thinned leaving one healthy plant at each place. Each plot comprised eight rows with 12 plants in each row. Second succeeding crop *palak* cv. HS-25 (in second cropping sequence) was sown on 24 and 22 June during 1992 and 1993, respectively. The seeds were sown in rows 25 cm apart and when plants were 10-12 cm high the crop was thinned to maintain 10 cm spacing between plants. Each plot comprised fifteen rows with 35 plants in each row. Full quantity of P and K and half of N were applied as basal dose as per treatment and remaining half dose of N was top dressed as per recommendation for okra and *palak* during both the years. All cultural practices adopted were as per recommendation for okra and *palak*. Data on growth and yield characters were recorded during both the years of investigation.

Table 2. Effect of residual and applied fertility levels on growth and yield characters in second succeeding crop of okra

Treatment	Plant height (cm) at 90 D/P		Days taken to 50% flowering		Number of fruit/plant		Total fruit yield q/ha	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
1. Fertilizer applied to potato crop								
A. Fertility (NPK) Level								
F-1	115.95	104.80	45.96	45.20	15.63	18.20	68.87	73.34
F-II	116.44	107.14	45.70	45.33	15.93	18.82	69.98	74.92
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
2. Fertilizer applied to second succeeding crop								
N_0	89.30	74.80	44.66	44.33	11.08	13.00	44.60	47.90
N_1	101.03	94.81	45.80	44.91	13.41	15.75	59.20	62.00
N_2	113.20	104.37	46.25	45.08	15.33	20.50	64.92	87.38
N_3	135.30	120.54	46.50	45.80	19.91	23.46	79.78	92.22
NPK	140.15	125.33	46.96	46.50	21.66	24.08	99.06	103.47
C.D. at 5%	5.91	6.53	0.59	0.72	3.26	2.70	16.26	17.44

RESULTS AND DISCUSSION

Residual effect on okra : In second succeeding crop okra, the residual effect of higher NPK level previously applied to potato significantly influenced plant height and number of fruits per plant but only during 1992-93 and fruit yield (Table 2) and NPK content of plant (Table 3) during both the years of investigation over recommended dose of fertility. The better growth and yield performance during second year may be due to the cumulative effect of fertilizers applied to the same plot (Table 1). Residual effect of zinc previously applied to potato had no effect on any of the growth and yield characters during both the years (Table 2, 3) suggesting that the residual effect of NPK was more than that of zinc. Residual effect of fertilizers applied to potato crop on subsquent crops has also been reported (1,2).

Increase in nitrogen levels increased the hieght of okra plant (Table 2). Plant height recorded at 75% of the recommended N was at par with the recommended dose of NPK. The results corroborate findings of Khan and Jaiswal (3) and Lenka *et al.* (4). Increase in height with higher level of nitrogen may to due to an increased uptake of nitrogen, which being the constituent of protein and the protoplasm, vigourously induced the vegetative development of the plants. Nitrogen, however, delayed flowering. Highest number of days taken to attain fifty per cent flowering with recommended dose of NPK but it was statistically at par with application of 75% of recommended N.

Table 3. Effect of residual and applied fertility levels on NPK content of foliage of second succeeding crop, Okra

Treatment	NPK content of foliage					
	N%		P%		K%	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
Fertilizer applied to potato crop						
A. Fertility (NPK) level						
F-I	2.08	2.05	0.120	0.124	1.76	1.81
F-II	2.10	2.09	0.122	0.126	1.79	1.85
C.D. at 5%	0.01	0.02	0.001	0.02	0.02	
B. Zinc						
Z_0	2.08	2.06	0.120	0.125	1.77	1.82
Z_1	2.09	2.06	0.121	0.125	1.78	1.84
C.D. at 5%	NS	NS	NS	NS	NS	NS
Fertilizer applied to second succeeding crop						
N_0	1.62	1.59	0.115	0.119	1.70	1.74
N_1	1.82	1.79	0.115	0.119	1.71	1.75
N_2	2.05	2.02	0.116	0.120	1.71	1.75
N_3	2.35	2.18	0.116	0.120	1.72	1.76
NPK	2.64	2.60	0.135	0.149	2.01	2.10
C.D at 5%	0.02	0.04	0.004	0.003	0.03	0.04

Increased level of nitrogen significantly improved the number of fruit per plant and fruit yield (Table 2). Number of fruits per plant and fruit yield recorded with 75% nitrogen of recommended dose were statistically at par with recommended dose of N,P,K, during both the years. Singh *et al.* (5) has also suggested that fertilizer residues provided ample scope to reduce the dose of costly P and K fertilizers in potato based cropping system. Signicantly higher N, P and K content (Table 3) of foliage was recorded when higher fertilizer dose was previously applied to the potato crop. Nitrogen content increased significantly with every increase in N level, however, N; P and K content of foliage was signignificantly higher where recommended dose of NPK applied to second succeeding crop of orka. The increase in N, P and K content may probably be due to the increased availability of nutrients which encouraged uptake and concentration in different organs of plant.

Residual effect on *palak*: Days taken to first and second cutting of the *palak* were not influenced by the NPK and zinc previously applied to potato crop, however, it decreased singnificantly by about 10 days with increased level on nitrogen and NPK given to *palak* (Table 4). Minimum number of days taken to first cutting was recorded where recommended dose of NPK was applied to the second succeeding crop of *palak*. With the treatments of recommended dose of NPK and 75% N of the

Table 5. Effect of residual and applied fertility levels on NPK content of foliage in second succeeding crop of *palak*

Treatment	NPK content of foliage					
	N%		P%		K%	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
Fertilizer applied to potato crop						
Fertilizer (NPK) level						
F-I	1.54	1.49	0.114	0.107	2.19	2.12
F-II	1.57	1.54	0.116	0.113	2.21	2.21
C.D at 5%	N.S.	0.02	N.S.	0.001	N.S.	0002
B. *Zinc*						
Z_0	1.56	1.53	0.114	0.110	2.21	2.17
Z_1	1.55	1.51	0.115	0.110	2.19	2.17
C.D at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Fertilizer applied to secondsucceeding crop						
N_0	1.43	1.42	0.110	0.105	2.10	2.06
N_1	1.47	1.43	0.110	0.105	2.11	2.06
N_2	1.50	1.46	0.110	0.107	2.11	2.08
N_3	1.59	1.56	0.111	0.108	2.12	2.09
NPK	1.79	1.75	0.131	0.124	2.54	2.47
C.D at 5%	0.02	0.03	0.003	0.03	0.04	

Table 4. Effect of residual and applied fertility on growth and yield characters of second succeeding crop, *palak*

Treatment	Days taken to first cutting		Days taken to second cutting		Total yield q/ha	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
Fertilizer applied to potato crop						
A. *Fertility (NPK) level*						
F-I	40.46	42.00	33.12	33.88	107.44	80.20
F-II	39.80	41.72	32.86	33.70	109.11	82.14
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
B. *Zinc*						
Z_0	40.26	41.96	33.08	33.37	107.72	80.55
Z_1	40.00	41.76	32.90	33.71	108.83	81.50
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Fertilizers applied to second succeeding crop						
N_0	46.66	48.33	39.33	40.00	75.48	56.08
N_1	43.00	44.00	35.00	36.33	81.31	62.96
N_2	38.33	40.33	32.66	33.06	93.75	70.82
N_3	36.66	38.66	39.33	30.33	132.88*	102.02*
NPK	36.00	38.00	28.66	29.33	158.18*	114.12*
C.D. at 5%	1.58	1.72	1.21	1.60	28.79	13.54

*The yield data include the yield of third cutting also.

recommended dose to *palak*, third cutting was also obtained. Maximum yield was recorded with recommended dose of NPK which was statistically at par with 75% N applied to the second succeeding crop. Higher NPK level previously applied to potato crop increased *palak* yield but the differences were significant during the second year only. Application of zinc to potato crop did not influence *palak* yield significantly. The yield obtained with 75% N alone of the recommended dose was as good as obtained with recommended dose of NPK suggesting that the second succeeding crop of *palak*, in potato based cropping system, did not need additional P and K fertilizers as also reported by Grewal *et al.* (2)

Significantly higher N, P and K content of foliage were recorded during 1992-93 only, where higher fertilizer dose was applied to potato crop (Table 5). The significant effect during second year may be due to cumulative effect of fertilizers. Nitrogen content increased significantly with every increase in nitrogen level. However, N, P and K content of foliage was significantly higher where recommended dose of NPK was applied to the *palak* crop.

The results suggest that in both the potato based cropping systems, second succeeding crops of okra or *palak* did not need additional P and K fertilizer but 75% nitrogen of the recommended dose was enough to raise the successful crops of okra and *palak*.

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EFFECT OF FERTILISER N RATE AND NITRIFICATION INHIBITOR ON THE NUTRIENT UPTAKE OF POTATO - II. SECONDARY NUTRIENTS

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

It is reported that the use of nitrification inhibitor or the ammonium nutrition decreases the content of Ca and Mg in different plants (2,3,4,). Little information is available on the response of N nutrition under field conditions on the uptake of secondary nutrients at different growth stages. The present investigation was undertaken to study the effect of N fertilization and a nitrification inhibitor, CMP (1 - Carbamoyl - 3(5) methyl pyrazole) on the uptake of Ca and Mg during the growth period of potato crop.

The Ca and Mg contents were estimated in dry matter adopting Versenate method. The uptake was determined on the basis of the Ca and Mg contents in foliage and tubers and the dry matter produced during the growth period.

Calcium uptake : It is evident from the data (Table1) that the Ca uptake by the tops and tubers increased gradually during the growth period. The amount of Ca already taken up till the flowering period accounted for 63-68% of the total Ca requirement of the crop. From that, only 2% Ca was transported to the tubers in the same period (flowering). Batz (1) reported that the potato plant at the time of flowering absorbed 90% of its total Ca requirement. The different N levels increased Ca uptake by the tops and tubers during the growth period (Table 1). The increase in the total Ca uptake at physiological maturity was found to be between 90-102% at 240 kg N/ha without and with CMP, respectively over the control treatment. In the presence of CMP, the Ca uptake by the tops and tubers was not much affected during the growth period. The Ca removal calculated uniformly for 100 quintals fresh tubers inclusive of its foliage amounted to 95 kg (Mean of all N levels).

Magnesium uptake : The data presented (Table 2) show that the Mg uptake by the tops increased steadily and reached its maximum at tuber bulking phase, whereas the Mg uptake by the tubers continued to increase till its physiological maturity. The total Mg uptake showed a trend similar to the Mg uptake by the tops. The results reveal further that the amount of Mg already taken up till the flowering

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Table 1. Ca uptake (kg/ha) during the growth period at different N levels

N levels/ (kg/ha)	Ca uptake (kg/ha) Tops				Tubers		
Days*	21	35	65	100	35	65	100
Without CMP							
0	7.2	25.0	30.8	41.3	0.5	0.8	2.0
80	12.5	31.7	47.7	47.2	0.7	1.3	3.6
160	17.8	45.5	74.2	69.9	0.8	1.7	3.4
240	16.8	52.5	69.4	61.7	1.1	2.0	3.9
Mean	13.6	38.7	55.5	55.0	0.8	1.5	3.2
With CMP							
0	6.7	22.0	28.9	36.9	0.5	1.2	2.3
80	13.3	31.7	34.2	39.1	0.7	1.2	3.6
160	13.2	43.7	71.3	68.5	1.0	1.9	4.2
240	12.7	49.9	65.5	79.9	0.8	1.3	4.7
Mean	11.5	36.8	50.0	56.1	0.8	1.4	3.7
CD (0.05)							
N Levels				9.04			N.S
CMP				N.S.			N.S.
N×CMP				N.S.			N.S.

*after emergence

Table 2. Mg uptake (kg/ha) during the growth period at different N levels

N levels/ (kg/ha)	Mg uptake (kg/ha) Tops				Tuber		
Days*	21	35	65	100	35	65	100
Without CMP							
0	1.4	3.7	2.4	3.6	1.3	5.9	6.6
80	2.3	5.3	6.5	4.4	1.9	5.8	7.9
160	4.2	11.5	17.2	9.7	2.1	7.5	8.9
240	4.1	11.1	14.9	9.5	2.5	8.6	8.4
Mean	3.0	7.9	10.3	6.8	2.0	7.0	8.0
With CMP							
0	1.2	4.1	3.1	2.6	1.6	5.0	7.5
80	2.6	5.5	4.7	2.7	2.4	5.9	2.6
160	3.2	12.2	16.5	9.0	2.8	7.4	8.3
240	3.5	13.1	17.4	12.9	2.5	7.9	9.3
Mean	2.6	8.7	10.4	6.8	2.3	6 5	8.3
CD (0.05)							
N Levels				1.95		N.S	
CMP				N.S.		N.S.	
N × CMP				N.S.		N.S.	

*after emergence

period (on 35th day), accounted for 67-73% of the total Mg requirement of potato plant at physiological maturity. From that, nearly 20% Mg was transported to the tubers at the same period. According to Batz (1), the potato plant absorbed until the flowering period 57% of its total Mg requirement. In the present study, 100 q fresh tubers inclusive of its haulms removed on an average 22 kg/ha of Mg from the soil. The different N levels increased the Mg uptake during the growth period and thereby, a spectacular increase was observed at the maturity phase in the treatment of 240 kg N/ha with CMP (Table 2). The use of CMP did not alter much the Mg uptake at different growth stages. The uptake values at physiological maturity were even slightly higher in the presence of CMP. The results indicate that the uptake of divalent cations, viz. Ca and Mg by potato crop was not adversely affected by dominant ammonium nutrition of potato plant.

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STUDIES ON POTATO BASED CROP ROTATIONS IN EASTERN UTTAR PRADESH

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Multiple cropping system of agriculture provides scope to utilize resources effectively and efficiently. Not only this, it also enhances the food production and keeps the production at high levels and stabilizes the productivity of the crops. Keeping these facts in mind experiments were conducted to find out the production potential of various potato based cropping systems under agro-climatic conditions of eastern U.P.

Experiments were conducted during 1990-91 and 1991-92 in randomised block design with four replications at N.D. University of Agriculture and Technology, Kumarganj, Faizabad. The soil of the experimental field was loamy in texture. The pH of the soil was 7.5, available N (100 and 130 kg/ha), organic carbon (0.25 and 0.25%), Four cropping systems, viz. C_1-potato-okra-paddy, C_2 potato-*urd*-maize, C_3-potato-*moong*-okra, C_4-wheat-bottle gourd-paddy were tried. The crops were raised as per their recommended package of practices. The gross plot size was 7.2 x 7.2 m. The source of N, P and K were urea, single superposhphate and muriate of potash. The net profit and cost of cultivation were calculated on nearest existing market price.

Crop yield : The potato yielded almost similar under all the potato based cropping systems (Table 1). However, the potato yield equivalent varied with variation in crop sequences. The highest (490.31 q/ha) potato yield equivalent was recorded from potato-*moong*-okra. The potato-okra-paddy was the next best cropping system. Contrary to this, the wheat based cropping system i.e., wheat-bottle gourd-paddy produced the lowest potato yield equivalent (257.69 q/ha). The results showed that potato based systems were more productive than wheat based systems. Soni and Kaur (3) reported that in addition to two principal crops, a third crop of legume in summer season or short duration variety of potato taken in between the two principal crops was more productive. The higher potato yield equivalents in different cropping systems were mainly attributed to higher yields as well as price of okra in comparison to cereal and pulses yields and their prices.

Economics : Economics of different systems showed that the cost of cultivation (Rs. 24225/ha) was highest in potato-okra-paddy system and minimum cost of

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Table 1. Yield of crop (q/ha) obtained from different cropping systems (average of 2 years)

Cropping systems	Potato	Cereals			Legumes		Vegetable		
		Rice	Wheat	Maize	Urd	Moong	Okra	Bottle guord	Potato equivalent
Potato-okra-paddy	247.63	43.9	-	-	-	-	42.43	-	473.82
Potato-*urd*-maize	248.18	-	-	45.61	11.60	-	-	-	397.46
Potato-*moong*-okra	254.77	-	-	-	-	13.065	60.90	-	490.31
Wheat-bottle gourd-paddy	-	45.69	33.25	-	-	-	-	75.99	257.69

Table 2. Economics of various cropping systems (average of 2 years)

Rotations	Yield (q/ha)		Gross income (Rs./ha)	Cost of cultivation	Net return (Rs./ha)
	M.P.	B.P.			
Potato-	247.93	-	30972.5	14850.0	16122.50
Okra-	42.30	35.92	13625.0	4075.0	9550.5
Paddy	43.90	60.20	11577.0	5300.0	6277.0
			56175.0	24225.0	31950.0
Potato-	248.18	-	31027.0	14850.0	16177.0
Urd-	11.69	19.89	10346.5	3660.0	6686.5
Maize	45.60	73.63	8313.5	3600.0	4713.5
			49687.0	22110.0	27577.0
Potato-	254.70	-	31869.0	14850.0	17019.0
Moong-	13.6	25.14	12351.0	3685.0	8666.0
Okra	60.9	40.70	17091.0	4050.0	13041.0
			61311.0	22585.0	38726.0
Wheat-	33.25	51.70	12533.0	5181.5	7351.0
Bottle gourd	76.0	-	7605.0	3000.0	4605.0
Paddy	45.20	68.5	12108.8	5300.0	6798.8
			32246.8	13481.5	18755.3

cultivation (Rs. 13481.50/ha) was recorded in wheat-bottle guard-paddy cropping system. The highest gross income (Rs. 61311/ha) was obtained by the potato-*moong*-okra crop sequence. The higher gross income with this cropping system was because of higher yield of potato as well as okra with higher prices. Besides, the yield of okra vegetable also gave more profit as compared with cereal and legume crops. Baker (1) and Rao and Willy (2) concluded that multiple cropping systems with legumes after special advantage to farmers reduced the probability of low income. Maximum net profit (Rs. 38726.0/ha) was obtained from potato-*moong*-okra. The minimum gross income (Rs. 32246.50)/ha and net profit (Rs. 18765.0/ha) was obtained from the wheat-bottle gourd-paddy cropping sequence.

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J. Indian Potato Assoc. 22 (3-4) : 159-161 (1995)

EFFECT OF POTATO BASED INTERCROPPING SYSTEM ON YIELD AND ECONOMICS

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

Intercropping is one of the efficient tools available at present to increase net-returns per unit area. In this respect, no work has been done under Madhya Pradesh conditions. An experiment was, therefore, conducted to evaluate the intercrop to fetch maximum net-return and better utilization of resources in case of potato.

A field experiment was conducted during *rabi* season of 1991-92 and 1992-93 at Zonal Agricultural Research Station, Chhindwara (M.P.) under AICPIP. The soil available is clay loam and contained 383, 16 and 600 kg/ha of available nitrogen, phosphorus and potassium, respectively with 7.8 pH. The experiment was laid out in a randomized block design with four replications having plot size of 4.2 × 3.0 m. The treatment comprised potato, onion, and fennel as sole crops, potato × onion, potato × fennel in furrows as intercrop with and without recommended doses of fertilizer to onion and fennel. Potato was planted on 20th Oct. & 7th Nov. at 60 ×20 cm. Onion and fennel were planted on 29 Oct. and 8th Nov. within the potato rows with inter row spacing 10 and 20 cm. Sole onion and fennel were planted at 20 × 10 cm and 30 × 20 cm. respectively. The recommended doses of fertilizers were applied to potato (120:100:100 kg NPK/ha), Onion (50:60:40 kg. NPK/ha) and fennel (20:20:10 kg NPK/ha) but fertilizer application to intercrop was as given in table 1.

Yield of main crop : The highest average yield of 290.8 q/ha was obtained with sole crop of potato. Lowest yield of potato (227.6 q/ha) was obtained from fennel intercrop without recommended dose of fertilizer (Table 1). Yield reduction in potato due to intercrop was higher when inter crop was grown without recommended dose of fertilizer, because of the competition for nutrient, soil moisture and solar energy. Singh and Rathi (2) also observed reduction in tuber yield by 6% when intercropped with mustard.

Potato equivalent yield : The highest potato equivalent yield 367.7 q/ha was recorded with potato + onion with recommended dose of fertilizer and lowest in fennel sole crop i.e. 130.5 q/ha. All the intercropping systems produce higher potato equivalent yield than the sole crop. It is due to maximum utilization of renewable and non-renewable resources of the production and higher economic value of inter crop produce.

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Table 1. Effect of treatments of main and intercrop on yield and net returns

Treatments	Yield (q/ha) 1991-92		Yield (q/ha) 1992-93		Av. Yield (q/ha)		Potato equivalent yield			Av. net return
	main crop	intercrop	main crop	intercrop	main	inter crop	1991-92	1992-93	Av. yield	(Rs/ha)
Potato (Sole)	266.3	——	315.3	——	290.8	——	266.3	315.3	290.8	38674
Onion (Sole)	295.5	-	281.0	-	288.2	-	260.7	321.1	290.9	48510
Fennel (Sole)	4.6	-	9.9	-	7.2	-	86.2	174.8	130.5	21820
Potato + Onion*	186.7	130.5	281.8	73.8	234.3	102.8	301.8	366.1	33.0	45990
Potato + Onion**	201.3	152.7	293.6	92.6	247.5	122.7	366.0	399.3	367.7	50497
Potato + Fennel*	193.2	2.5	227.6	3.5	227.6	3.0	240.8	324.2	282.5	37088
Potato + Fennel**	218.4	2.8	281.4	4.7	294.9	3.7	270.8	364.4	317.6	4270
CD at 5%	26.3	——	25.3	——	——	——	19.8	35.3	21.3	2222

Note :
01. For intercrop* without and** with recommended dose of fertilizer.
02. The price per quintal of potato, onion and fennel Rs. 170/-, 150/- and 3200/- for 1991-92 and Rs. 175/-, 200/- and 3100/- for 1992-93, respectively.
03. Average net returns have been calculated by deducting the cost of seed & fertilizer from the gross income.

Net return : Potato+onion with recommended dose of fertilizer gave the highest net return of Rs. 50497/ha followed by potato + onion without recommended dose of fertilizer. The lowest net returns were obtained under fennel grown as sole crop (Table 1).

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EFFECT OF COST REDUCTION SCHEDULES ON YIELD AND ECONOMICS OF POTATO PRODUCTION

V.P. Jaiswal[1]

Seed and fertilizers are two major input in potato (*Solanum tuberosum* L.) cultivation. Optimum seed rate for medium to large seed size tuber is 30-40 q/ha in plains (1, 2, 4, 6) accounting more than 50% of total cost of cultivation. Many a times use of optimum seed rate is not possible because of inability to utilize input to the tune of recommended level. Under such condition, use of higher dose of fertilizers at reduced seed rate may increase the tuber yield. Present investigation, therefore, was undertaken to investigate the best combination of fertilizers and seed rate in order to reduce the cost of cultivation.

Field experiment was conducted at Central Potato Research Station, Jalandhar during autumn 1991-92 and 1992-93. Cost reduction schedules were prepared through combination of 3 seed rates (30, 22.5 and 15 q/ha) of equal weight of seed size tuber (35-40g) and 3 fertility levels (100, 75, and 50% fertilization at recommended doses (180 kg N, 80 kg P_2P_5, 120 kg K_2O/ha). Combination of 100% seed rate (30 q/ha) and 100% fertilizer dose acted as a check. Experiment was conducted in randomized block design with four replications. The soil was sandy loam containing 0.385% organic carbon, 11.2 kg available P and 174.7 kg available K/ha during 1992-93 with pH 8.2. Tubers of cv. Kufri Badshah pre-sprouted for 7 days were planted on 9th October in 1991 and 12th October in 1992. Net plot size was 3.6 x 2.4m during both the years. Spacing between rows was 60 cm while spacing within row varied according to seed rate. Haulm cutting was done on 16th January, 1992 and 25th January, 1993. Harvesting was done 10-15 days after haulm cutting. Recommended plant protection measures and agronomical practices were followed.

In general, yield level during 1991 was higher than 1992. Tubers/plant and tuber weight/plant were significantly higher at lower seed rate (Table 1). This was due to more intra-row spacing available to each plant at lower seed rate which resulted in less competition for nutrient and moisutre. The number of stems/m^2 were found to be significantly higher at optimum seed rate (30 q/ha). Number of stems/m^2 decreased significantly from 25 to15 with decrease in seed rate from 30 to 15 q/ha. Sekhon and Singh(7) reported 27.1 to 35.3 stems/m^2 to be optimum for medium size tubers for getting good yields. Fertility level significantly increased the

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Table 1. Effect of seed rate and fertilizer levels on growth and yield attributes of potato (1992)

Fertilization* (%)	Seed rate (q/ha) 30.0	22.5	15.0	Mean
		Plant height (cm)		
100	80.9	72.3	76.1	76.4
75	74.7	73.2	69.9	72.6
50	65.3	64.7	65.9	65.3
Mean	73.6	70.1	70.6	
		No. of tuber plant^{-1}		
100	5.0	5.1	7.6	5.9
75	5.1	6.1	5.9	5.7
50	4.6	4.7	7.0	5.4
Mean	4.9	5.3	6.8	-
		Tuber Wt. plant^{-1}		
100	395	456	623	491
75	377	462	548	462
50	315	375	493394	
Mean	362	431	555	
		No. of stem m^{-2}		
100	26	20	16	21
75	25	19	15	20
50	24	19	14	19
Mean	25	19	15	-
CD (P=0.05)	Height	Tuber Plant^{-1}	Tuber Wt. plant^{-1}	Stem m^{-}
Fert.	3.45	NS	41 - 2	NS
Seed.	NS	0.95	41 - 2	2.2
F× S	NS	NS	NS	NS

			N	P_2O_5	K_2O	
* Fertilization (%)	100	deotes	180	80	120	(recommended)
	75	"	135	60	90	(75% of rec.)
	50	"	90	40	60	(50% of rec.)

plant height and tuber weight/plant; being maximum at 100% fertilization. Seed rate and fertility level both significantly influenced the tuber yield during both the years. The highest tuber yield (364 q/ha), maximum net return (Rs. 16,380/ha) and highest cost : benefit ratio (1.82) were recorded at optimum seed rate (30 q/ha) with 100% fertilization. All other levels of seed rate and fertilizer significantly reduced the tuber yield as well as net return. Pooled data showed that optimum seed rate (30 q/ha) significantly increaed the mean tuber yield by 15% as compared to seed rate at 22.5 q/ha. This could be due to higher number of stems/m^2 at optimum seed rate. The results are in conformity with the findings of Kushwah and Grewal (5), Jaiswal and Saini (3) who reported that lower seed rate (20 q/ha) gave significantly lower yield than seed rate of 30 to 40 q/ha. 100% fertilization gave significantly higher

Table 2. Effect of seed rate and fertilizer levels on tuber yield (q/ha) and economics

Fertilization (%)	Seed rate (q/ha) 30.0	22.5	15.0	Mean
100	364	314	-	339
75	332	291	-	312
50	299	263	-	281
Mean	332	289	-	-
	Net income (Rs. ha⁻¹) and cost : benefit ratio			
100	16380 (1.82)	13630 (1.77)	-	15005 (1.79)
75	13935 (1.72)	12085 (1.71)	-	13010 (1.72)
50	11390 (1.62)	10040 (1.62)	-	7143 (1.62)
Mean	13902 (1.72)	11918 (1.70)	-	-
CD (P=0.05)			Pooled	
Treatment			13.0	
Fert.			9.2	
Seed.			7.5	
F × S			NS	

Nutrient cost : N (Rs. 6.90 kg^{-1}), P (Rs. 12.50 kg^{-1}), K (Rs. 6.50 kg^{-1}) Cost of seed = Rs. 300 q^{-1} cost of produce = Rs. 100 q^{-1} Parentheses value correspond to cost : benefit ratio.

mean tuber yield and the increase was 9 and 21% compared to 75 and 50% fertilization repectively. Interaction between seed rate and fertilization were found to be nonsignificant. Data presented in table 2 revealed that reduction in seed rate to the extent of 25% invariably reduced the tuber yield to the extent of 12-14% irrespective of the level of fertilization. Further reduction to 50% in optimum seed rate during 1992, yield decreased to the extent of 17-25%. Net return and cost : benefit ratio were maximized at 100% fertilization at all seed rates, suggesting that under condition of resource constraint, if seed rate has to be reduced, reduction in fertilization is not economically advised.

On the basis of these findings, it may be suggested that reduction of cost through seed is not advised to obtain maximum yield. However, if fertilizer has to be reduced to the tune of 50% to meet the budget, under such constraint condition, it is better to reduce the seed rate to the extent of 25% and use 100% of recommended fertilizer dose.

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ACCUMULATION AND DISTRIBUTION PATTERN OF SULPHUR-CRITICAL STAGE OF REQUIREMENT AND TISSUE TESTING IN POTATO PLANT

J.P. Singh[1] and O.P. Srivastava[2]

Accumulation and distribution pattern of the nutrient in different plant parts through the growth period is helpful in indicating the critical stage of the nutrient requirement and thus the time of tissue testing and S-application. No information is available on accumulation and distribution pattern of sulphur in potato grown under short day conditions in vast area of the Indian sub continent.

A field experiment was conducted in an alluvial soil at Vegetable Research Farm of Banaras Hindu University, Varanasi (25.2 °N latitude and 83.1°E longitude) in the year 1989-90. The soil was deficient in sulphur with 9.6 kg S/ha (0.15% $CaCl_2$ extractable). Treatments were two levels of sulphur, 0 and 25 kg/ha replicated 12 times in randomized block design. Plot size was 4.2m × 2.8m (7 rows of 14 tubers each). Crop was uniformly fertilized with N-P_2O_5-K_2O @ 180, 80 and 150 kg/ha, respectively, through sulphur free fertilizers. Sulphur was applied through gypsum at planting. Pre sprouted tubers (50-55g) of cv. Kufri Badshah were planted in the last week of October. Crop was optimally irrigated with low sulphur (1.5 ppm SO_4-S) deep tube well water, manually weeded and normal plant protection measure were followed. Plants were periodically sampled after 10 days interval starting from 30 days after planting (DAP). Leaf, stem and tubers were separated, chopped and dried in oven at 70°C. Dry matter yield of different plant parts was expressed on per plant basis. Samples were analyzed for total S concentration (1). Accumulation of S in different tissues was calculated by the product of dry matter and S concentration.

Sulphur application increased the S concentration (Table 1) and accumulation (Table 2) in leaf, stem and tubers. In all the tissues, S concentration decreased with age of the crop, due to dilution effect of growth and partly due to redistribution from leaf and stem to tubers.

Accumulation of S in tissues being a product of dry matter and S concentration, was maximized in leaves at 40 DAP, remained more or less same up to 70 DAP and decreased thereafter (Table 2). About 61% of the maximum accumulation was over

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Table 1. Effect of sulphur application on concentration of sulphur in tissues of potato plant

Plant Parts	Levels of S (kg/ha)	Stages of growth (days after planting)						
		30	40	50	60	70	80	90
		S concentrarion (% dry matter)						
Leaf	0	0.30	0.30	0.26	0.26	0.25	0.24	0.23
	25	0.45	0.43	0.35	0.32	0.28	0.27	0.25
	Mean	0.37	0.37	0.30	0.29	0.26	0.25	0.24
Stem	0	0.22	0.16	0.14	0.09	0.07	0.05	0.05
	25	0.32	0.30	0.28	0.22	0.11	0.09	0.09
	Mean	0.27	0.23	0.21	0.15	0.09	0.07	0.07
Tuber	0	-	0.12	0.09	0.09	0.09	0.09	0.11
	25	-	0.16	0.16	0.14	0.13	0.13	0.14
	Mean	-	0.14	0.12	0.12	0.11	0.11	0.12
C. D. (<0.05 P)								
Leaf		0.03	0.03	0.03	0.03	0.02	0.02	NS
Stem		0.03	0.02	0.02	0.03	0.02	0.02	0.02
Tuber		-	0.02	0.02	0.02	0.02	0.02	0.02

Table 2. Effect of sulphur application on total S accumulation in tissues of potato plant

Plant Parts	levels of S (kg/ha)	Stages of growth (days after planting)						
		30	40	50	60	70	80	90
		S accumulation (mg/plant)						
Leaf	0	20.5	37.0	39.7	39.2	41.2	35.7	30.2
	25	38.0	60.0	59.9	56.9	55.2	42.1	36.4
	Mean	29.2	48.5	49.8	48.0	48.2	38.9	33.3
Stem	0	6.0	10.0	9.7	6.5	5.5	4.2	4.2
	25	11.2	21.1	23.4	18.2	11.4	8.2	7.4
	Mean	8.6	15.5	16.5	12.4	8.4	6.2	11.6
Tuber	0	-	5.5	17.0	37.2	51.0	76.2	94.2
	25	-	7.2	31.6	66.7	83.9	108.0	129.4
	Mean	-	6.4	48.6	52.0	67.4	92.1	111.9
Total	0	26.5	52.5	66.4	82.9	97.7	116.1	124.4
	25	49.2	88.3	114.9	123.6	150.5	158.3	173.2
	Mean	37.8	70.4	90.6	103.2	124.1	137.2	148.8
C.D. (<0.05P)								
Leaf		0.4	2.9	2.8	2.9	2.9	2.3	1.9
Stem		0.6	1.1	1.1	1.0	0.8	0.4	0.7
Tuber		-	0.5	3.8	3.6	4.5	6.6	7.9
Total		2.5	5.6	6.4	7.1	7.9	7.8	9.3

at 30 DAP. This early accumulation indicated an early need of sulphur for optimum growth and yield of potato. In stems accumulation of S maximized at 50 DAP, but 52 to 94% of the maximum accumulation was over at 30 to 40 DAP, respectively. Accumulation of S in tubers increased linearly from 40 to 90 DAP. Similarly the total S accumulation increased linearly up to 90 DAP with 61% of the maximum accumulation taking place at 50 DAP, emphasizing once again the early requirement

of sulphur supply to potato. Maximum increase in S concentration in leaf tissues due to sulphur application coupled with maximum accumulation suggested that S deficiency can be easily detected by tissue testing between the period 30 to 40 DAP.

Highest concentration of S in leaf tissue compared to stem and tubers and maximum accumulation at an early stage of growth appears to be of significance for the growth and yield of potato. This indicates requirement of sulphur at early stage of growth. Therefore, application, either foliar or soil, later in the season may not be beneficial.

It is concluded from the results that if needed, sulphur has to be applied to potato at the earliest i.e. at the time of planting. The optimum time for tissue testing of S in potato crop grown in plains was indicated to be between 30 to 40 days after planting.

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FERTILIZER ECONOMY OF POTATO BASED CROPPING SEQUENCE IN MADHYA PRADESH

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

Potato-okra-soybean is more viable and profitable potato based cropping system as against most popular maize-wheat-cowpea crop sequence in Satpura plateau of Madhya Pradesh (1).

In view of increased fertilizer cost, efficient use of fertilizers in cropping systems is imperative. Hence, the present investigation was conducted to find out the fertilizer response to yield and economics of potato based sequence.

The study was carried out at Zonal Agricultural Research Station, Chhindwara during 1991 to 1994. The soil is clay loam having pH 7.8, it contained 383, 16, and 600kg/ha of available nitrogen, phosphorus and potassium, respectively. The experiment was laid out in split plot design with four replications. First crop of potato (Kufri Badshah) was planted in the first week of November at 60 x 20 cm spacing with recommended dose of 120;100;100kg N, P_2O_5 and K_2O ha. The second crop of okra (Parbhani Kranti) having three levels of fertilizers (viz.0, 50 and 100% of recommended dose i.e. 50;25;25 N, P_2O_5 and K_2Okg/ha) was sown in the first week of March at 40 x 10 cm distance. During *Kharif*, third crop of soybean (JS-80-21) was sown in the last week of June at 40 x 6 cm distance along with three fertilizer levels (viz.0, 50 and 100% of recommended dose i.e. 20;80;20 N, P_2O_5 and K_2O kg/ha.

Average yield of potato was 268.5 q/ha with net return of Rs. 33033/ha and cost benefit ratio of Rs.1.80 per rupee investment (Table 1). The yield of okra increased with the application of NPK over control, but difference between 50% (91.4 q/ha) and 100% (92.9 q/ha) recommended dose of fertilizers was non significant. The maximum net return of Rs. 18,843/ha with higher cost benefit ratio 2.67 was recorded with 50% recommended dose of fertilizers to okra. The last crop soybean of the sequence was taken after okra. Significant differences were obtained among the different levels of fertilizers . An average yield of 25.2 q/ha and maximum net return of Rs.13038/ha with cost benefit ratio of Rs.2.89 per rupee investment was obtained with 50% of recommended fertilizer doses given to soybean in the preceding crop of okra. Maximum net return of Rs. 64, 906/ha and the

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Table 1. Effect of fertilizer on yield and economics (Mean of 1991-94) of potato-okra-soybean crop sequence in Madhya Pradesh

Treatments	Yield (q/ha)			Mean	Cost of Cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Cost: Benefit ratio
	91-92	92-93	93-94					
Potato	286.4	225.9	293.2	268.5	18270	51303	33033	1.80
Okra (0% RDF)	77.5	70.0	78.5	75.9	6623	21307	14684	2.21
Okra (50% RDF)	93.6	86.0	94.7	91.4	7054	25897	18843	2.67
Okra (100% RDF)	92.2	90.0	96.7	92.9	7494	26355	18861	2.51
SEm ±	5.1	3.0	3.3	3.5	-	-	-	
CD at 5%	NS	10.2	11.2	10.5	-	-	-	
Okra (0% RDF)								
Soybean (0% RDF)	21.7	20.3	19.0	20.3	3683	14151	10468	2.84
Soybean (50% RDF)	22.6	21.3	20.4	21.4	4508	14938	10430	2.31
Soybean (100% RDF)	25.5	23.5	23.0	24.0	5333	16038	10705	2.00
Okra (50% RDF)								
Soybean (0% RDF)	22.5	21.1	19.3	21.0	3683	14477	10794	2.93
Soybean (50% RDF)	27.2	23.3	25.0	25.2	4508	17546	13038	2.89
Soybean (100% RDF)	27.1	23.2	28.8	26.4	5333	17437	12104	2.26
Okra (100% RDF)								
Soybean (0% RDF)	24.8	22.1	21.0	22.6	3683	15711	12028	3.26
Soybean (50% RDF)	26.2	23.3	24.3	24.6	4508	17175	12667	2.80
Soybean (100% RDF)	25.6	23.6	24.5	24.6	5333	17168	11835	2.21
SEm ±	0.5	0.4	0.3	0.3	-	-	-	
CD at 5%	1.5	1.1	1.0	1.0	-	-	-	

Note :- Potato RDF 120:100:100 kg N, $P_2 O_5$ and $K_2 O$/ha.
Okra RDF 50: 25:25 kg N, $P_2 O_5$ and $K_2 O$/ha.
Soybean RDF 20: 80:20 Kg N, $P_2 O_5$ and $K_2 O$/ha.
RDF = Recommended doses of fertilizers.

per rupee return on investment was highest (Rs. 2.17) with 50% recommended dose to okra followed by 50% recommended dose to fertilizer to soybean. Thus for getting maximum net return and higher cost benefit ratio after potato, the second (okra) and third (soybean) crop require half dose of recommended fertilizers.

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I, Dr SM Paul Khurana, hereby declare that the above particulars are true to the best of my knowledge and belief.

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Sd/-
SM PAUL KHURANA
Editor-in-Chief

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FIELD AND STORAGE INFESTATION OF POTATO TUBER MOTH IN KANGRA

K. S. Kapoor and K.C. Sharma[1]

Pest damage to potato in the field as well as in the stores due to insect-pests is a major constraint for potato production. The potato tuber moth, *Phthorimaea operculella* Zeller (Lepidoptera: Gelechindae) is one of the serious pests of potato throughout the country and causes heavy losses in field and stores (3, 5). In country store, the pest has been reported to cause about 70% loss particularly during summer months (2). Larvae mine the foliage, stems and tubers in the field and tubers in the country stores. Keeping in view the alarming attack of this pest in stores in Kangra district of Himachal Pradesh, present studies were conducted during 1989-1990 to have a fair assessment of this pest in the field and stores where three crops of potato are grown in a year. Potato stores in eight localities, viz., Bhawarna, Chimbalhar, Dari, Dhad, Mator, Nagrota Bagwan, Palampur and Panchrukhi in Kangra valley were selected. For this purpose 100 randomly selected samples were collected from the stores in each locality and were kept in polythene bags for the emergence of moths.

Field infestation of larvae on stem, leaves and other tender parts were collected in five randomly selected plants at weekly intervals starting from January till May. The data on field infestation of potato tuber moth were correlated with the different weather parameters.

Results revealed that moth infestation varied from locality to locality. Maximum infestation of the pest was found at Nagrota Bagwan (72.5%) followed by Chimbalhar (68.0%), Mator (67.5%), Palampur (53.0%), Dari (52.0%), Panchrukhi (49.5%), Dhad (35%), and Bhawarna (32.5%). Higher infestation of the pest at Nagrota Bagwan, and also at Chimbalhar, Mator, Dari, Palampur and Panchrukhi may be due to the fact that the stores in these localities were humid, *kuchha* and uncleaned in contrast to dry, ventilated, *pucca* and treated stores in other localities. The per cent damage in stores due to this pest in Kangra valley was reported to vary from 30-60% (5).

Weekly observations on the field infestation of the potato tuber moth in the Kangra district revealed that there was no population of the pest from January to the last week of February. However, in the last week of February, a larval population of 0.5 larvae per plant was found. After that, an increase in population was observed

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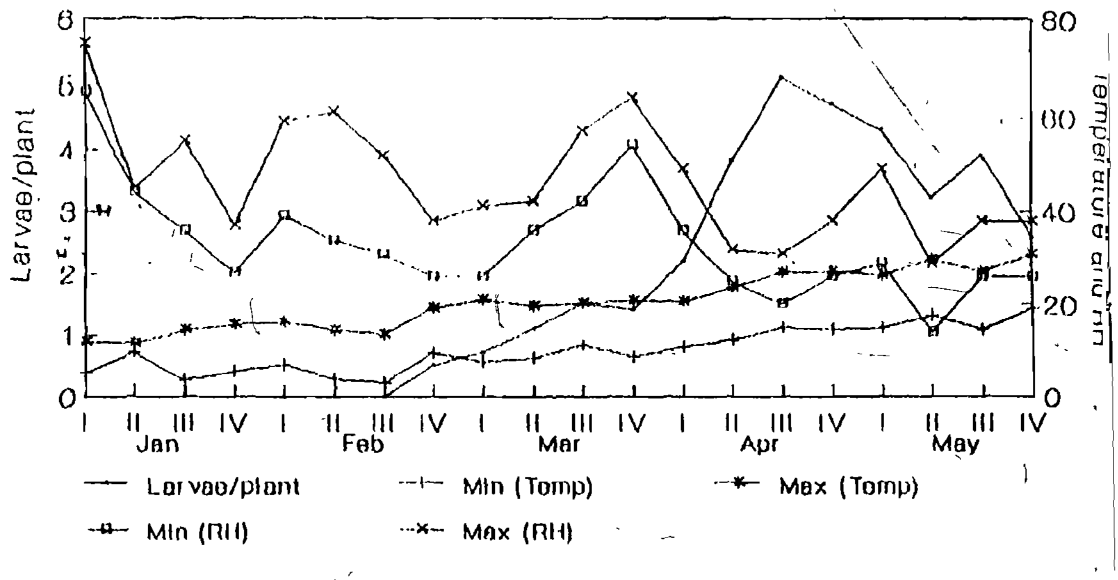

Figure 1. Population fluctuation of potato tuber moth w.r.t. weather factors in Kangra district of Himachal Pradesh

till third week of April when a maximum population of 5.1 larvae per plant was observed. In the last week of May, only 2.6 larvae per plant were found. Correlating the pest population with weather parameters, it was observed that maximum and minimum temperatures were positively correlated, while negative correlation was found with low and high humidity. The relationship with rainfall was also negatively correlated with the pest infestation (r = 0.0409) indicating that higher temperature favoured the pest population while rainfall was detrimental. Hains (1) reported that low temperature (< 10^0 C) is not suitable for egg hatching in this pest.

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PERFORMANCE OF SELECTED CROSSES FOR TRANSPLANTED SEEDLING POTATO CROP*

S.K. Pandey[1]

Two methods of raising TPS have been successful in India i.e. (i) raising the crop by seedling transplanting in the field and (ii) producing seedling tubers in the first year and using these tubers as seed next year (4). One hundred and five crosses were studied for combining ability of parents selected on the basis of genetic divergence (5) during 1989-90 at Modipuram, Meerut. Out of these, eight promising crosses, selected on the basis of their performance for yield and tuber characters were further evaluated in a large trial in 1990-91 for their suitability in raising transplanted seedling potato crop.These croosses involved parents with good combining ability for yield, showed high positive SCA effects and uniformity in foliage and tubers.

Seedlings were transplanted in October, 1990 in field at Central Potato Research Station, Modipuram (Meerut) in three replications using randomized block design. The sub-plot size was kept at 14.40 m^2 (6 rows of 20 seedlings each). Standard cultural and manurial practices were followed during the crop period. The data on per cent germination, seedling survival, vigour and uniformity of foliage and tubers (on the scale of 1-5 with 1 being the least and 5 the most vigorous/uniform), total and marketable yield and number of tubers per plant were recorded. The data on total yield and marketable yield/plant were converted in to q/ha and the number of tubers/plant were converted in to tubers per m^2. A randomized block design analysis was done.

The analysis of variance (Table 1) showed significant differences among the crosses for all the characters studied except vigour. The results (Table 2) showed that these populations when used as transplanted seedlings in field, yielded between 15.2 to 18.6 t/ha with nearly 70 to 87% marketable yield. The populations Kufri Jyoti x EX/B-687 and Katahdin x EX/B-687 showed yields of 17 to 18 t/ha, marketable yield of about 81% and high tuber uniformity (rating 4.33 as against 4.5 to 5.0 of commercial varieties). These figures compare well with the best selected TPS populations of Central Potato Reseach Institute and International Potato Center (Region SW Asia), New Delhi (1.2.3) and can be introducted for evaluation in the large scale trials.

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Table 1. Analysis of variance

Source	df	MSS							
		Seed germination	Seedling survival	Vigour	Foliage uniformity	Yield (Q/ha)	Marketable yield (Q/ha)	No. of tuber/m²	Tuber uniformity
Replication	2	0.167	2.792	0.292	0.167	45.375	45.792	8.375	0.292
Treatment	7	40.667**	9.976**	0.476	1.089**	474.423**	741.565**	985.405**	0.762*
Error	14	1.024	1.173	0.244	0.214	66.994	51.030	16.708	0.244

Table 2. Performance of transplanted seedlings

Cross	Seed germ.	Seedling Survival	Vigour	Foliage uniformity	Yield (q/ha)	Mkt. Yld. (q/ha)	Tubers per m²	Tuber uniformity
Kufri Jyoti x EX/A-680-16	98.33	86.70	4.67	4.00	176.0	139.30	138.00	3.70
Kufri Jyoti x EX/B-687	99.00	86.67	4.67	4.67	186.00	151.00	116.67	4.33
Katahdin x EX/A-680-16	97.00	87.00	4.33	4.33	163.00	143.33	125.00	3.67
Kufri Jyoti x EX/B-687	97.33	84.33	4.33	4.67	176.00	142.33	106.67	4.33
Kufri Jyoti x EX/A-679-10	97.00	89.67	3.67	3.33	152.00	106.67	125.33	3.00
Kufri Badshah x VB-8	98.67	86.33	4.00	4.00	157.67	119.33	91.00	3.67
Kufri Bahar x VB-8	96.33	90.00	4.00	4.33	160.33	139.33	101.33	3.67
Kufri Jeevan x EX/A680-16	88.00	87.33	3.67	3.00	151.67	117.00	86.00	3.00
LSD (1%)	1.46	1.56	0.71	0.67	4.73	10.27	2.36	0.71

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ROLE OF NITROGEN LEVELS AND HAULM CUTTINGS ON ECONOMIC YIELD OF RED AND WHITE POTATOES

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

Potato is an important cash crop and it produces more food per unit area and time than the cereals. Production of crop depends on the contribution of many factors, among them judicious application of nitrogen and date of haulms cutting are of vital importance. Present study was undertaken to investigate the effect of these two factors on economical yield of potato crop.

Two separate experiments, one on potato variety Kufri Bahar (white skined) and other on Kufri Lalima (red skined) were conducted with four levels of nitrogen (0, 50, 100, and 150 kg/ha) and five dates of haulms cutting (80, 90, 100, 110, and 120 DAP). Treatments were laid in R.B.D. factorial with three replications at the Institute of Agricultural Sciences, B.H.U., Varanasi during *rabi* season of 1986 and 1987. Well sprouted tubers of each variety were planted at inter and intra row spacing of 60 x 20 cm. N, P, and K were applied through urea, single super phosphate and muriate of potash respectively. Full dose of phosphorus (50 kg/ha) and potassium (80 kg/ha) to all the plots and half dose of nitrogen as per treatments, were applied as basal dressing as band placement. The remaining half dose of nitrogen was top dressed as per the treatments at the time of earthing. The crop was grown in irrigated condition. The haulms were cut manually and tubers were harvested one week after haulms cutting.

Increase in levels of nitrogen from 0-150 kg/ha increased the yield from 114.0 to 240.3 q/ha in cv. Kufri Bahar and 120.3 to 281.4 q/ha in cv. Kufri Lalima. Delayed haulm cutting from 80-120 DAP increased the yield from 168.4 to 221.1 in cv. Kufri Bahar and 180.8 to 254.5 q/ha in cv. Kufri Lalima (Table 1). The higher yield at higher nitrogen levels was due to the better vegetative growth resulting in assimilation of more carbohydrates and translocation to the tubers which ultimately helped in the enlargement of tuber size and weight (2, 5). Delayed haulm cutting up to maturity progressively increased the yield due to continuous translocation of photosynthates over a long period (1, 3).

Although the yield and net profit increased upto 150 kg N/ha and removal of haulms at 120 DAP, the most economical dose was 100 kg N/ha i.e. Rs. 21443.5

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Table 1. Effect of N levels and haulms cutting on total tuber yield and net profit (pooled over the years)

Treatments	Kufri Bahar		Kufri Lalima	
	Yield (q/ha)	Net profit (Rs./ha)	Yield (q/ha)	Net profit (Rs./ha)
N Levels				
0	114.0	4118.2	120.3	6267.3
50	188.7	15335.6	233.1	22479.8
100	231.8	21443.5	270.2	29912.8
150	240.3	22606.6	281.4	31590.6
CD at 5%	13.6	1832.6	20.0	3561.7
Days after planting				
80	168.4	12013.1	180.8	15697.9
90	179.7	13717.6	205.3	19608.7
100	192.1	15883.2	231.9	23854.1
110	207.3	17847.7	246.3	26171.9
120	221.1	19918.2	254.5	27473.9
CD at 5%	14.9	2048.9	22.4	3982.2

and Rs. 29912.8 and removal of haulms at 120 DAP i.e. Rs. 19918.2 and Rs. 27473.9 in cvs. Kufri Bahar and Kufri Lalima, respectively. In general net profit was more in cv. Kufri Lalima, as compared to Kufri Bahar due to its better response to nitrogen and suitability in North Indian conditions (4).

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