ISSN 0970-8235
J. Indian Potato Assoc. 29 (3 - 4) : 99-184, 2002

JOURNAL OF THE INDIAN POTATO ASSOCIATION

Volume 29, No. 3 - 4
(August-December, 2002)
(Issued April, 2003)

POTATO
INDIAN ASSOC.
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Official Journal of
The Indian Potato Association
Central Potato Research Institute, Shimla - 171 001

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ISSN 0970 - 8235
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29 (3-4) August-December, 2002

Contents

Influence of temperature and relative humidity regimes on aggressiveness of A1 and A2 mating types of *Phytophthora infestans* — Jhilmil Gupta, B.P. Singh, M.R. Khan, and P.H. Singh 99

Evaluation of menthol and mentha oil as potato sprout inhibitors — Ashiv Mehta and H.N. Kaul 107

Assessing in-season trends in potato crop using remote sensing and GIS - A case study for West Bengal — Ashvir Singh, S. Panigrahy and J.S. Parihar 113

Suppression of potato sprout growth by alcohols, acetaldehyde and 2, 4-dichlorophenoxy acetic acid-ethyl ester at higher temperature — Vijay Paul and R. Ezekiel 119

Chlorophyll fluorescence induction kinetics in potato: Effects of water stress and high light intensities — Ashoo Sharma, J.S. Minhas, P.S. Basu and Jitendra Mohan 123

Physiological losses in potatoes under non-refrigerated storage : Effect of N, P and K fertilizers — Ashiv Mehta and S.P. Singh 129

Changing scenario of insect pests of potato in Satpura plateau of Madhya Pradesh — S.R. Dharpure 135

Fertilizer management in potato-*bajra*-groundnut and potato-groundnut-*til* cropping systems under North Gujarat conditions — G.V. Sasani, C.K. Patel, N.H. Patel and R.N. Patel 139

Standardization of spacing for seed tuberlet production from TPS under nursery beds in Gujarat — B.T. Patel, A.V. Barad, S.M. Chaudhari, C.K. Patel and R.N. Patel 143

Integrated nutrient management in potato-vegetables crop sequence under rainfed hilly condition of Meghalaya — S.K. Singh and S.S. Lal 147

Nitrogen and potassium interaction effect on yield attributes of potato — Gyanendra Kumar Rai, M.M. Verma and Jagdish Singh 153

New record of a painted bug , *Bagrada cruciferarum* Kirkaldy (Pentatomidae : Homoptera) on potato in Satpura plateau of Madhya Pradesh — S.R. Dharpure 155

On-farm evaluation of TPS derived transplants and seedling tubers in Satpura zone — D.N. Nandekar 157

Room temperature storage of some advanced potato hybrids and varieties in the plains of Gujarat — R.N. Patel, V.H. Kanbi, C.K. Patel, N.H. Patel and S.M. Chaudhari 159

Correlation and path analysis of some economic characters in potato — P.B. Patel, N.H. Patel and R.N. Patel 163

Response of potato to NPK fertilization in *terai* soils of West Bengal — S.B. Goswami 165

Effect of different concentrations of thiourea on emergence and tuber yield in potato cv. Kufri Jyoti — S.P. Uniyal and A.C. Mishra 167

Performance of potato hybrids/varieties in the saline soils of North Bihar — S. Kumar, S.M. Paul Khurana and S.K. Pandey 171

Genetic divergence among advanced hybrids and varieties of potato — Akhilesh Chandra Mishra, N.P. Singh and Hari Har Ram 175

Comparative growth performance and yield of potato cultivars in mid-West plains of Uttar Pradesh — Manoj Raghav 177

Book Review 181

Honarary & Distinguished fellows of IPA 183

List of referees (2000-2002) 184

J. Indian Potato Assoc. 29 (3 - 4) : 99-106, 2002

INFLUENCE OF TEMPERATURE AND RELATIVE HUMIDITY REGIMES ON AGGRESSIVENESS OF A_1 AND A_2 MATING TYPES OF *PHYTOPHTHORA INFESTANS*

Jhilmil Gupta[1], B.P. Singh[2], M.R. Khan[3] and P.H. Singh[1]

ABSTRACT: Aggressiveness of A_1 and A_2 mating types of *Phytophthora infestans* was compared at three temperature regimes *viz.*, 15, 18 and 21° C and two levels of relative humidity viz., 85% and 100% using potato cultivars Kufri Chandramukhi and Kufri Jyoti. Data revealed that A_2 mating type isolates were more aggressive at all the three temperature regimes but the differences were non-significant. Interaction between temperature regimes x cultivars was also non-significant. Zoosporangial germination in A_2 mating type isolates was significantly higher than A_1 mating type isolates at 10, 18, 20 and 23° C. A_2 mating type isolates also showed higher aggressiveness both at 85 and 100% RH but the differences were more pronounced at 100% RH.

INTRODUCTION

Aggressiveness of *Phytophthora infestans* is affected by several factors, out of which temperature and humidity are most important (1, 4, 5). Optimum temperature and relative humidity for various developmental stages of *P. infestans* have been studied in great detail and documented (1, 3, 7, 8, 9, 11, 14). During the last two decades, *P. infestans* structure across the globe, including India, has undergone a sea change. Hitherto unknown A_2 mating type (new population) has appeared in almost all the potato growing regions in the country. Studies tend to suggest that two mating types of *P. infestans* (A_1 and A_2 mating types) have differential response to host resistance and environmental factors. However, there is no experimental proof to substantiate this fact. Present investigation was carried out to study response of A_1 and A_2 mating types of *P. infestans* to varying regimes of temperature and relative humidity using susceptible and moderately resistant cultivars.

MATERIALS AND METHODS

Production of *P. infestans* inoculum: *P. infestans* race 1.2.3.4.5.7.8.10 was multiplied using tuber-slice method. The zoosporangia were gently dipped in sterilized distilled water to dislodge them. The zoosporangial suspension was then incubated at 12° ± 2°C for 60-90 minutes for zoospores release. The zoospore suspension was calibrated to a desired level (6×10^4) using haemocytometer under a microscope (10 x) for each isolate.

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Effect of temperature on aggressiveness of *P. infestans*: Aggressiveness of four isolates each of A_1 and A_2 mating types was compared at three temperature regimes, *viz.* 15, 18 and 21°C on two potato cultivars, *viz.* Kufri Chandramukhi (susceptible) and Kufri Jyoti (moderately resistant) using detached leaf method (13). Five leaflets were used for testing each isolate. Plants of both the cultivars were raised in 20 cm earthen pots in a glasshouse. On 40th day of planting the terminal leaflet of 4th leaf from the top was placed on plastic separator of the incubation tray and inoculated with 100 µl zoosporangial suspension containing 6 x 10^4 zoospores./ml. In all, three sets of trays were prepared and incubated in separate BOD incubators at temperatures of 15, 18 and 21°C for five days. The lesion area was measured using the following formula:

$$\text{Area} = \frac{\pi ab}{4}$$

where a and b are the length and width of the lesion, respectively.

Effect of relative humiditty on aggressiveness of *P. infestans*: Effect of two levels of relative humidity, *viz.* 85% and 100% on *P. infestans* aggressiveness of five isolates each of A_1 and A_2 mating types was studied on two potato cultivars, *viz.* Kufri Chandramukhi and Kufri Jyoti. Potato plants were raised as described above. Two sets, each consisting of 60 plants (30 plants for each cultivar) were shifted to two humidity chambers where 85 and 100% RH was maintained. Plants were inoculated by placing filter paper discs dipped in zoosporangial suspension containing 6 x 10^4 zoosporangia/ml and incubated at 18±1°C in dark for 48 hours. Subsequently, the chambers were illuminated with 120-140 µmoles m^{-2} s^{-1} fluorescent light for 3 days. Fitness components, *viz.* infection frequency (IF), lesion area (LA) and sporulation capacity (SC) were measured on 6th day of inoculation and composite fitness index (CFI) was calculated as described by Tooley *et al.* (12). For estimating IF, the total number of lesions formed on all the inoculated leaflets were counted. IF is expressed as:

$$\text{IF} = \frac{\text{Total number of lesions formed}}{\text{Number of leaflets inoculated}}$$

Composite fitness Index (CFI) was calculated by the following formula (13);

$$\text{CFI} = \text{IF} \times \text{LA} \times \text{SC}$$

where, IF = infection frequency; LA = Lesion area; and SC = Sporulation capacity.

Effect of temperature on zoosporangial germination: Five isolates each of A_1 and A_2 mating types were compared for their zoosporangial germination at five temperature regimes, *viz.* 10, 18, 20, 23 and 30°C. *P. infestans* zoosporangia of all the isolates were grown and multiplied on tuber slices and washed in distilled water as per method described in earlier section. The zoosporangial concentration was adjusted at 10^4 zoosporangia/ml and 2 ml suspension of each isolate was added to a glass cubet separately. Five sets of all the isolates were prepared and shifted to five different incubators maintained at 10, 18, 20, 23 and 30°C. Zoosporangial germination (both direct and indirect) was recorded after 24 and 48 hours using a haemocytometer.

RESULTS

Effect of temperature on aggressiveness of A_1 and A_2 mating types: Data on aggressiveness (mean over isolates, temperature regimes and cultivars) of two mating types revealed that A_2 mating type was slightly more aggressive but the differernces were nonsignificant (mean lesion area (MLA) 4.37 and 4.63 cm^2, in A_1 and A_2 mating types, respectively). Interaction between temperature regimes and cultivars was also statistically non-significant. Similarly, interactions between mating types x temperature regimes and mating types x cultivar were also non-significant.

Aggressiveness of *P. infestans*, irrespective of the mating types, varied with temperature regimes on both the cultivars. It was highest at 18°C, followed by 21°C and 15°C (6.89, 4.91, 2.83 cm^2 MLA at 18, 21 and 15°C, respectively; $LSD_{(0.05)}$ = 0.35) on cv. Kufri Chandramukhi. Similar trend was observed on cv. Kufri Jyoti (Fig. 1).

Inter-isolate variation: Among A_1 mating type isolates, aggressiveness of isolate KCM(K)2 was highest on cv. Kufri Chandramukhi, which was statistically at par with KCM(K)13 (5.21 and 4.80 cm^2 MLA, respectively; $LSD_{(0.05)}$ = 0.68). This was followed by KCM(K)14, which was at par with KCM(K)10 (4.41 and 4.18 cm^2 MLA, respectively; $LSD_{(0.05)}$ = 0.68). Similar trend in aggressiveness of all the isolates was observed on cv. Kufri Jyoti (Fig. 2).

Aggressiveness of all the A_2 mating type isolates followed the same trend on both the cultivars. The isolate GT-2 proved most aggressive (6.08 and 5.26 cm^2 MLA on Kufri Chandramukhi and Kufri Jyoti, respectively). This was followed by isolates GT-4 (5.75 and 4.67 cm^2), GT-5 (4.55 and 3.60 cm^2) and GT-3 (4.02 and 3.10 cm^2). Isolates GT-2 and GT-4 were at par with each other but significantly more aggressive than GT-3 and GT-5 (Fig. 2).

Interactions between isolate x temperature, isolate x cultivar and isolate x cultivar x temperature were non-significant.

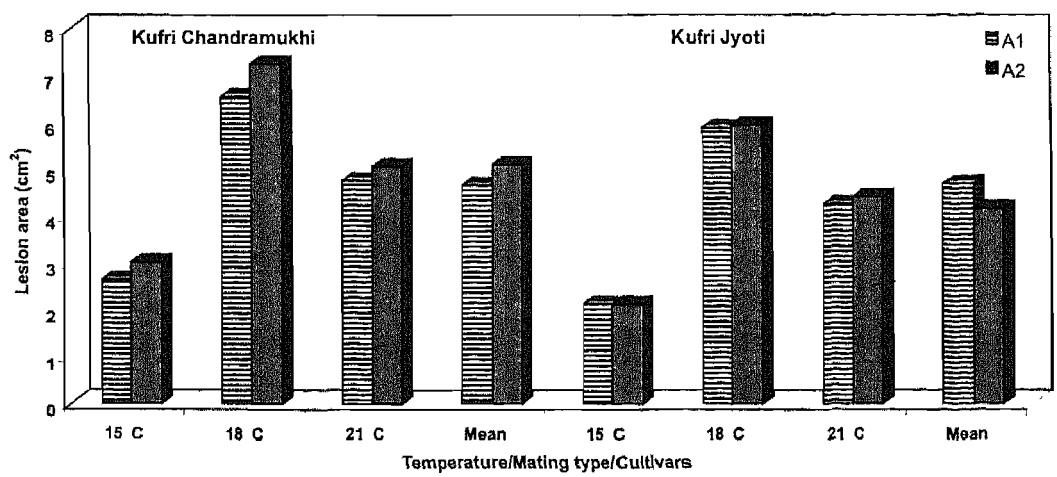


Fig. 1. Effect of temperature on aggressiveness of Phytophthora infestans mating types on detached leaves (mean over temperature)

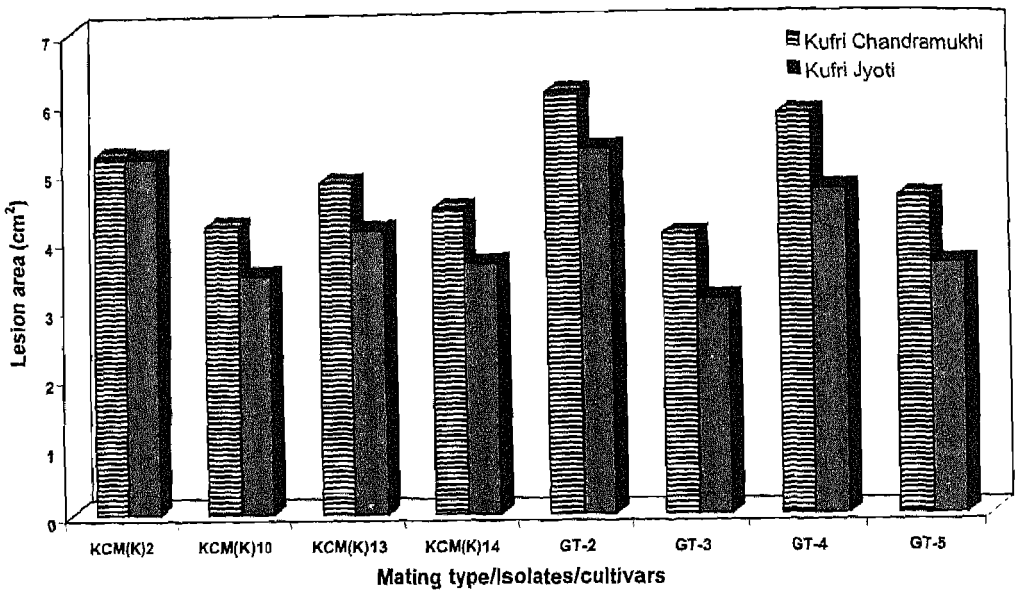


Fig. 2 Effect of isolates on aggressiveness of A_1 and A_2 mating types on detached leaves (mean over isolates)

Effect of relative humidity (RH) on composite fitness index: Data on composite fitness index (CFI) (mean over isolates/cultivars/relative humidity) revealed that A_2 mating type isolates were more fit than the A_1 mating type isolates (CFI 43867 and 33643 for A_2 and A_1 mating types, respectively; LSD $_{(0.05)}$ = 45.84). Among the two RH regimes, 100% RH was more favourable to disease development than 85% RH (CFI 62831 and 14678 for A_2 and A_1 mating types, respectively).

Interaction between mating types and RH revealed that A_2 mating type isolates (mean over isolate and cultivars) were comparatively more fit than A_1 mating type isolates both at 85% and 100% RH. However, differences were more pronounced at 100% RH (CFI 70588 and 55075 in A_2 and A_1 mating types, respectively; LSD $_{(0.05)}$ = 64.83).

Interaction between the mating types and cultivars was also significant. A_2 mating type was more fit on both the cultivars. The differences among the cultivars were almost similar (CFI of A_1 and A_2 mating types 44119 and 54462 on cv. Kufri Chandramukhi and 23165 and 33276 on cv. Kufri Jyoti, respectively, Table 1).

The interaction between mating type x RH x cultivar was significant. A_2 mating type isolates (mean over isolates) were comparatively more aggressive than A_1 mating type at both the RH regimes as well as cultivars (Table 1). Significant differences in CFI were observed among isolates of each mating type (Table 2, 3). Interactions between isolate x RH, isolate x cultivar and isolate x cultivar x RH were also significant.

Effect of RH on fitness components: Fitness components, *viz.* infection frequency (IF), lesion area (LA) and sporulation capacity (SC) did not follow the composite fitness index (CFI) pattern. It varied with RH regimes, cultivars and mating types (Table 4).

Table 1. Effect of relative humidity on fitness index of *Phytophthora infestans* mating types

Mating types	*Composite fitness index at RH (%) / Cultivars*						*Mean over cultivars*		
	85%			*100%*					
	Kufri Chandramukhi	*Kufri Jyoti*	*Mean*	*Kufri Chandramukhi*	*Kufri Jyoti*	*Mean*	*Kufri Chandramukhi*	*Kufri Jyoti*	*Mean*
A_1	15,131	9,288	12,210	73,107	37,042	55,075	44,119	23,165	33,643
A_2	21,108	13,183	17,146	87,817	53,359	70,588	54,462	33,276	43,867
Mean	18,120	11,236		80,462	45,201				
$LSD_{(0.05)}$	Mating type = 45.84 RH = 45.84 Cultivar = 45.84 Mating type x RH = 64.83 Mating type x Cultivar = 64.83 RH x Cultivar = 64.83 Mating type x RH x Cultivar = 91.71								

Table 2. Effect of relative humidity on aggressiveness of A_1 mating type isolates

Isolates	*Composite fitness index at RH(%) / Cultivars*						*Mean*
	85%			*100%*			
	Kufri Chandramukhi	*Kufri Jyoti*	*Mean*	*Kufri Chandramukhi*	*Kufri Jyoti*	*Mean*	
KCM(K) 2	21,239	14,724	17,982	98,450	81,266	89,858	53,920
KCM(K) 10	8,689	5,495	7,092	55,259	10,909	33,084	20,088
KCM(K) 13	17,339	12,601	14,970	80,665	46,648	63,657	39,314
KCM(K) 14	10,907	3,988	7,448	55,894	12,957	34,426	20,937
Patna C	17,479	9,630	13,555	75,266	33,429	54,348	33,952
Mean	15,131	9,288		73,107	37,042	55,075	
$LSD_{(0.05)}$	Isolate = 56.70 Isolate x RH = 80.19 Isolate x Cultivar = 80.19 Isolate x Cultivar x RH = 113.40						

Table 3. Effect of relative humidity on aggressiveness of A_2 mating type isolates

Isolates	*Composite fitness index at RH(%) / Cultivars*						*Mean*
	85%			*100%*			
	Kufri Chandramukhi	*Kufri Jyoti*	*Mean*	*Kufri Chandramukhi*	*Kufri Jyoti*	*Mean*	
GT-2	36,992	22,637	29,815	1,73,399	1,18,140	1,45,770	87,793
GT-3	4,268	2,372	3,320	28,722	6,908	17,815	10,568
GT-4	36,839	25,300	31,070	1,07,977	94,410	1,01,194	66,132
GT-5	14,714	7,926	11,320	72,726	24,395	48,561	29,941
SH-9	12,728	7,682	10,205	56,262	22,942	39,602	24,904
Mean	21,108	13,183		87,817	53,359		
$LSD_{(0.05)}$	Isolate = 56.70 Isolate x RH = 80.19 Isolate x Cultivar = 80.19 Isolate x Cultivar x RH = 113.40						

Table 4. Fitness components of A_1 and A_2 mating types isolates

Cultivar	*Relative humidity (%)*	*Mating type*							
		A_1				A_2			
		IF	*LA*	*SC*	*CFI*	*IF*	*LA*	*SC*	*CFI*
Kufri Chandramukhi	85	0.86	1.94	8,806	15,131	0.81	1.97	11,438	21,108
	100	1.0	3.56	20,391	37,042	0.92	3.50	25,208	53,359
Kufri Jyoti	85	0.54	1.19	13,679	9,288	0.58	1.32	14,322	13,183
	100	0:85	1.35	29,032	37,042	0.87	1.61	31,020	53,359

IF = Infection frequency; LA = Lesion area (cm^2); SC = Sporulation capacity / cm^2; CFI = Composite fitness index

At 85% RH, among A_1 mating type isolates, the isolate KCM(K)2 showed highest IF on cv. Kufri Jyoti, followed by KCM(K)13, Patna C, KCM(K)14 and KCM(K)10. Similar trend was observed with regard to LA. However, SC did not follow this trend. It was highest in isolate KCM(K)10 and least in case of KCM(K)14.

Among A_2 mating type isolates, GT-2 & GT-4 showed highest IF (0.81 each), followed by GT-5 and SH-9 (0.48 each) and GT-3 (0.33). GT-2 isolate also showed highest lesion area and GT-3 the least one. SC did not follow this trend. It was highest for the isolate GT-4 and least for GT-3.

At 100% RH regime A_1 mating type isolates followed, by and large, the same trend as occurred at 85% RH in respect of IF and LA. However, pattern of SC was altogether different at the two RH regimes. Isolate KCM(K)2 showed highest SC at 100% RH but was less than KCM(K)10 at 85% RH. Pattern of fitness components in A_1 and A_2 mating type isolates at both the RH regimes was almost similar. Pattern of fitness components on Kufri Chandramukhi was slightly different to that of cv. Kufri Jyoti.

Effect of temperature on zoosporangial germination: Germinability of A_2 mating type (mean over isolates and temperature regime) was significantly higher than A_1 mating type (64.91 and 49.45 % germination in A_2 and A_1 mating types, respectively). Among temperature regimes, 10°C was most suited for zoosporangial germination (mean over isolate 91.35%), followed by 18°C (78.57%). The difference in the germination at 20 and 23°C was not significant. No germination whatsoever was observed at 30°C. At 10°C, the germination was indirect (through release of zoospores), whereas at 18°C both direct and indirect germination was recorded, latter being more pronounced. At 20 and 23°C, both types of germination were observed in equal proportion (Table 5). Interaction between mating type and temperature was significant. Zoosporangial germination in A_2 mating type was significantly higher than A_1 mating type at the temperature regimes tested (Table 5). Inter-isolate variation in germination of both the mating types was recorded.

Table 5. Effect of temperature on sporangial germination of *Phytophthora infestans* mating types

Mating type	*Temperature regimes / % germination*				*Mean*
	10° C	*18° C*	*20° C*	*23° C*	
A_1	87.61	65.18	19.92	25.08	49.45
A_2	95.09	91.96	36.76	35.84	64.91
Mean	91.35	78.57	28.34	30.46	
$LSD_{(0.05)}$	Mating type = 2.04 Temperature = 2.88 Mating type x Temperature = 4.05				

DISCUSSION

The aggressiveness of *P. infestans* is moderated/conditioned by several factors out of which temperature and humidity are most important. Although effect of temperature on *P. infestans* and its ability to infect and cause the disease has been well understood but, there is hardly any information on the effect of temperature on aggressiveness of the two mating types (8). The present study on the effect of three temperature regimes, *viz.*, 15, 18 and 21°C, on aggressiveness of 4 isolates each of A_1 and A_2 mating types on detached leaves revealed that A_2 mating type was more aggressive at all the temperatures tested than A_1 mating type but the differences were non-significant. Similar observations were made by Mizubuti and Fry (8) who observed new lineages, US-7 and US-8 (A_2 mating type) to be more aggressive (overall as well as component wise) than old lineage (A_1 mating type).

Like aggressiveness, temperature also affects zoosporangial germination. Temperature lower than 20°C (optimum between 12-13°C) favours indirect germination of zoosporangia, whereas temperatures higher than 20°C (optimum 24°C) favours direct germination without liberation of zoospores (1, 6). Mizubuti and Fry (8) recorded lower germination of A_2 mating type zoosporangia than the A_1 mating type. In the present study, however, zoosporangial germination in A_2 mating type was significantly higher than A_1 mating type at 10, 18, 20 and 23°C.

Increase in the fitness components revealed pivotal role of RH in the blight development (10). This holds true for both, mating types and cultivars. The A_2 mating type scored over A_1 mating type at both the humidity regimes as well as on the cultivars tested. Similar effect of RH observed with regard to the composite fitness index (CFI) of the two mating types signifies the role of moisture in the disease development. This confirms earlier findings where aggressiveness of *P. infestans*, irrespective of mating types, increased with the increase in relative humidity (2). Greater CFI score of A_2 mating type over A_1 type as observed in the present study conclusively proves that A_2 mating type is more aggressive than A_1 mating type irrespective of the level of relative humidity.

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MS Received: 08.07.2002

J. Indian Potato Assoc. 29 (3 - 4) : 107-112, 2002

EVALUATION OF MENTHOL AND MENTHA OIL AS POTATO SPROUT INHIBITORS

Ashiv Mehta and H.N. Kaul[1]

ABSTRACT: Efficacy of volatile monoterpene menthol and its natural source mentha oil was studied for inhibition of potato sprouting during storage in a store with passive evaporative cooling (17-30° C, 75-95% RH). Different methods and duration of application were evaluated. Treatments with mentha oil were more effective than all comparable treatments with menthol. All dip as well as vapour treatments with mentha oil and only vapour treatment with menthol significantly reduced the sprouting of tubers till 100 days of storage. All treatments in general, reduced the sprout growth however, rotting of tubers was increased in some of the treatments after 80 days. Dip treatment induced depressions on tubers, hence only vapour treatment of tubers was finally evaluated for confirmation. All treatments with menthol and mentha oil significantly reduced the sprouting and sprout growth of tubers as compared to control without any increase in rottage of tubers till 100 days of storage. However, treatment with mentha oil for 10 days increased the rottage of tubers after 80 days of storage.

INTRODUCTION

The potato crop in the major potato growing areas of India is harvested in the month of February, after which the temperatures start shooting up. Rising temperatures result in higher physiological losses in untreated stored tubers. Lowering temperatures in well designed insulated stores run on passive evaporative cooling (ECS) could reduce rotting and weight loss but the problem of sprouting still remained (5). Chemical sprout inhibitors proved effective in reducing physiological losses, sprouting and sprout growth in ECS from March to June (8), but are not environment friendly. Therefore, a pressing need exists to search alternative sprout inhibitors that are phytochemical in nature and are more acceptable.

Certain volatile monoterpenes having low mammalian toxicity which are among the major constituents of several easily obtainable essential oils from plants, are reported to effectively inhibit sprouting and fungal growth for a short duration of 7 days at relatively low molar concentrations (10). Recently, researchers have started examining the essential oils for sprout suppressing properties as an alternative to CIPC at 8- 10°C (1, 2), but no detailed study has so far been reported. This study was, therefore, designed to assess the relative efficacy of volatile monoterpene menthol and its natural source, oil of *Mentha arvensis* (Japanese mint) which contains 80-90% menthol (4) for the inhibition of potato sprouting during storage at higher temperatures in ECS (17-30°C, 75-95% RH) with an objective to determine their potential as sprout inhibitors of potatoes.

MATERIALS AND METHODS

Healthy potato crops of cv. Kufri Chandramukhi were raised in sandy loam soils at the farm of Central Potato Research

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Station, Jalandhar during the years 1996- 1999 following recommended cultural practices. The harvested tubers were kept in heaps in the field for 15-20 days to allow them to cure before selecting samples of undamaged tubers within the weight range of 40-60 g. Different methods of application of the compounds (direct application and vapour treatment) were evaluated during first two years. Following treatments were applied uniformly as immediate post harvest treatment before storage :

Mentha oil

T_1 = 5 min. dip followed by 5 day air tight conditions

T_2 = 10 min. dip followed by 5 day air tight conditions

T_3 = 5 min. dip followed by 10 day air tight conditions

T_4 = 10 min. dip followed by 10 day air tight conditions

T_5 = Vapour treatment for 5 days under air tight conditions

T_6 = Vapour treatment for 10 days under air tight conditions

Menthol

T_7 = 5 min. dip followed by 5 day air tight conditions

T_8 = 10 min. dip followed by 5 day air tight conditions

T_9 = 5 min. dip followed by 10 day air tight conditions

T_{10} = 10 min. dip followed by 10 day air tight conditions

T_{11} = Vapour treatment for 5 days under air tight conditions

T_{12} = Vapour treatment for 10 days under air tight conditions

T_{13} = Untreated control

For dip treatment, emulsions of pure mentha oil and menthol (E. Merck) were prepared at 1% concentration in distilled water with 0.05% (v/v) Tween-80 as an emulsifier and control tubers were treated with Tween-80 alone. Tubers were dipped in emulsion for 5/10 minutes and excess liquid was drained. After air drying, the tubers were kept in airtight containers for 5/10 days. Vapour treatment of tubers was given in 4 l dessicator flasks containing 15 cm filter paper discs with either 1.0 ml of mentha oil or 1.0 g of menthol crystals. The amount of menthol was in excess of the amount theoretically sufficient to saturate the headspace in the flasks (9). No direct contact between the compound and the tubers occurred. Controls had untreated filter papers.

All treatment flasks and airtight containers were opened for five minutes on alternate days to equilibrate O_2 and CO_2 concentration with ambient air. All treatment concentrations and durations used were atleast equal to or higher than those found to be effective in inducing sprout supppression without causing extensive rottage in a preliminary study (unpublished). Two replicates of 25 tubers each were treated. Additional control tubers were stored in jute bags to determine the eventual effect of box environment on sprouting behavior. There were initial differences in sprouting pattern of tubers up to 30 days of storage after which the behaviour of different controls became comparable. Hence the control treatment in jute bags only has been presented in this paper.

Confirmatory studies were continued with bigger sample size (4 replications of 50 tubers each) with only vapour treatment of tubers which proved more effective. It was observed that opening of cans during the treatment period was essentially required to reduce the rottage of tubers in case of mentha oil treatment, whereas the sprout suppressant effect of menthol was reduced where the cans were opened during the treatment period. The treatments included in the confirmatory experiment were as follows:

T_1 = Mentha oil for 5 days (cans opened)

T_2 = Mentha oil for 10 days (cans opened)

T_3 = Menthol for 5 days (cans not opened)

T_4 = Menthol for 10 days (cans not opened)

T_5 = Menthol for 12 days (cans not opened)

T_6 = Control.

Observations on per cent tubers sprouted, average sprout length (maximum), sprout weight (g kg^{-1} tuber weight) and per cent rotting of tubers were recorded after every 20 days. Tubers having atleast one sprout longer than 0.5 cm were counted as sprouted. Statistical analysis was done after angular transformation of the original data (3). After 100 days of storage, tubers were examined carefully for tuber texture that consisted of relative tuber tactile properties of treated tubers and those from 4° C storage. The tubers from 4° C were defined as firm.

RESULTS AND DISCUSSION

Sprouting and sprout growth: All dip as well as vapour treatment with mentha oil (T_1-T_6) and vapour treatment with menthol (T_{11},T_{12}) significantly reduced the sprouting of tubers till 100 days of storage (Table 1). Dip treatment with menthol (1%) for 10 minutes (T_8, T_{10}) significantly suppressed sprouting for 60 days, whereas dip treatment for 5 minutes (T_7, T_9) was less effective and showed significant sprout suppression till 40 days of storage only (data not included). Untreated control tubers showed cent per cent sprouting by 40 days. The sprout growth remained suppressed in all treatments and maximum sprout length remained significantly lower till 100 days of storage as compared to control (Table 1). Reduction in sprout length due to the effect of treatment was more in mentha oil (55.1-100 %) as compared to menthol (20.7-38.0 %).

Table 1. Sprouting behaviour, rottage and appearance of treated tubers after 100 days of storage in ECS

Treatments	*Sprouting (%)*	*Max. sprout length (cm)*	*Rottage (%)*	**Appearance of tubers*
T_1	80.0 (64.2)	1.50	17.5 (25.4)	F
T_2	64.0 (51.4)	1.38	18.5 (26.1)	F
T_3	34.0 (36.2)	0.63	32.5 (35.4)	F
T_4	26.5 (31.6)	0.50	39.0 (39.2)	F
T_5	48.0 (44.1)	1.63	8.0 (17.5)	F
T_6	0.0 (5.7)	0.00	20.5 (27.5)	F
T_7	100.0 (90.0)	2.50	0.0 (5.7)	SS
T_8	100.0 (90.0)	2.75	0.0 (5.7)	SS
T_9	100.0 (90.0)	2.25	19.0 (26.6)	SS
T_{10}	100.0 (90.0)	2.63	17.5 (25.4)	SS
T_{11}	67.5 (56.3)	2.88	15.0 (23.3)	SS
T_{12}	62.0 (52.6)	2.25	14.0 (22.7)	SS
T_{13}	100.0 (90.0)	3.63	0.0 (5.7)	S
SE m±	3.15	0.21	1.7	-
CD (0.05)	9.70	0.65	5.4	-

* F = Firm , SS = Slightly shrivelled, S = Shrivelled
Figures in parenthesis denote transformed values

Saturated concentrations of menthol in gaseous phase were found phytotoxic to emerged potato sprouts for 24 hrs (10) and repeated application of mentha oil by ultrasonic nebulization has been reported

recently to effectively suppress sprouting at 8- 10 °C (2). Higher level of sprout inhibition observed during storage up to 100 days in case of mentha oil than all comparable treatments with menthol indicated the possible synergistic effect of various other monoterpenes and aromatic compounds present in mentha oil in addition to its major component menthol. GC composition of *M. arvensis* in India recorded many other constituents in addition to menthol e.g. 1,8-cineole, limonene, menthone, pulegone, octanol- 3, isomenthone, methyl acetate, neomenthol, piperitone (7). Many of these compounds were found toxic to emerged potato sprouts for 7 days (10).

Loss due to rottage: Tuber rotting was not detected till 60 days of storage. All treatments which effectively suppressed sprouting till 80 days of storage recorded a concomitant increase in rotting of tubers compared with no treatment control (Table 1). Earlier workers (10) have also reported increased rotting of tubers after treatment with natural sprout inhibitors.

Physical appearance of tubers : Visual rating for tuber texture after 100 days of storage revealed that tubers treated with mentha oil were firm with minimum losses as compared to menthol treated tubers which appeared slightly shrivelled (Table 1). The untreated control tubers recorded significantly higher shrivelling which is due to higher weight loss because of sprouting and advanced sprout growth. Losses due to evaporation and respiration are significantly increased on sprouting (9). Dip treatment with emulsions of mentha oil as well as menthol induced depressions on tuber skin. Whereas the vapour treatment even for long duration (10 days), when the tubers did not come in direct contact with the volatilized compounds showed positive results. The treatments significantly suppressed sprouting without having any adverse effect on tuber skin and the tubers appeared sound even after 100 days of storage.

Confirmatory experiment with vapour treatment of tubers: All treatments with the same source of mentha oil (stored at 4-6°C for 1 year) and menthol significantly decreased the sprouting of tubers during storage up to 100 days as compared to control (Fig.1). The reduction in sprouting due to the effect of treatment was more with mentha oil (57.9-100%) as compared to menthol (39.7- 46.7%) on 100 days of storage. All treatments also reduced the sprout growth (sprout length and sprout weight) of tubers as compared to control till 100 days of storage (Fig. 2). Vapour treatment with menthol for 12 days proved more effective than 10-day treatment in suppressing the sprout growth of tubers (Fig.

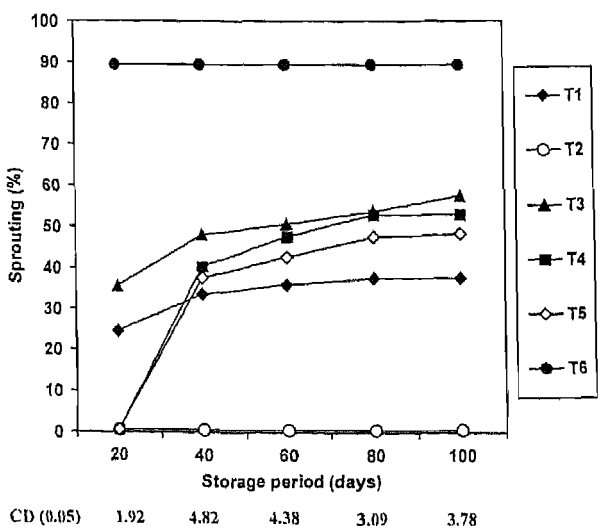


Fig. 1. Per cent tubers with sprouts during storage after vapour treatment with mentha oil and menthol. (Values in the figure are angular transformed)

2). The treatments did not influence the rottage of tubers except with mentha oil for 10 days where a significant increase in rottage was observed as compared to control. At the end of storage, treated tubers appeared firm and sound as compared to control which were much shrivelled with multiple sprouts.

The sprout suppression effect of mentha oil however, could not be achieved up to the same level with different sources of oil in the subsequent years. It may be due to the reason that the composition of mentha oil is reported to be widely influenced by climate and season during growth and the developmental stage of the plants at the time of oil extraction (6). Organoleptic evaluation on a small scale indicated no effect of treatments on sensory qualities of fresh fried chips.

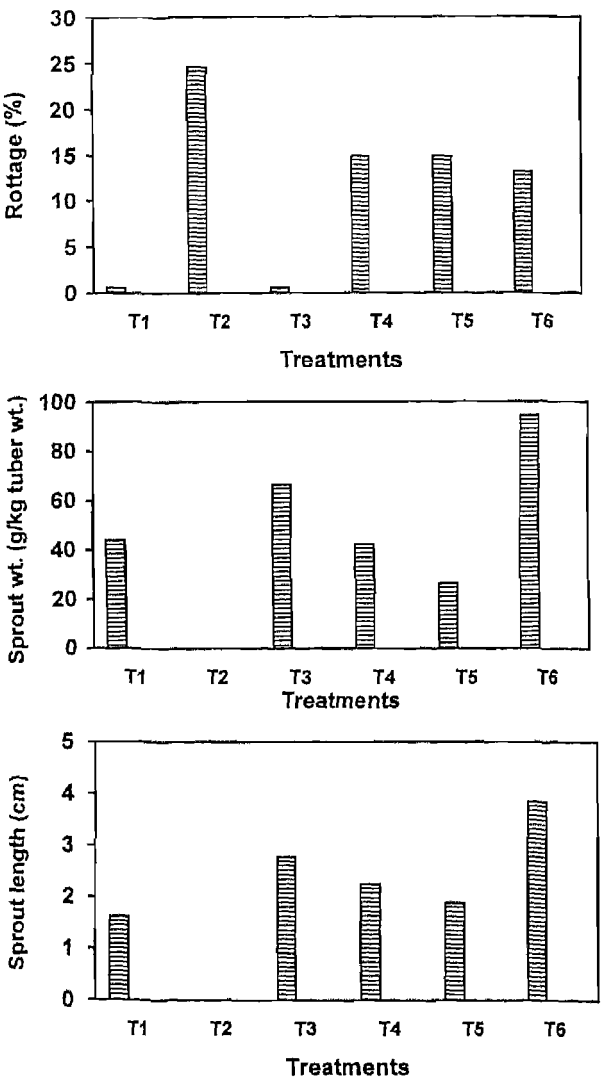


Fig. 2. Effect of vapour treatment with mentha oil and menthol on sprout growth and rottage of tubers after 100 days of storage CD (0.05) : Rottage 3.75; Sprout wt. 4.54; sprout length 0.35

Summarizing the results it may be concluded that menthol is a potent natural sprout inhibitor under non refrigerated storage conditions, which can be exploited for commercialization. Mentha oil, though more effectively suppressed sprouting, but can pose difficulty in development on commercial scale due to variability in chemical composition of oils procured from different sources. Experiments are being conducted (including tuber quality and flavour testing) to determine the commercial potential of menthol for use as sprout inhibitor of stored potatoes.

ACKNOWLEDGEMENTS

The authors thank Director, CPRI, Shimla and Head, CPRS, Jalandhar for providing necessary facilities and Mr. Raj Kumar for statistical analysis. Thanks are also due to Mr. Yogesh Gupta for help in recording the observations and to M/s Balwinder Singh Sodhi, Pholariwal, Jalandhar for the gift of mentha oil.

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MS Received: 12.07.2001

J. Indian Potato Assoc. 29 (3 - 4) : 113-117, 2002

ASSESSING IN-SEASON TRENDS IN POTATO CROP USING REMOTE SENSING AND GIS - A CASE STUDY FOR WEST BENGAL

Ashvir Singh, S. Panigrahy and J.S. Parihar[1]

ABSTRACT: Potato being a commercial semi-perishable vegetable crop, the relative crop performance information early in the season is of prime importance for its management. Satellite remote sensing data with its synoptic, temporal coverage of an area in multi-spectral bands has been used successfully for crop survey. This study addresses the feasibility of assessing the regional potato crop prospects early in the season and detecting the changes in comparison to previous years using temporal IRS WiFS data. The study was carried out for the predominantly potato growing area of West Bengal. Results showed that, though the mapping accuracy of acreage of potato at district level is poor due to the low spatial resolution, it is feasible to assess the trend of major growing areas and detect the pockets where change has occurred with good accuracy.

INTRODUCTION

Potato is an important commercial vegetable crop in India and its contribution to the national economy is significant. It is a short duration crop of 90-100 days and fits well in various cropping systems. In India potato is grown in about 1.50 million hectares of area with a production of 25.06 million tonnes (3). Uttar Pradesh, West Bengal, Bihar, Assam and Punjab are major potato growing states in the country accounting for around 80 per cent of acreage and 85 per cent of country's potato production (3). Among these states, West Bengal is one of the major potato growing states having 25 per cent share in the total potato area and production of the country. Potato crop requires precise monitoring due to its year-to-year fluctuation in production and impact on the day-to-day life of the common person. Satellite remote sensing is one of the best tools available to derive accurate and timely information on the spatial distribution of crops over large areas. Crop inventory using space-borne remote sensing data is about two decades old in India (1). Satellite based remote sensing methodology for acreage estimation of major agricultural crops such as rice, wheat, sorghum, cotton, grapes, etc. is well established (2, 6). However, efforts in acreage estimation of major horticultural crops using remote sensing techniques have been very few. Some work has been carried out for mapping of potato crop, determining site suitability for potato crop and optimum locations for cold storage (4, 5, 7). However, no attempt has been made to assess the in-season potato crop prospects that is a vital input for taking decisions on utilization of produce. The present work was carried out to develop a remote sensing and GIS based procedure to identify the trend in potato acreage early in the season and deviations compared to previous years.

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MATERIALS AND METHODS

The study area falls in the agro- climatic zone of lower Gangetic plains of India, encompassing Hoogly, Bardhman and Midnapore (East & West) districts in West Bengal. It extends between 86°50' and 88°30'E and 23°00' and 24°30'N. The four districts account for more than 70 per cent of the potato area in the state. Potato is grown as an irrigated crop during December-March. Generally, medium late varieties are grown having duration of 3-3.5 months. The area has alluvial soil, rich in fertility and of humid climate.

The Indian Remote Sensing Satellite (IRS) WiFS (wide field sensor) data with 188 m spatial resolution in red and NIR bands were used in this study. Multi-date data acquired from December to March during 1996, 1999, 2000 were used to study the crop growth. Optimum bio-window were selected based on the temporal spectral signature. Data acquired during the optimum bio-window was used to assess yearly fluctuations in potato area. Data were geo-referenced using Ground Control Points from 1:250,000 scale Survey of India topographic maps. A GIS database of the district and block boundary, rail, road, major drainage network, and village name was created using Arc/Info software. Ground truth data on potato and other crops were collected using GPS and false colour composite (FCC) prints of 1:50,000 scale. These ground truth sites were transferred to the GIS database and used for signature study and classification accuracy evaluation. Data were classified using a two-step Isodata clustering technique (8). In the first step an agricultural area mask was created. Further classification within this mask was carried out to obtain the potato cropping pattern. This approach was used to avoid misclassification with non-agricultural vegetation classes like forest, homestead, etc. The work was carried out using EASI/PACE image processing software in IBM RS 6000/ 37T computer system.

RESULTS AND DISCUSSION

As observed during field visits, potato crop is grown in the study area in rice–potato and fallow-potato rotation, the former constituting 90% of potato acreage. The former rotation was followed in areas where rainy season rice was harvested by second fortnight of November. Similar observations have been made by other workers (4, 5). Potato under this rotation is planted during November end to mid December. Analysis of temporal WiFS data showed that data acquired during mid-January was of optimum period to account for most of potato fields (both early and late ones). Rape seed/mustard is the other competing crop grown during this season. However, the calendar of this crop is slightly different from potato. Mustard crop is in peak growth stage in December while potato attains full vegetative growth by mid-January. Thus, the last fortnight of January was adjudged as the optimum bio-window for potato crop study. Single date data acquired during this period gave maximum contrast to identify potato crop from all other vegetation classes. Since the crop attained maximum leaf area index (LAI) by mid-January, the crop appeared bright red in the False Colour Composite of IRS WiFS data (red and NIR bands) acquired during the second fortnight of January (Figure 1). A two-step Isodata clustering technique

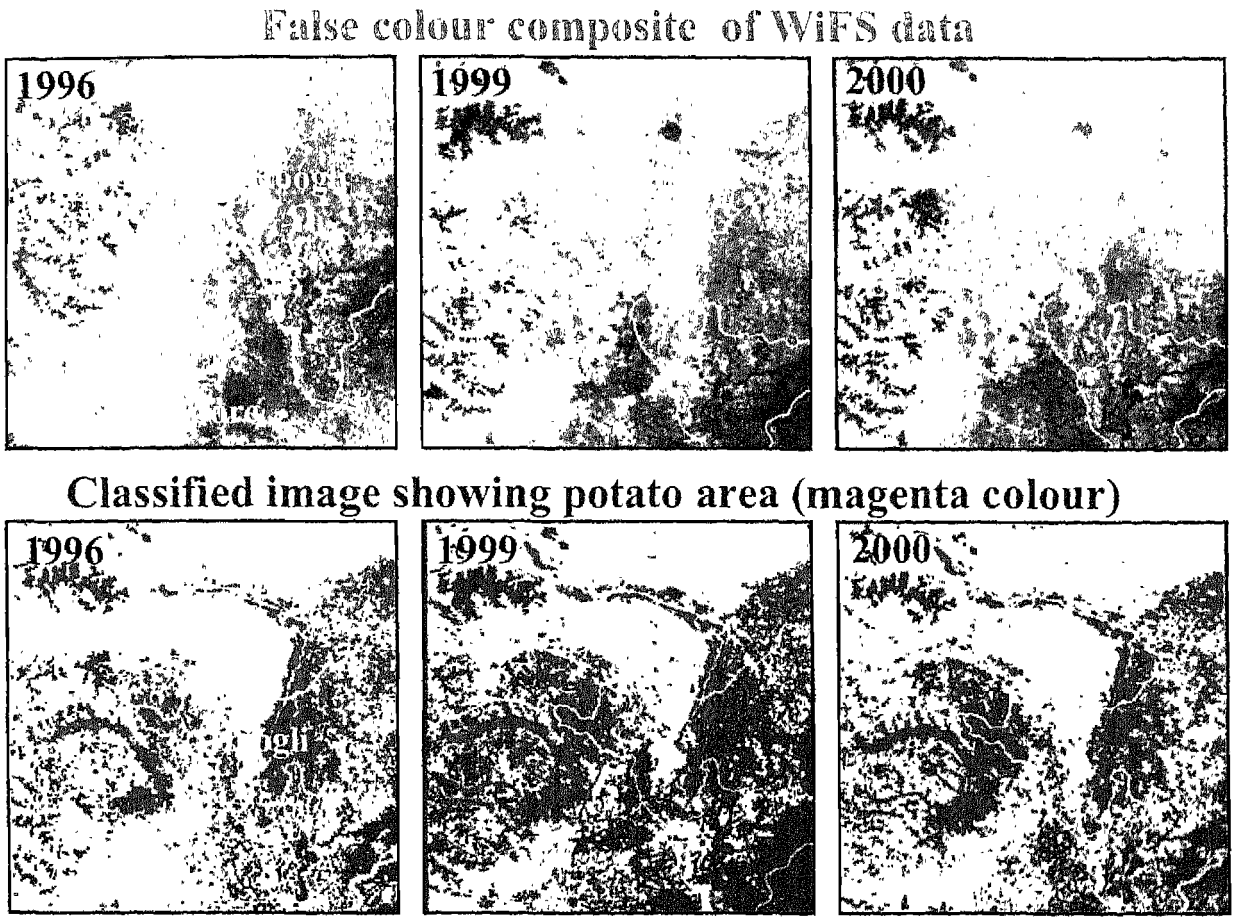


Fig. 1. Potato crop distribution in the study area during 1996, 1999 and 2000 as observed in false colour composite and classified images of IRS WiFS data

was used to classify potato area. In the first step, the non-agricultural areas like forest, homesteads, scrublands, water *etc.* classified using temporal data acquired during the base year (1996) was used as a mask to delineate the potential agricultural area. Further classification was carried out within this mask. Classification of single date data acquired during this period resulted around 90 per cent accuracy for training site pixels. Though, the individual field size was small (<1 ha), however, since the crop is grown in contiguous fields, the synthetic field size was found to be large enough to be identified in WiFS data. Only such large fields were used as ground truth sites to evaluate the classification accuracy. Comparative fluctuation in crop area from year to year was carried out using data acquired on January 20, 1996, January 24, 1999 and January 19, 2000. Analysis showed that potato crop grown in scattered pattern and small holdings resulted in over estimation of acreage due to commission from fallow area. Thus, though the desirable accuracy was poor for acreage in absolute sense using the WiFS resolution, it could highlight the distribution and pattern of potato area accurately. This enabled to detect year to year change in the

crop pattern accurately. Hence, the current technique focused on detecting the annual changes in potato cropping pattern to estimate the crop prospects. This technique also enabled to identify the locations having any appreciable increase or decrease in potato crop area both for pure pixels and/or mixed pixels. Normalized difference vegetation index (NDVI) was used to analyze the crop vigour. NDVI highlights the crop behaviour using the radiance of red and NIR bands that are indicator of the chlorophyll and cellular condition of the plant. It has a good correlation with leaf area index (LAI) and green biomass. A threshold NDVI value was used to signify the change in vigour of the potato crop.

Results showed that there was appreciable increase in area under potato crop during 2000 over 1996 and 1999 (Table 1). It also revealed inter district variation in potato acreage. It was observed that in 2000 Hoogly district had higher acreage compared to 1999 and 1996 (Table 2). On the other hand potato area was more in Midnapore during 1999 compared to 1996 and 2000. There was an increasing trend in potato area in Bardhman district over the year. Data in table 2 also revealed a quantum jump in potato in Midnapore district in 1999 over 1996 and then declined in 2000. The spatial variation in potato area over the year is shown in figure 1. NDVI assessment showed that the crop condition in general was good in all the years. However, the inter district variation was observed in crop vigour during all three years. Potato crop vigour was high in Hoogly and Bardhman when compared to Midnapore.

Table 1. Trend of potato area in the major potato growing districts (Bardhaman, Hoogly and Midnapore) of West Bengal during 1996, 1999 and 2000

Year	*Area (% of geographic area)*
1996	15.20
1999	14.87
2000	18.91

Table 2. Change in potato area in the major potato growing districts of West Bengal

District	*Potato area (% of geographic area)*		
	1996	*1999*	*2000*
Bardhman	9.71	9.81	11.71
Hoogly	28.42	17.09	30.09
Midnapore	7.46	17.71	15.47

ACKNOWLEDGEMENTS

This work has been carried out under the 'Horticultural Crop Inventory', an RSAM project of ISRO. We are thankful to Dr N. Kundu, Scientist, IWM&ED, Calcutta for his support in ground data collection and other valuable information. Valuable suggestions by Dr M Chakraborty, System Manager during the course of this study is also acknowledged.

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MS Received: 5.06.2002

J. Indian Potato Assoc. 29 (3 - 4) : 119-122, 2002

SUPPRESSION OF POTATO SPROUT GROWTH BY ALCOHOLS, ACETALDEHYDE AND 2, 4-DICHLOROPHENOXY ACETIC ACID-ETHYL ESTER AT HIGHER TEMPERATURES

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ABSTRACT: Sprout suppression effect of methanol, ethanol, acetaldehyde and ethyl ester derivative of 2,4 dichlorophenoxy acetic acid (2,4-DEE) was investigated using tubers of the popular potato cultivar Kufri Bahar. Sprouts present at the time of treatment were killed by all the four chemicals tried but the second growth of sprouts was differentially affected by different treatments. Methanol (50 and 100%), ethanol (40, 80 and 100%) and acetaldehyde (30%) applied @ 0.5 ml/kg tubers remained effective for 10 days while 2,4-DEE applied @ 62 mg/kg tubers, was effective in checking sprout growth up to 40 days after treatment. The study suggests that there is a need to screen more chemicals with herbicidal property for use as sprout suppressants at higher storage temperatures.

INTRODUCTION

Overproduction of potatoes has resulted in frequent gluts and proper storage of potatoes is essential for efficient post-harvest management. The cold storage space available in India is 10.3 million tonnes and this is not sufficient for the storage of potatoes especially during the glut years (5). Therefore, non-refrigerated storage of potatoes is required for storing potatoes for 3-4 months. When potatoes are stored in non-refrigerated storage structures or in traditional storage methods, sprouting takes place after the dormancy period is over. Once the tubers sprout their keeping quality deteriorates. Weight loss increases in sprouted potatoes (4) and the increased weight loss has been attributed to higher permeability of the epidermis of sprout to water (1). Chemicals are used for checking sprout growth in potatoes during storage and CIPC (Chlorophenyl-isopropyl phenyl carbamate) is the most common sprout suppressant used on potato. Most of the sprout suppressants are effective at lower temperatures i.e. below 15°C. There is a need to look for cheap chemical sprout suppressants, which will be effective at higher storage temperatures of around 25°C, the temperature that prevails in traditional methods and non-refrigerated methods of potato storage. Therefore, an attempt was made to suppress sprout growth in potatoes during high temperature storage by using commonly used alcohols and aldehydes, since there are reports that long chain alcohols have sprout suppression effect (2). 2,4-D ethyl ester, a herbicide was also tried since CIPC (a commercially used sprout suppressant) is also known to have herbicidal property.

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MATERIALS AND METHODS

Tubers of Kufri Bahar harvested from the crop planted on 30 October, 1998 at CPRI-C, Modipuram was used for the experiment. Cultural practices recommended for the region were followed. Dehaulming was done at crop maturity of 115 days (15 Feb., 1999). Field curing of 20 days was given before the final harvest on 5 March 1999. Fresh and healthy tubers weighing 75-120 g were dipped in dithane M-45 solution (0.3%) for 10 minutes before storing these tubers on 7 March, 1999 in a walk-in-chamber maintained at temperature of 18±2°C and RH of 85±5%. One month after storage (50 days after haulm cutting), chitting was observed in all the tubers. At this stage, tubers were treated with different concentrations of volatile chemicals like alcohols (methanol and ethanol) and acetaldehyde. Treatment with volatile chemicals was given by placing 2 ml of chemical/40 tubers (@ 0.5 ml/kg tubers) in petriplates on the top of potatoes kept in polythene bags. Precaution was taken to avoid direct contact of chemical with tubers. Higher concentration of 1.25 ml/kg tubers was also tested for acetaldehyde (30% of solution). Bags were kept tied for 6 days (6 to 12 April, 1999) and then tubers were stored in hessian cloth bags. Effect of 2,4-D on sprout growth was studied by its application as single spray (2500 ppm) on tubers. (100ml of 2,4-DEE was sprayed on 40 tubers, which was equivalent to 62 mg of 2,4-DEE/kg tubers). A lot of 40 tubers was used for each replication and there were three replications for each treatment. Sprouting behaviour of tubers in terms of sprouting percentage, total sprout number/ tuber and length of longest sprout (cm) was recorded after 40, 55, 70 and 90 days of storage. Complete randomized design was followed for the experiment. The obtained data from three replications were subjected to CRD one factor analysis by using MSTAT C software. Means were then separated by using Duncan's Multiple Range Test. Statistical design and procedures as described by Gomez and Gomez (6) were followed.

RESULTS AND DISCUSSION

Methanol, ethanol, acetaldehyde and 2,4-DEE at the concentrations tried were effective in killing the sprouts present at the time of treatment. However, there was second growth of sprouts and the chemicals tried were differentially effective in checking the growth of second sprouts. By 40 days after storage (DAS), ethanol was very effective in checking sprout growth but by 55 DAS, the sprout suppression effect of methanol, ethanol and acetaldehyde was lost. (Table 1). Only 2,4-DEE was effective in suppressing sprout growth up to 55 DAS. Similarly at 40 DAS, the length of the longest sprout was also effectively reduced by all the chemicals tried (Table 2). However, by 55 DAS, only 2,4 DEE was effective with the differences among other treatments becoming less prominent. By 90 DAS, the treatments effect was non-significant. Significant differences in the number of sprouts per tuber were observed only at 40 DAS and thereafter, the differences were non-significant (Table 3).

Sprout suppression by long chain alcohols has been reported by Burton (1). C_9 alcohols are effective in sprout control, whereas branched chain, C_8, C_{13}, C_{16}, C_{17} and C_{21} alcohols are not (8). In this study short chain

Table 1. Effect of different post-harvest chemical treatments on sprouting percentage of potato tubers in Kufri Bahar

Treatment		*Days after storage*			
		40	55	70	90
1.	Tubers (unsprayed control)	33^{b} (35^{b})	85^{b} (67^{b})	100^{a}	100
2	Tubers sprayed with water	52^{a} (46^{a})	87^{ab} (69^{b})	100^{a}	100
3.	Tubers enclosed in polythene bags for 6 days	28^{bc} (32^{b})	83^{b} (66^{b})	100^{a}	100
4.	50% methanol (0.5ml / kg tubers)	26^{bc} (31^{b})	100^{a} (89^{a})	100^{a}	100
5.	100% methanol (0.5ml / kg tubers)	10^{d} (18^{c})	86^{b} (69^{b})	100^{a}	100
6.	40% ethanol (0.5ml / kg tubers)	0^{e}	86^{b} (68^{b})	100^{a}	100
7.	80% ethanol (0.5ml / kg tubers)	0^{e}	100^{a} (89^{a})	100^{a}	100
6.	100% ethanol (0.5ml / kg tubers)	0^{e}	100^{a} (89^{a})	100^{a}	100
9.	30% acetaldehyde (0.5ml / kg tubers)	20^{c} (26^{bc})	86^{b} (69^{b})	93^{b}	100
10.	30% acetaldehyde (1.25ml / kg tubers)	0^{e}	100^{a} (89^{a})	100^{a}	100
11.	2,4-DEE [2500 ppm (62mg/kg tubers) as single spray on tubers]	4de (9^{d})	19^{c} (26^{c})	70^{c}	100
	CD at P = 0.01	9.21	13.3	5.3	NS

Values followed by simular letter/s are non-significant over one another at P = 0.01; Values in parentheses request the tranformed means by using are sine transformation

Table 2. Effect of different post-harvest chemical treatments on length (cm) of longest sprout of potato tubers in Kufri Bahar

Treatment		*Days after storage*			
		40	55	70	90
1.	Tubers (unsprayed control)	1.5^{a}	1.8^{ab}	2.0^{ab}	3.3
2.	Tubers sprayed with water	0.9^{ab}	2.2^{a}	2.5^{ab}	4.7
3.	Tubers enclosed in polythene bags for 6 days	0.9^{ab}	1.7^{ab}	3.1^{ab}	5.8
4.	50% methanol (0.5ml / kg tubers)	0.8^{ab}	1.8^{ab}	2.3^{ab}	3.0
5.	100% methanol (0.5ml / kg tubers)	0.4^{b}	1.6^{ab}	1.9^{a}	3.3
6.	40% ethanol (0.5ml / kg tubers)	0.0^{c}	1.9^{ab}	2.2^{ab}	3.1
7.	80% ethanol (0.5ml / kg tubers)	0.0^{c}	2.1^{ab}	3.1^{a}	3.5
6.	100% ethanol (0.5ml / kg tubers)	0.0^{c}	2.5^{a}	3.0^{ab}	3.8
9.	30% acetaldehyde (0.5ml / kg tubers)	0.5^{b}	1.3^{b}	1.8^{b}	3.3
10.	30% acetaldehyde (1.25ml / kg tubers)	0.0^{c}	1.9^{ab}	2.1^{ab}	3.2
11.	2,4-DEE [2500 ppm (62mg/kg tubers) as single spray on tubers]	0.4^{b}	0.6^{c}	1.3^{c}	2.7
	CD value	0.67**	1.16*	1.11*	NS

Values followed by similar letter/s are non-significant over one another; * and ** represent significance level at P=0.05 and P=0.01 respectively

alcohols, ethanol and methanol were also found to be effective in suppressing sprout growth and ethanol was more effective than methanol. Acetaldehyde was also better than methanol. Compounds containing 9-10 carbon atoms per molecule have been generally found to be effective in suppressing sprout growth (2, 7). The results reported here show that even compounds containg 1-2 carbon atoms are effective in suppressing sprout growth for a short period. However 2 carbon compounds (ethanol and acetaldehyde) were more effective than 1-carbon compound (methanol). The sprout suppression effect of ethanol and methanol lasted only for 40 days. Nonanol (3-5-5- Trimethylhexan-1-ol) also suppresses sprout growth but its suppression effect is not persistent and growth can occur within 2-3 weeks (3). 2,4-D ethyl ester was also found to be effective in suppressing sprout growth up to 55 days. Ethyl ester of 2,4,5-trichlorophenoxy acetic acid is known to

Table 3. Effect of different post-harvest chemical treatments on total sprout number/tuber in Kufri Bahar

	Treatment	Days after storage			
		40	55	70	90
1	Tubers (unsprayed control)	1.0^{cd}	2.0	2.0	2.6
2	Tubers sprayed with water	1.0^{cd}	1.0	1.6	2.4
3	Tubers enclosed in polythene bags for 6 days	1.4^{bc}	1.4	1.8	2.2
4	50% methanol (0.5ml / kg tubers)	2.6^{a}	2.6	3.0	3.6
5	100% methanol (0.5ml / kg tubers)	2.2^{ab}	2.6	2.6	3.8
6	40% ethanol (0.5ml / kg tubers)	0.0^{d}	1.2	2.2	3.0
7	80% ethanol (0.5ml / kg tubers)	0.0^{d}	1.6	2.2	2.6
8	100% ethanol (0.5ml / kg tubers)	0.0^{d}	2.6	2.6	3.2
9	30% acetaldehyde (0.5ml / kg tubers)	1.4^{bc}	1.8	2.8	4.0
10	30% acetaldehyde (1.25ml /kg tubers)	0.0^{d}	2.0	2.2	3.2
11	2,4-DEF [2500 ppm (62 mg/kg tubers) as single spray on tubers]	0.4^{cd}	1.4	2.0	2.4
	CD value at P=0.01	1.07	NS	NS	NS

Values followed by similar letter/s are non-significant over one another

inhibit sprout growth in potatoes (2). Compounds with herbicidal property like chloropropham (3) and imazethapyr (9) are also known to be effective sprout suppressants. This study indicated that compounds with herbicidal property were more effective than lower alcohols and acetaldehyde in suppressing sprout growth. More compounds need to be screened for sprout suppression at higher storage temperatures.

ACKNOWLEDGEMENTS

Authors are thankful to Dr. G.S. Shekhawat, former Director, CPRI, Shimla and the Joint Director, CPRIC, Modipuram for facilities and encouragement.

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MS Received: 22.03.2002

J Indian Potato Assoc. 29 (3 - 4) : 123-127, 2002

CHLOROPHYLL FLUORESCENCE INDUCTION KINETICS IN POTATO: EFFECTS OF WATER STRESS AND HIGH LIGHT INTENSITIES

Ashoo Sharma, J.S. Minhas[1], P.S. Basu[2] and Jitendra Mohan[3]

ABSTRACT : Changes in the fluorescence induction kinetics were seen in potato leaves subjected to water stress. The adverse effect of water stress was quantified in terms of half quenching time of variable fluorescence ($q^{1/2}$) , which was more in the stressed leaves compared to those under non-stressed (turgid) conditions. High irradiance levels also affected the half quenching time of variable fluorescence and the effect was more pronounced when drought and high irradiance factors were combined. The effective quantum yield was greatly reduced in water stressed plants exposed to high light intensities.

INTRODUCTION

Potato is considered to be more sensitive to water stress than other C_3 crops. The decline in photosynthesis in potato is fast and substantial even at a relatively low level of water stress (10).

Vos and Oyarzun (11) reported an almost complete inhibition of photosynthesis in potato at y_w –1.2 mega pascal (MPa) as compared to other C_3 crops that are little or hardly affected at this level of water stress (-1.2 MPa).

Photosynthesis is a process that involves reactions at five different functional levels: Process at pigment level, primary light reactions, thylakoid electron transport reactions, dark enzyme stroma reactions and slow regulatory feedback processes. These processes involve the transfer of electrons from water to carbon dioxide (CO_2). The chlorophyll fluorescence is associated with the primary events in this sequence and CO_2 reduction is the last event in electron transfer (9). Therefore, any change occurring in the chlorophyll fluorescence kinetics in leaves of the plants subjected to various stresses (heat, light or water stress) can provide the necessary and vital information regarding the state of the photochemical processes (6). The present study was aimed to see the effect of drought on some photochemical events of photosynthesis.

MATERIALS AND METHODS

Plants : Uniform sized (50g) single sprouted tubers of Potato (*Solanum tuberosum* L.) cv. Kufri Sindhuri were planted in pots containing 4000 cm^3 sandy loam soil mixed with fertilizers (containing 150 mg nitrogen, 100mg phosphorus and 100 mg potassium per kg soil, pH 5.5-6). Plants were grown during August to December under average maximum/minimum temperature of 21/15^0 C, about 14h daylength in August and 10 h daylength in December, in a glass house at

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Shimla (31° 06' N, 77° 10 'E). Measurements were taken on 45 day old plants when daylength was about 12 h. The 4th leaf from top was invariably used for the measurements. Pots were watered every 2 days with the normal water supply, at 250ml per pot.

Water stress treatment: Irrigation was withdrawn for some period to induce water stress. Water potentials of the 4th leaf were determined using a Wescor HR-33T microvoltmeter (WESCOR, USA) in the dew point mode.

Fluorescence induction kinetics: Chlorophyll fluorescence induction kinetics of the leaves was measured using PAM-flurometer (Mini-PAM, Walz, Germany) attached with recorder having chart speed of 20mm/min^{-1} (Recorder model, LKB fraction collector, Sweden). Leaves of turgid (-0.2 MPa) or stressed (-1.2 MPa) plants were allowed to adapt for sufficient time prior to the measurement. Then dark adapted leaves were excited with a weak modulated light having frequency of 0.6 KHz, 655 nm wavelength and intensity of 0.15 µmol photons m^{-2} s^{-1}. The fluorescence value at this light level was represented by Fo, minimal fluorescence. In the reduction kinetics it has been reported (9) that dark incubation for several minutes is necessary to fully oxidize primary quinons acceptors of PSII (Q_A), the first stable acceptor of photosystem II (PSII), because only then the true Fo level is observed. Thereafter leaf was flashed with a saturating light of 4000 µmol photons m^{-2} s^{-1} for a very brief period of 400 milli-seconds. The fluorescence rose to maximum value denoted by Fm and within a fraction of second decreased to its initial value Fo. The Fm was represented as maximal fluorescence. The difference between Fm and Fo i.e. (Fm-Fo) is known as variable fluorescence denoted by Fv. The time taken to decline the variable fluorescence Fv back to its Fo value is known as complete quenching of variable fluorescence. On the other hand, the time taken for half decay or when Fv declined to half of its full value was represented as half quenching time, $q^{1/2}$.

In case of light adaptation, leaves were sequentially exposed to various actinic light levels such as 150, 300 and 500 µmol photons m^{-2} s^{-1}. The saturating flash of light 4000 µmol photons m^{-2} s^{-1} was then superimposed once the leaves were adequately adapted to these irradiance levels. The half quenching time $q^{1/2}$ of variable fluorescence was calculated in a similar manner as in the case of dark adapted leaves.

The quantum yield of PSII was represented by the ratio of variable fluorescence, Fv to maximal fluorescence, Fm. The formula for calculating quantum yield is given below:

Quantum yield = Fv/Fm= (Fm-Fo)/Fm

The quantum yield obtained from light-adapted leaves was known as effective quantum yield.

RESULTS AND DISCUSSION

The quantum yields of dark adapted turgid and water stressed leaves at zero irradiance level varied little (Fig. 1) showing that the photochemical efficiency of photosystem II i.e. the efficiency by which photons absorbed in PSII antenna complex are delivered to open PSII reaction centers was not affected by water stress.

On the other hand, half quenching time of variable fluorescence, (8) $q^{1/2}$ decreased with increasing levels of irradiance upto 500 µmol photons m^{-2} s^{-1} in turgid leaves (Table 1). The half quenching time of variable fluorescence, $q^{1/2}$ was higher in stressed as compared to turgid ones (Table 1) at all light intensities. Moreover $q^{1/2}$ increased with increase in irradiance in water-stressed leaves (Table 1) indicating that fluorescence took greater time to quench under water stressed conditions and that a high irradiance accentuated the effect of water stress on $q^{1/2}$.

Table 1. Effect of light intensity and water stress on half quenching time of variable fluorescence in potato

Irradiance levels (µmol photons m^{-2} s^{-1})	*Half quenching time ($q^{1/2}$) (in seconds)*	
	Turgid leaf (-0.2MPa)	*Water-stressed leaf (-1.2 MPa)*
0	0.3 ± 0.06	0.49 ± 0.04
150	10.0 ± 0.54	20.60 ± 0.34
300	7.5 ± 0.46	15.38 ± 0.62
500	6.0 ± 0.45	20.84 ± 0.75

Values are the mean of five replications with ± standard error of means

An increase in $q^{1/2}$ in water-stressed conditions has also been reported by Jefferies (3). The quenching of fluorescence has been attributed to photochemical or non-photochemical means (5). Under turgid conditions the decline in $q^{1/2}$ with increasing irradiances could be due to an increase in electron transport rate (ETR). Holmes *et al.* (2) reported that ETR increased with increase in irradiance levels in leaves when not under stress. The transport of electrons through thylakoid membrane results in an establishment of a proton gradient across the membrane and the fluorescence might be quenched by Qe quenching (due to electron transport) (9). On the other hand under water stressed conditions a reduced electron transport rate at high irradiances might increase $q^{1/2}$ (1). It has also been reported that

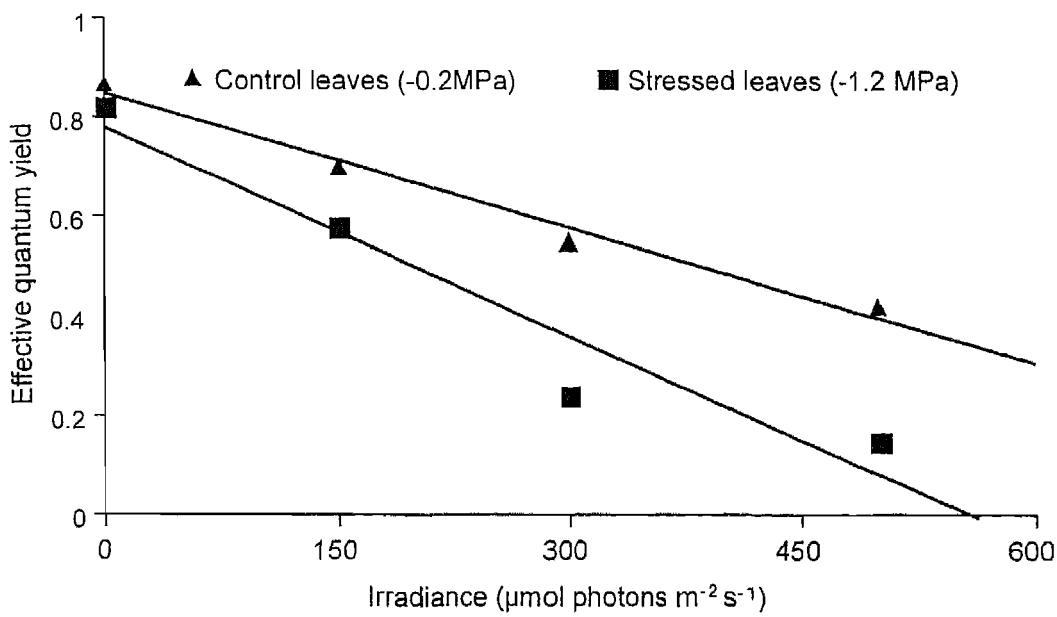


Fig. 1. Response of quantum yield to increasing irradiance levels in turgid control (-0.2 MPa) and stressed (-1.2 MPa) leaves of potato nonstressed control leaves (-0.2 MPa)and stressed leaves (-1.2 MPa)

with increase in irradiance levels, a build up of transthylakoid pH gradient converts photochemically active centers into photochemically inactive centers with low fluorescence yield and with increased ability to dissipate excitation energy as heat (12). In water stressed conditions some nonradiative means of quenching might be active that are rather slow in dissipation.

Light adapted leaves showed a declining trend in the effective quantum yield with increasing light intensities in both turgid and water stressed conditions (Fig.1). This indicated that under continuous exposure to light, more of the Q_A pool remains in reduced state and has also been reported to be due to decline in the efficiency of primary photochemistry (7). The effective quantum yield was more reduced in water stressed leaves (Fig. 1) than turgid ones that might be due to photoinhibition and increased heat dissipation. Powles (8) reported that the degree of damage to photosynthetic capacity induced by water stress can be amplified by high irradiances and the present study also indicated the same. The increase in the $q^{1/2}$ under water stress is manifested by a decline in the carbon fixation and indicated the involvement of nonstomatal factors that inhibits photosynthesis under drought. It has been reported that $q^{1/2}$ is closely correlated with net assimilation rate and total dry matter production (4) which could be a sensitive indicator of any perturbation in the CO_2 fixation processes under stressed conditions.

ACKNOWLEDGEMENTS

We are thankful to the Indian Council of Agricultural Research, New Delhi, India for providing financial support, and to Dr G.S. Shekhawat, former Director, CPRI, Shimla for providing facilities for this work.

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MS Received: 26.09.2001

J. Indian Potato Assoc. 29 (3 - 4) : 129-134, 2002

PHYSIOLOGICAL LOSSES IN POTATOES UNDER NON-REFRIGERATED STORAGE : EFFECT OF N, P AND K FERTILIZERS*

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ABSTRACT: Physiological losses in potato tubers as influenced by fertilizer nutrients, N P K and farm yard manure (FYM) in balanced and unbalanced combinations were studied for two years during storage in an evaporatively cooled store (ECS). Mean physiological weight loss (respiration + evaporation) and total storage losses increased from 7.5 to 13.7 per cent and 11.0 to 21.0 per cent, respectively between 90 and 120 days of storage. Physiological weight loss contributed maximum (65.2%) to the total weight loss followed by sprout loss (22.1%) and loss due to tuber rots (12.7%). Application of potassium through NK and NPK, where N was applied half at planting and half at earthing up, significantly reduced the weight loss and total storage losses up to 120 days of storage. Combined application of NPK and FYM however, increased storage losses over comparable treatment without FYM. N, P and K treatments with and without FYM had no influence on sprouting, sprout growth and rottage in tubers during storage.

INTRODUCTION

A total of 90 per cent of potato production in India is from the Indo-Gangetic plains, where the crop is harvested from January to March before the onset of long hot summer. Storage under ambient conditions in Indian plains can result in enormous losses due to shrinkage, sprouting and attack by micro-organisms. The perishable nature of potatoes coupled with increased production and insufficient cold storage facilities often result in post harvest glut and consequent crash of prices due to distress sale. Processing of potatoes, a suitable remedy to avoid market glut has assumed significance. But for processing, potatoes need to be stored at higher temperatures because exposure to low storage temperatures (2-4 ° C) leads to starch conversion to sugars. This will cause dark coloured processed products as a result of a Maillard reaction between reducing sugars and amino acids in the potatoes (3). Under the prevailing circumstances, short term non refrigerated storage of potatoes for 3-4 months after the harvest has been advocated in an evaporatively cooled store (ECS) in Indian plains to minimize storage losses and render potatoes fit for table as well as processing purposes (4, 9).

Storability of potatoes is affected by a number of cultural practices including fertilization, but the information on the effect of different fertilizers and organic manure on keeping quality of tubers during non-refrigerated storage is lacking. The present investigation was, therefore, conducted with a commercial potato cultivars, Kufri Chandramukhi to study the effect of

*Part of the Ph.D. thesis (2001) of Sr. author, approved by CCS University, Meerut- 250 005 (Uttar Pradesh)

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nutritional management practices on physiological losses in potatoes stored in ECS and to develop optimum NPK and FYM levels which could improve the storability of potatoes under non-refrigerated conditions.

MATERIALS AND METHODS

Field experiments were conducted at the farm of Central Potato Research Station, Jalandhar during 1997-1999. Treatments (Table 1) consisted of balanced and unbalanced combinations of fertilizer nutrients N, P and K with FYM. Time of nitrogen application found affecting the storage losses in a preliminary study (unpublished) was also included in the treatments. In all, 10 treatments were replicated 4 times in a randomized block design (plot size 4.2 x 2.4 m). Full dose of phosphorus and potash through diammonium phosphate and muriate of potash, respectively and FYM was applied at the time of planting. Nitrogen was applied through calcium ammonium nitrate at planting and through urea at earthing up.

Table 1. Treatment details of the experiment

T_1	=	N (90 kg BD + 90 kg TD)
T_2	=	N (90 kg BD + 90 kg TD) + P*
T_3	=	N (90 kg BD + 90 kg TD) + K*
T_4	=	N (90 kg BD + 90 kg TD) + P + K
T_5	=	N (135 kg BD + 45 kg TD) + P + K
T_6	=	T_4 + FYM*
T_7	=	T_1 + FYM
T_8	=	N (135 kg BD + 45 kg TD) + FYM
T_9	=	N (67.5 kg BD + 67.5 kg TD) + FYM
T_{10}	=	N (45 kg BD + 45 kg TD) + FYM

BD and TD mean basal dose and top dressing, respectively
* P was applied @ 80 kg P_2O_5 ha^{-1}; K was applied @ 120 kg K_2O ha^{-1}; FYM was applied @ 30 tonnes ha^{-1}

Pre-sprouted seed tubers were planted in October and haulm cutting was done in January at full maturity. Recommended cultural practices were followed. Harvested tubers were heaped in the field for 15-20 days for curing of the skin. Undamaged and apparently healthy tubers were stored in ECS for 120 days (13-30°C, 75-98% RH) starting from the first week of March.

All observations were recorded at fortnightly intervals. Weight loss was recorded from 20 marked tubers. Respiration rate (fresh weight basis) was measured by an infrared gas analyser (CD-301, CID, Inc., USA) using the standardized method (14). Weight of carbon loss (mg of C present in CO_2) during storage was calculated from rate of respiration (10). The difference between weight loss and carbon loss was assumed to be transpiration loss even though the ultimate source of some water loss was probably generated during respiration. Sprouting and rotting was recorded in 4 replications of 100 tubers. Tubers having at least one sprout 0.5 cm or more in length were recorded as sprouted and sprout weight was recorded in undisturbed separate lots. Data was statistically analysed in completely randomized design and correlations were worked out between storage parameters (2).

RESULTS AND DISCUSSION

Physiological weight loss (Respiration and evaporation): Physiological weight loss progressively increased during storage in ECS up to 120 days of storage (DOS). Mean weight loss increased from 2.70 to 13.70 per cent between 60 and 120 DOS (Table 2). A gradual increase in weight loss of tubers during storage is in accordance with earlier findings (11).

Weight loss greater than 10 per cent during storage results in higher monetary loss as the market value decreases due to shrivelling of tubers (5) and peeling losses during processing also increase (11). Mean weight loss remained well below this level up to 90 DOS (7.5%) and the tubers remained firm. With the increase in weight loss up to 13.7%, tubers appeared slightly shrivelled after 120 days of storage. Linnemann *et al.* (8) however, reported much higher weight loss (17.1%) after 120 days of storage at 28° C. The reduced weight loss in this study can be attributed to high relative humidity and low water vapour pressure deficit inside the ECS. Importance of high relative humidity in maintaining minimum weight loss during storage is well documented (15).

Application of NK (T_3) and NPK (T_4) reduced the mean weight loss of tubers as compared to N alone after 120 days of storage (Table 2). Reduction in weight loss of tubers due to the application of K has been reported earlier also (13). Reduced weight loss of tubers during storage in the two treatments resulted in lesser shrivelling of tubers and low peeling losses during processing (data not included). Soil application of N, ¾ as basal dose and ¼ as top dressing in case of NPK (T_5) however, recorded no reduction in weight loss of tubers as compared to N alone. Combined application of NPK and FYM (T_6) increased the weight loss of tubers over comparable treatment without FYM (T_4), may be because extensive fertilizer application is reported to increase losses due to respiration and evaporation (7).

Respiratory loss: Mean respiration rate increased from 8.90 to 25.09 mg CO_2 kg^{-1} h^{-1} between 60 and 120 days of storage (Table 2). Increase in respiration rate of tubers during storage was concurrent with the onset of sprouting and advanced sprout growth up to 120 DOS. Respiration rate of sprouted tubers is high because it includes the respiration of tubers and the sprouts (1). Application of N alone (T_1) recorded minimum respiration rate of tubers (Table 2), which was increased by the application of N, P, K and FYM in various combinations with N (T_2- T_{10}).

Table 2. Physiological weight loss (%) and respiration rate (mg CO_2 kg^{-1} h^{-1}) of tubers during storage in ECS (mean of 2 years)

Treatment	*Storage period (days)*					
	Weight loss			*Respiration rate*		
	60	*90*	*120*	*60*	*90*	*120*
T_1	2.51	7.31	13.69	7.26	13.72	22.92
T_2	2.38	7.35	13.81	7.33	14.77	27.56
T_3	2.48	6.80	12 63	7.90	14.28	25.81
T_4	2.44	6.77	12.62	8.09	14.95	27.23
T_5	2.84	7.74	13.77	8.44	15.13	25.18
T_6	3.14	7.70	14.24	8.63	16.22	25.53
T_7	2.66	7.85	13.64	10.28	18.00	24.87
T_8	2.86	7.70	14.29	9.69	18.32	25.24
T_9	2.63	8.06	14.38	10.82	18.06	24.03
T_{10}	3.06	7.76	13.98	10.53	18.37	22.52
Mean	2.70	7.50	13.70	8.90	16.18	25.09
SE m ±	0.17	0.29	0.43	0.33	0.39	0.58
CD (0.05)	0.48	0.81	1.19	0.93	1.10	1.64

Mean total weight loss and respiratory carbon loss was 27.0 mg g^{-1} and 2.84 mg g^{-1} tuber fresh weight after 60 DOS which increased to 137.0 mg g^{-1} and 9.87 mg g^{-1} tuber weight, respectively after 120 days (Table 3). Contribution of respiratory carbon loss to total weight loss was slight (7.1 to 10.5%) and transpiration was the major source of weight loss during storage as reported earlier also (10).

Application of NK (T_3) and NPK (T_4) though minimized total weight loss as compared to N alone (T_1), the respiratory loss was comparatively high (Table 3). Application of FYM either with N (T_7- T_{10}) and NPK (T_6) increased the total as well as respiratory carbon loss over comparable treatments without FYM (T_1 and T_4).

Table 3. Total weight loss (T) and respiratory loss (C) during storage as affected by fertilizer nutrients (mean of two years)

Treatment	*Loss	Storage period (days)		
		60	90	120
T_1	T	25.10	73.20	136.90
	C	1.87	4.32	8.47
T_2	T	23.80	73.50	138.10
	C	1.93	4.64	9.47
T_3	T	24.80	68.00	126.30
	C	2.06	4.81	9.61
T_4	T	24.40	67.70	126.20
	C	2.16	5.03	9.38
T_5	T	28.40	77.40	137.70
	C	2.30	5.26	9.89
T_6	T	31.40	77.00	142.40
	C	2.29	5.28	9.91
T_7	T	26.60	78.50	136.10
	C	2.64	6.03	10.60
T_8	T	28.60	77.00	142.90
	C	2.52	5.70	10.20
T_9	T	26.30	80.60	143.80
	C	2.94	6.21	10.86
T_{10}	T	30.60	77.60	139.80
	C	2.70	6.09	10.35
Mean	T	27.00	75.00	137.00
	C	2.84	5.33	9.87
Transpiration loss		24.16	69.67	127.13

* mg g^{-1} tuber fresh weight

Sprout loss: Sprouting of tubers started after 30 days of storage and 74 and 100 per cent tubers had sprouted up to 60 and 90 days of storage, respectively. Progressive increase in sprout weight was from 2.18 to 4.63 per cent between 90 and 120 DOS (Table 4). Application of NPK fertilizers in different combinations with FYM had no effect on sprouting and sprout growth in tubers during storage.

Correlations estimated between different storage parameters were highly significant between weight loss and sprout weight (r= 0.962**) and respiration rate and sprout weight (r= 0.945**). Kolbe *et al* (6) also found a linear relationship between sprout volume and tuber weight loss and increase in respiration rate with sprouting and advanced sprout growth is also well documented (12). Correlation between weight loss and respiration rate was also highly significant (r= 0.980**). There was however, no association between respiration rate at harvest (0 day) and weight loss after 120 days of storage indicating thereby that respiration rate, which contributes very little to total weight loss during storage, cannot predict weight loss under non-refrigerated storage conditions.

Loss due to tuber rots: Incidence of tuber rotting was not detected till 90 DOS and overall mean losses due to rots increased from 1.28 per cent after 90 DOS to 2.67 per cent up to 120 days (Table 4). NPK treatments with or without FYM had no influence on the rottage of tubers.

Total storage losses: Total losses due to the

Table 4. Sprout weight, rottage and total losses in tubers during storage in ECS as affected by fertilizer nutrients

Treatment	Storage period (days)					
	Sprout weight (%)		Rottage (%)		Total losses (%)	
	90	120	90	120	90	120
T_1	2.29	5.31	0.81	1.66	10.40	20.66
T_2	2.24	4.67	1.88	3.51	11.46	21.99
T_3	2.03	4.51	0.71	1.58	9.55	18.71
T_4	2.15	4.94	0.84	1.96	9.76	19.58
T_5	2.17	4.87	0.61	2.26	10.52	20.90
T_6	2.27	4.14	1.76	3.24	11.73	21.61
T_7	2.14	4.40	2.51	4.34	12.52	21.89
T_8	2.08	4.20	1.16	1.88	10.93	20.36
T_9	2.22	3.92	1.27	3.59	11.56	21.83
T_{10}	2.17	5.32	1.25	2.69	11.18	21.99
Mean	2.18	4.63	1.28	2.67	10.96	21.00
SE m ±	0.15	0.24	0.54	0.78	0.43	0.34
CD (0.05)	NS	NS	NS	NS	1.22	0.96

combined effect of physiological weight loss sprout loss and rottage in tubers increased from 10.96 after 90 DOS to 21.0 per cent after 120 days (Table 4). Physiological weight loss contributed maximum (65.2%) to the total storage losses followed by sprout loss (22.1%) and loss due to tuber rots (12.7%).

Application of NK (T_3) and NPK (T_4) significantly reduced total losses in tubers as compared to N alone (T_1) after 120 DOS (Table 4), a trend similar to weight loss of tubers. Combined application of NPK and FYM (T_6), however increased the total storage losses over comparable treatment without FYM (T_4).

From above studies it may be concluded that application of potassium through NK and NPK, where nitrogen was applied half at planting and half at earthing up, significantly reduced the physiological weight loss and total storage losses in tubers under non-refrigerated conditions. Application of additional nutrients through combined application of NPK and FYM however, increased losses during storage.

ACKNOWLEDGEMENTS

The authors are thankful to the Director, CPRI Shimla and the Head, CPRS, Jalandhar for providing facilities, to Dr. J.P. Singh for helpful suggestions and to Mr. Raj Kumar and Mr. Yogesh Gupta for assistance in statistical analyses and experimentation.

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MS Received: 2.02.2002

J. Indian Potato Assoc. 29 (3 - 4) : 135-138, 2002

CHANGING SCENARIO OF INSECT PESTS OF POTATO IN SATPURA PLATEAU OF MADHYA PRADESH

S.R. Dharpure[1]

ABSTRACT: Some insect pests which were observed sporadically on potato have now assumed the status of regular pests due to changing cropping pattern in Satpura plateau of Madhya Pradesh. Different solanaceous and cruciferous vegetables and crops like soybean, sunflower, maize; groundnut etc. grown in the area are the main hosts of these insects pest. *Holotrichia consanguinea* Blanchard, *Bagrada cruciferarum* Kirkaldy *Lipaphis erysimi* Kaltenbach from cauliflower, cabbage and musturd; *Aphis craccivora* Koch from beans and *Thrips tabaci* Lind. from onion while defoliators like *Helicoverpa armigera* Hubner from gram, sunflower and maize are observed to migrate on potato. Changed status of potato pests, their period of occurrence, extent of damage and major host plants are discussed in this paper.

INTRODUCTION

Insect pests of potato and their distribution in different parts of the country has been reported by Mishra (9). Of these, some are quite serious while others are reported to be minor pests. Insect fauna of potato in Satpura plateau of Madhya Pradesh has been reported by Dharpure (2,3,4,5) and Dharpure *et al.* (6). In the last decade change in the fauna has been observed which is mainly due to changing cropping pattern. The host plants for some new / sporadic pests are available in the off season, offering food and harborage to these pests; as a result they attain the status of important pests. The insect pests of other crops are also observed to migrate on the potato crop.

MATERIALS AND METHODS

Survey of potato fields of Jawahar Lal Nehru Krishi Viswa Vidyalaya, Zonal Agricultural Research Station, Chhindwara and farmers fields in the near vicinity of the farm in Chandangaon and Gurayya village was conducted from 1995-98. Survey was conducted thrice in a crop season from November tc March. The pest fauna, alternate hosts and main crops serving as host plants for new pest has been recorded

Identification of aphids and defoliator was done by Dr. O.P.Singh Sr. Scientist (Ento.), College of Agriculture Sehore (M.P.).Thrips species were identified by Dom Collin, Invertebrate identification team, Central Science laboratory, Sand Hutton,York U.K. *Dioxyna sorarculi, Taylorilugus pallidulus* other hemipterans were got identified from British museum, London.

RESULTS AND DISCUSSION

Different insect pests observed on potato crop in Satpura Plateau of M..P. have been mentioned in the table 1:

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Table1. Record of Insect Pests of potato and period of their activity in Satpura plateau

S.No	Common Name	Scientific Name	Taxonomic position		period of activity
1	Peach aphid	*Myzus persicae* Sulzer	Homoptera	: Aphididae	mid Dec to Feb
2	Cotton aphid	*Aphis gossypii* Glover	Homoptera	: Aphididae	mid Dec to Feb
3	Cabbage aphid	*Lipaphis erysimi* Kaltenbach	Homoptera	: Aphididae	mid Dec to Feb
4	Bean aphid	*Aphis craccivora* Koch.	Homoptera	: Aphididae	Jan to Mar
5	Leaf hopper	*Emposca devastan*Distant	Homoptera	: Cicadelidae	Nov to Jan
6	Whitefly	*Bemasia tabaci* Geendiius	Homoptera	Aleurodidae	Dec to Feb
7	Green bug	*Nezara viridulaLinn* Linn	Homiptera	: Pentatomidae	Jan
8	Painted bug	*Bagrada cruciferarum* Kirkaldy	Hemiptera	: Pentatomidae	Dec to Jan
9	Mirid bug	*Taylorilygus pallidulus* Wal	Hemiptera	: Miridae	Dec to Jan
10	Grasshopper	*Chrotogonous sp*	Orthoptera	: Acrididae	Dec to Jan
11	Mole cricket	*Gryllotalpa africana* P.deBeauv	Orthoptera	: Gryllotalpidae	Nov to Dec
12	Cutworm	*Agrotis ipsilon* Hufn.	Lepidoptera	: Noctuidae	Dec to Mar
13.	Gram caterpillar	*Helicoverpa armigera* Hubner	Lepidoptera	: Noctuidae	Dec to Feb
14.	Diamond backmoth	*Plutella xyllostella* (L.)	Lepidoptera	: Noctuidae	Jan to Feb
15	Green semilooper	*Plusia orichalsia* Fabr	Lepidoptera	. Noctuidae	Jan to Feb
16	Tobacco caterpillar	*Spodoptera litura* Fabr.	Lepidoptera	: Noctuidae	Jan to Mar
17	Potato top shoot borer	*Leucinodes orbonalis* Guen	Lepidoptera	: Pyralidae	Aug to mid Sept
18	Potato tubermoth	*Phthorimaea operculala* Zeller	Lepidoptera	: Gelechidae	Jan to Mar
19	Bihar hairy caterpillar	*Spilosoma oblique* Walker	Lepidoptera	: Agaristidae	Nov to Dec
20	Red hairy caterpillar	*Amsacta moori* Butl.	Lepidoptera	: Agaristidae	Nov to Dec
21	White grub	*Holotrichia consanguinea* Blanch.	Coleoptera	: Scarabaedae	Feb to Mar
22.	Flea beetle	*Phyllotreata cruciferarum* Duv	Coleoptera	: Alticidae	Dec
23.	Niger capsule fly	*Dioxyna sorarcula* Wiedmann	Diptera	: Tethritidae	Dec
24	Thrips	*Thrips tabaci* Lind.	Thysanoptera	: Thripidae	Nov to Feb
25.	Thrips	*Thrips palmi* Karney	Thysonoptera	: Thripidae	Nov to Feb
26.	Thrips	*Scirtothrips dorsalis* Hood	Thysonoptera	: Thripidae	Nov to Jan
27.	Thrips	*Haplothrips sp.*	Thysonoptera	: Phaleothripidae	Nov to Dec
28	Mites	*Polyphagotarsonemous latus* Banks	Acarina	: Acaridae.	Sept to Dec

Aphids species on potato reported from Satpura plateau zone (8) were *Myzus persicae* and *Aphis gossypii*. In the changed scenario two more species *Lipaphis erysimi* and *Aphis craccivora* were observed. Among hemipterans *Nezara viridula, Taylorilygus pakkidulus* and *Bagrada cruciferarum* were often seen on potato. Infestation of *B. cruciferarum* was regularly been noted on apical parts causing drooping. Defoliators were of minor importance in the zone earlier. *Helicoverpa armigera*, and *Spodoptera litura* are regularly observed on the crop. Three new species of thrips, viz. *Thrips palmi. Scirtothrips dorsalis* and *Haplothrips sp.* also constituted the part of changed scenario of potato pests in the zone.

There were some pests of potato which were often observed on the weed hosts. Weed hosts of *Myzus persicae* in the area were reported by Dharpure (5). Among the pests of weeds, the most common was *Myzus persicae* and *Thrips palmi* which were recorded on different weed hosts as mentioned in table 2.

Besides the weeds mentioned in table 2, *Portulaca oleracea, Solanum nigrum* and *Melelotus indica* were also noted to serve as alternate/ collateral hosts. *Chenopodium album* was the major weed host which served as alternate/ collateral host of *Myzus persicae, Thrips palmi* and *Scirtothrips dorsalis*. Population of *M. persicae* on this weed was recorded to be

Table 2.Weed hosts of *Myzus persicae* and *Thrips palmi* and period of pest activity

Weed hosts	*Period of infestation*		*Peak activity*	
	Myzus persicae	*Thrips palmi*	*Myzus persicae*	*Thrips palmi*
Chaenopodium album	Dec I- Mar II	Nov-Jan	Jan IV	Nov II
Euphorbia hirta	Dec II- Mar I	N.R*.	Jan IV	N.R.
Amaranthus viridis	Dec IV-Mar IV	Oct-Jan	Feb II	Nov II
Launa asplenifolia	Feb II	N.R.	Feb I	N R.
Argemon mexicana	Feb I – Feb IV	Jan I- Jan II	Feb II	Jan II
Convolvulus indica	Feb I – Feb IV	Jan II -Jan III	Feb II	Jan II

*N.R = Not recorded

around 20 aphids per plant during Jan. IV week.

In Satpura plateau of Madhya Pradesh there is a sizeable area under soybean cultivation in *Kharif* season. Vegetables are also grown year round. The insect pests attacking vegetables, soybean and other crops in the zone are also noted to migrate on potato crop. Some of the common pests migrating from other crops on potato are mentioned in the table 3.

The crops mentioned above served as the major host plants on which the pests feed and later/simultaneously migrate to potato crop. Cauliflower and cabbage crops are grown year round. These vegetables harbour *Lipaphis erysimi, Bagrada cruciferarum, Holotrichia longipennis , and Plutella xylostella* and serve as major source for the insect pests which were not seen on potato earlier or were of minor importance.*P. xylostella* is a serious pest of cauliflower during *kharif* season and also in summer in the zone. In *rabi* it is seen on potato crop also. Soybean crop grown in the zone is also a great source for *Spilosoma obliqua, Plusia orichalcea* and *Amsacta moori*. Okra crop grown in *Kharif* season provided good harborage to *Emposca devastans* as such sizeable population of this pest has observed in early potato.

Onion and garlic were the major sources from where the *Thrips tabaci* migrated on potato. Different species of thrips, viz. *Thrips palmi, Scirtothrips dorsalis* and *Haplothrips sp* have been recorded on potato crop in the

Table 3. Insect pests attaining the status of important pests and their major hosts in Satpura plateau

Insect pests migrating from other crops on potato		*Source as major host plants*
1.	***Lipaphis erysimi***	Cauliflower, cabbage and musturd
2.	***Aphis craccivora***	Beans & cowpea
2	***Bagrada cruciferarum***	Cauliflower, cabbage and musturd
3.	***Holotrichia longipennis***	Cauliflower and cabbage and ground nut
4.	***Thrips tabaci***	Onion and garlic
5.	***Helicoverpa armigera***	Gram, tomato, sunflower & maize
6.	***Emposca devastans***	Okra and sunflower
7.	***Spilosoma obliqua***	Soybean
8.	***Amsacta moori***	Soybean
9.	***Leucinodes orbonalis***	Brinjal
10.	***Plutella xylostella***	Cauliflower and cabbage

zone which serve as vectors of tomato spotted wilt virus causing stem necrosis disease (7). Due to this problem yield losses up to 20-30 per cent have been recorded (1).

The important insect pest recorded earlier were *Myzus persicae, Aphis gossypii, Agrotis ipsilon, Phthorimoea operculala* and some defoliators like *Epilachna vigintioctopunctata* in the zone.(8)The infestation of *Phthorimoea operculala* was also sporadic. The damage was mainly noted on leaves as leaf miner or the store in summer (2,3). Aphids being most important vector of viruses like PLRV and PVY responsible for degeneration of seed stock and yield reduction of potato (7) causing losses to the tune of 20-80 per cent (8). Early planting was advocated for this zone. In the early planted crop of potato i. e. planted by the end of October, the damage of cutworm was also found lowest 4.5% as against 11.5% in late planted crop of last week of November (6). Thus planting of potato in October in the zone was advantageous. Due to changing scenario of insect pests e.g. infestation of thrips in early planted crop, there is a great problem of potato stem necrosis in the zone causing yield losses to the tune of 20-30 percent (1). Number of defoliators and sucking pests are becoming important pests in potato crop in the zone.

Cropping pattern in the zone is playing great role in providing the harborage to the sporadic pests which are gradually attaining the status of important pests in potato crop.

ACKNOWLEDGEMENTS

The author is grateful to Dr. S.M.Paul Khurana, Project Coordinator, AICPIP, CPRI, Shimla for encouragement and critical suggestions in preparation of this manuscript

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MS Received: 25.10.2001

J. Indian Potato Assoc. 29 (3 - 4) : 139-142, 2002

FERTILIZER MANAGEMENT IN POTATO-*BAJRA*-GROUNDNUT AND POTATO-GROUNDNUT-*TIL* CROPPING SYSTEMS UNDER NORTH GUJARAT CONDITIONS

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ABSTRACT: Two potato based cropping systems, viz. potato-*bajra*-groundnut and potato-groundnut-*til* (sesame) were evaluated under five fertility levels at Deesa during 1997-99. Potato crop was given recommended dose of NPK, while following two crops were given different fertilizer doses. The pooled results showed that potato-groundnut-*til* gave higher production and net returns over potato-bajra-groundnut sequence. In potato-bajra-groundnut, all the three crops should be fertilized with recommended rates of NPK fertilizers, while in the sequence potato-groundnut-*til*, potato should be fertilized with 100% NPK and succeeding two crops required half of recommended dose of NPK fertilizers.

INTRODUCTION

Under North Gujarat condition, potato is a major crop during *rabi* season and *bajra* or groundnut is preferred by farmers during summer season for assured returns. However, the fertilizer needs of potato based systems needs to be worked out so as to sustain their yields. The knowledge of residual effects of applied nutrients is essential to formulate the fertilizer schedule for such systems. Therefore, the present study was undertaken to evaluate the remunerative potato based crop sequences along with fertilizer schedules under irrigated conditions at Deesa of North-Gujarat.

MATERIALS AND METHODS

Field experiments were conducted during 1997-1999 at Potato Research Station, Gujarat Agril. University, Deesa. The soil of the experimental field was sandy having pH 7.7 and 0.29% organic carbon. The soil fertility status was 168, 38 and 215 kg, available N, P_2O_5 and K_2O/ha, respectively. The experiment was conducted on same site for each year in split-plot design with four replications. The treatments comprised two cropping systems, viz. C1=potato-*bajra*-groundnut and C2= potato-groundnut-*til* (sesame) and five fertilizer schedules (Table 1). Among the five fertilizer schedules, potato crop was applied @100% of recommended dose. Half dose of nitrogen and whole P and K were applied at the time of planting as per treatment and remaining half dose of N was top dressed at 30-35 days after planting. Potato cv. Kufri Badshah was planted during third week of November at an inter and intra-row spacing of 50 x 20 cm. All the recommended agronomical practices were adopted to raise the crop successfully.

Potato crop was harvested in first week of March. After potato crop, the individual plots,

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without changing the layout, were prepared for second summer crops (*bajra* variety MH-169) and third crops (*kharif* crops viz. groundnut variety G.G-2 and sesame variety G.T-1). The summer and *kharif* crops were raised as per the recommended package of practices. For comparison between crop sequences, yields of all the two succeeding crops were converted in to potato equivalent on the prevailing price basis and individual yield was also statistically analysed (4).

RESULTS AND DISCUSSION

Effect of treatments on yields: Results revealed highest potato equivalent yield with potato-groundnut-*til* (361.6 q/ha) sequence followed by potato-*bajra*-groundnut (343.6 q/ha) (Table 1). The sequence, potato-groundnut-*til* gave significantly higher potato tuber yield of 258 q/ha followed by the sequence, potato-*bajra*-groundnut (216 q/ha). This is due to rotational effect of sequence (2, 3). The yield of bajra after potato at 100% NPK dose was at par with the *bajra* yield obtained with 50% NPK dose (F2) in the sequence C1. The groundnut (sequence-C1) taken after summer bajra gave yield at par with groundnut (13.6 q/ha) with 100% NPK fertilization (F1) and under 50% NPK dose F2 (12.3 q/ha). This benefit was due to the residual effect of fertilizers received by preceding crop (6).

The fertilizer schedules significantly influenced the potato equivalent yield (PEY). Fertilizer schedules F2 and F4 were

Table 1. Interaction effects of cropping sequence & fertilizer schedules on potato equivalent yield (q/ha) (pooled over 3 years)

Fertilizer schedules	*Rabi*		*Summer*		*Kharif*		*Potato equivalent yield(q/ha)*	
	C1	C2	C1	C2	C1	C2		
	Potato	*Potato*	*Bajra*	*Groundnut*	*G'nut*	*Sesame*	*C1*	*C2*
F1	224.2	270.5	80.2(63.5)	68.1(15.4)	60.7(13.6)	43.7(7.0)	368.2	382.3
F2	228.1	275.7	69.8(53.3)	67.6(15.2)	55.6(12.3)	41.8(6.7)	351.3	385.1
F3	218.8	267.8	63.0(48.8)	60.8(13.6)	56.7(12.6)	39.1(6.3)	339.7	368.5
F4	210.5	239.2	73.1(57.4)	61.9(13.7)	61.3(14.1)	42.9(6.9)	344.9	343.9
F5	198.7	234.8	66.0(51.3)	55.5(12.1)	52.0(11.7)	38.1(6.1)	313.9	328.3
Mean	216.1	257.6	70.4(54.9)	62.8(14.0)	57.3(12.8)	41.1(6.6)	343.6	361.6
CD(0.05) for C	23.99		NS(5.11)		NS(NS)		NS	
CD(0.05) for F	21.10		7.7(5.6)		NS(NS)		24.0	
CD(0.05) for C x F	NS		NS(NS)		NS(NS)		NS	

Treatments details (fertilizer schedules):

	Rabi crops (Potato)	Summer crops (*Bajra* & G'nut)	Kharif crops (G'nut & Sesame)
F1	NPK*	NPK*	NPK*
F2	NPK*	½N ½P ½K	NPK*
F3	NPK*	½N ½P ½K	½NPK
F4	NPK*	NP_0K_0	NPK*
F5	NPK*	$N½\ P_0K_0$	NPK*

NPK indicate full recommended dose of NPK fertilizer
*Figures in parentheses indicate respective crop main yield (q/ha)
*Recommended fertilizer dose:
Potato, 220-110-220 N, P_2O_5 and K_2O, kg/ha
Groundnut, 25-50-00 N, P_2O_5 and K_2O, kg/ha for summer
Groundnut, 12.5-25-00 N, P_2O_5 and K_2O, kg/ha for *Kharif*
Sesame 30-15-00 N, P_2O_5 and K_2O, kg/ha
Bajra 80-40-00 N, P_2O_5 and K_2O, kg/ha

significantly at par with F1, however, F1, was significantly superior to rest of the fertilizer schedules. Similarly F2 and F3 were at par in terms of PEY, but F2 was superior to F3, F4 and F5 (5). The interaction effect between fertilizer schedules and cropping systems was non-significant, however, the PEY in sequence C2 (362 q/ha) was higher than the sequence C1 (344 q/ha).This might be due to groundnut taken after potato sequence left residual effect (3). In the sequence C2, PEY was higher under all the five fertilizer schedules (F1 to F5) as compared to C1 sequence. But fertilizer schedules F1, F2 and F3 were significantly superior to F4 and F5 and were at par with each other in terms of PEY(1).

Effect of treatments on net returns: Net returns were in general higher with potato, followed by *bajra*, groundnut and sesame (Table 2). The net returns of potato were higher when grown in potato-groundnut-*til* than the potato-*bajra*-groundnut sequence. The returns were affected by the schedules. Potato-*bajra*-

Table 2. Yields and economics of cropping sequence and fertilizer schedules (Averaged over three years)

Cropping sequence	*Fertilizer schedule*	*Yield (q/ha)*		*Input cost (Rs./ha)*	*Produce price (Rs/ha)*	*Net return (Rs./ha)*	*Total return (Rs./ha)*
		MP	*BP*				
C1-potato	F1	224.0	-	33200	89600	56400	56400
	F2	228.0	-	33200	91200	58000	58000
	F3	219.0	-	33200	87600	54400	54400
	F4	211.0	-	33200	84400	51200	51200
	F5	199 0	-	33200	79600	46400	46400
Bajra	F1	63.5	134	5300	32100	26800	83200
	F2	53.3	120	4445	27400	22955	80955
	F3	48.8	114	4445	25220	20775	75175
	F4	57.4	130	4785	29460	24675	75875
	F5	51.3	118	4188	26420	22232	68632
Groundnut	F1	15.4	32	7720	25660	17940	101140
	F2	15.2	31	7720	25280	17560	98515
	F3	13.6	33	7720	23040	15320	90495
	F4	13.7	31	7210	23030	15820	91675
	F5	12.1	31	7720	20630	12910	81542
C2-Potato	F1	271.0	-	33200	108000	74800	74800
	F2	276.0	-	33200	110400	77200	77200
	F3	278.0	-	33200	107200	74000	74000
	F4	239.0	-	33200	95600	62400	62400
	F5	235.0	-	33200	94000	60800	60800
Groundnut	F1	13.6	47	8220	24160	15940	90740
	F2	12.3	49	6690	22370	15685	92885
	F3	12.6	45	6690	22500	15810	89810
	F4	14.1	44	7820	24670	16850	79250
	F5	11.7	42	7510	20910	13400	74200
Til (Sesame)	F1	7.0	-	6620	17500	10880	101620
	F2	6.7	-	6620	16750	10130	103015
	F3	6.3	-	6620	15750	9130	98940
	F4	6.9	-	6130	17250	11120	90370
	F5	6.1	-	6620	15250	8630	82830

*Inputs cost for each crop includes fertilizers and seed cost

*The average market price of product per quintal of potato, *bajra*, groundnut and sesame (*til*) and by product (BP) of *bajra* and groundnut are Rs.400, 400, 1500, 2500, 50 and 80, respectively

groundnut gave highest net return when all the crops were fertilized with recommended dose of fertilizer. Potato-groundnut-sesame crop sequence gave highest net returns of Rs.1,03,015/ha when potato was fertilized with recommended rate and groundnut and *til* were given fertilizer at half recommended rate.

On the basis of three years experimentation, it can be concluded that in potato-groundnut-sesame, potato required recommended dose of NPK, and two succeeding crops (groundnut and sesame) required half of the recommended dose of NPK, while in potato-*bajra*-groundnut sequence, all the three crops should be fertilized with recommended rate of NPK fertilizers.

ACKNOWLEDGEMENTS

Authors thank Dr. SM Paul Khurana, Project Coordinator, AICPIP, Shimla for his encouragement and guidance.

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MS Received: 20.07.2002

J. Indian Potato Assoc. 29 (3 - 4) : 143-146, 2002

STANDARDIZATION OF SPACING FOR SEED TUBERLET PRODUCTION FROM TPS UNDER NURSERY BEDS IN GUJARAT

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ABSTRACT: A field experiment was conducted during the *rabi* season of 1998 with five levels of inter row and two intra row spacings in Factorial Randomized Block Design with four replications. The inter row spacing of 10 cm gave significantly highest number and weight of 10-20gm, 20-40gm as well as total tuberlets. The widest spacing of 30 cm was significantly superior in terms of number of compound leaves, number and weight of tuberlets of 20-40 gm and >40 gm size. Similarly the closer intra row spacing of 5 cm gave significantly higher number and weight of total and the other categories of tuberlets except large sized compared to the wider spacing. But the wider intra row spacing of 10 cm significantly enhanced the production of large sized (> 40 gm.) tuberlets and the number of compound leaves.

INTRODUCTION

The major constraints for achieving higher productivity of potato in Gujarat State are shortage of quality seed and its price. Seed cost constitutes 40-45 per cent of the production cost (3), which becomes a heavy drain on the farmer's pocket. Moreover, the potato growers of state still depend on the northern states for their major requirement of the seed stock. The non-availability of good quality seed tubers, high seed cost and virus infiltration in seed tubers leading to degeneration of seed stock have lead to the development of true potato seed technology (TPS). The production of potatoes from TPS has received considerable attention of the small and poor potato growers. There is an acute need, to develop the TPS technology for getting more tuberlet production for the farming community. No efforts have been made in this direction in the state. So to standardize spacings for TPS sowing in nursery beds for getting large number of tiny seed tuberlets/ unit area, which can be multiplied later on in the next year to large scale for seed tuber production was tried.

MATERIALS AND METHODS

An experiment was conducted at Demonstration Farm, K.V.K., Gujarat Agricultural University, Deesa during *rabi* season of 1998 with hybrid TPS-C-3 in a Factorial Randomized Block Design with four replications. Experiment comprised 5 inter row (10, 15, 20, 25 and 30 cm) and 2 intra row spacings (5 and 10 cm). The soil of experimental field was well drained loamy sand with pH of 8.2. The recommended doses of fertilizer @ 220 Kg N, 110 Kg P_2O_5 and 220 Kg K_20 was applied. The crop was sown on 1st

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November and dehaulmed 90 days after sowing. Crop was harvested 10 days later as a curing process for storage.

Economics calculated, for the same, on the basis of how much area can be covered for the next year planting at 45 x10 cm spacing (for 10gm tuberlet) by the F1C1 tuberlets produced from TPS. Moreover, how much quantity of seed tubers required from market to plant the said area and its respective market price.

RESULTS AND DISCUSSION

There was no significant effect of inter and intra row spacing on per cent plant population, plant height and number of stems/ hill (Table 1). This may be due to the facts that both minimum and maximum inter and intra row spacing provided sufficient space to produce enough number of stems/hill and plant height. The similar results were also reported by Anon (1) and Singh (7).

The differences in number of compound leaves resulting from different inter and intra row spacings were significant. Number of compound leaves/plant increased with increase in inter and intra row spacing. This was probably resulted from increase in the row spacing, which played a positive role by providing more and more space resulting in nutrient availability and facilitated sunlight for photosynthesis, which led to the production of greater number of compound leaves. Earlier workers, Singh *et al.* (5) also reported similar results. Dry haulm yield (m^2) decreased with increase in inter and intra row spacing, might be due to lower density of plant population resulting in poor accumulation of total biomass. The results are in accordance with the findings of Singh *et al.* (4).

The differences in number and weight of tuberlets due to different inter row spacings is presented in table 2 which were observed to be significant. The inter row spacing of 10 cm gave significantly highest total number (472) and weight (4.13 Kg.) of tuberlets per m^2 over the other spacings except of 15 cm which stood at par in respect to only weight

Table 1. Effect of Spacings on yield attributing characters of potato

Treatment	*Final Plant Population (%)*	*Plant height (cm)*	*No. of Stems/ Hill*	*No. of compound Leaves/Plant*	*Haulm Yield (dry weight) Kg/m²*
Inter-row spacing (cm)					
10	86.8	35.5	1.3	11.0	0.51
15	86.2	34.5	1.3	11.6	0.49
20	87.7	32.9	1.3	13.0	0.41
25	86.6	34.3	1.2	14.4	0.39
30	87.8	35.6	1.2	15.4	0.36
C.D. at 5%	NS	NS	NS	0.49	0.028
Intra-row spacing (cm)					
5	87.2	34.6	1.3	12.6	0.51
10	86.9	34.5	1.2	13.6	0.36
C.D.at 5%	NS	NS	NS	0.30	0.018
Interaction (Inter x Intra)					
C.D.at 5%	NS	NS	NS	NS	0.04
C.V.%	1.7	8.27	13.2	3.64	6.33

Table 2. Effect of spacings on number and weight of tuberlets per m²

Treatment	No. of tuberlets/ m²					Weight of tuberlets Kg /m²				
	<10 g	10-20 g	20-40 g	>40 g	Total	<10 g	10-20 g	20-40 g	>40 g	Total
Inter-row spacing (cm)										
10	310	118	33	11	472	1.17	1.56	0 89	0.51	4.13
15	275	103	34	12	424	1.07	1.43	0.92	0.61	4.03
20	226	84	35	14	359	0.92	1.18	0.98	0.69	3.77
25	201	82	37	15	335	0.83	1.15	1 05	0 72	3.75
30	170	69	36	15	290	0.79	1.03	1.06	0.77	3.65
C.D.at 5%	15	10.5	NS	1.9	18.7	0.07	0.15	0.12	0.11	0.24
Intra row spacing (cm)										
5	265	103	37	11	416	1.05	1.41	1.03	0 54	4.03
10	208	81	33	15	337	0.86	1.13	0.93	0.78	3.70
C.D at 5%	9.4	6 6	2.3	1.23	11.8	0.04	0.09	0.07	0.07	0.15
Interaction (Inter x Intra)										
C.D.at 5%	21.1	NS	NS	NS	26.4	NS	NS	NS	NS	NS
C.V.%	6.14	11.13	10.06	14.12	4.84	6.97	11.52	11.63	16.07	6 13

(4.03 kg) of tuberlets. The same spacing was also found significantly superior over other spacings in respect to the different grades of tuberlets, viz. very small (<10 g) and small (10-20 g). The widest spacing 30 cm was found significantly superior in terms of large sized (>40 g) tuberlets and weight of medium sized tuberlets. This might be due to the fact that in 10 cm sufficient optimum number of plants required in m^2 area were present, which was reflected in the increase of number and weight of tuberlets per m^2 The results are in conformity with those reported by Kadian *et al.* (3), Kabir (2) and Singh (6) in transplanted TPS crop.

The differences in total number and weight of tuberlets due to the two intra row spacings were observed to be significant (Table 2). The closer spacing 5 cm gave significantly higher number (416) and weight (4.03 kg) of total tuberlets as compared to wider spacing 10 cm. The spacing of 5 cm also gave significantly superior response with respect to number and weight of very small (<10g), small (10-20g) and medium (20-40g) sized tuberlets. This probably resulted from the high density of plant population restricting the size of tubers but increasing the number of tubers.

The wider intra row spacing of 10 cm significantly enhanced the production of large sized tuberlets. This might be due to more space to underground area for the development of tuber size, which was reflected on higher number and weight of large sized tuberlets. Similar results were obtained by Kabir (2) in TPS crop.

The data presented in table 3 indicated that as the inter row spacing increased the net realization (Rs./ha) decreased. The highest net realization of Rs.3,04,651 per ha was obtained under inter row spacing of 10 cm. The same spacing has recorded the highest value of CBR (1: 2.96).

There was an appreciable increase in net realization due to intra row spacing of 5 cm. A higher net realization of Rs.2,63,436 per ha was recorded in intra row spacing of 5 cm as compared to 10 cm, which gave Rs.2,09,644 per ha. A higher CBR of 1:2.76 was noticed in 5

Table 3. Economics of inter and intra-row spacings

Treatment	Number of tuberlets m^{-2}	Number of tuberlets ha^{-1}	Area covered in ha. Next year	Gross realization (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	Net realization (Rs ha^{-1})	Cost Benefit Ratio (CBR)
Inter row spacing (cm)							
10	472	4716300	21.22	407424	1,02,773	304651	1:2.96
15	424	4241300	19.09	366528	92,777	273751	1:2.95
20	359	3591300	16.16	310272	85,092	225188	1:2.65
25	335	3352500	15.09	289728	82,269	207459	1:2.52
30	290	2903800	13.07	250944	79,192	171752	1:2.17
Intra row spacing (cm)							
5	416	4155500	18.70	359040	95,604	263436	1:2.76
10	337	3366500	15.15	290880	81,236	209644	1:2.58

N.B 1. Area can be covered in hectare for the next year is calculated on the basis of number of tuberlets (F1C1) produced ha^{-1} divided by 2,22,222 tuberlets required ha^{-1} for planting at a distance of 45 x 10cm (for the planting of 10 gm tuberlets) in Gujarat

2. Gross realization is calculated on the basis of area (ha) which can be covered in the next year by the F1C1 produce X cost of commercial seed required for one ha, i.e. 32 bags (each 80 Kg)

3. Cost of a bag of 80 Kg tubers = Rs. 600

4. Cost of seed (TPS) is considered as Rs 10,000 Kg^{-1}

cm spacing as compared to 10 cm, which gave a CBR of Rs. 1:2.58.

It may be concluded that as plant population increases there was an increase in number and weight of TPS tuberlets under nursery beds. Among the different spacings, inter row spacing of 10 cm and intra row spacing of 5 cm recorded maximum number and yield of tuberlets per m^2 with highest CBR and net realization. It will be helpful to the potato growers for good quality seed tuberlet production in enough quantity and at a cheaper rate from botanical seed. Potato growers can also multiply seed in the successive years by following seed plot technique, for their own interest, to have quality seed tuber production.

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MS Received: 25.07.2002

J. Indian Potato Assoc. 29 (3 - 4) : 147-151, 2002

INTEGRATED NUTRIENT MANAGEMENT IN POTATO-VEGETABLES CROP SEQUENCE UNDER RAINFED HILLY CONDITION OF MEGHALAYA

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ABSTRACT : The results of 2-year field experiment at Shillong indicated that potato-radish crop sequence gave higher production and monetary gain over potato-cabbage sequence in rainfed hilly areas of Meghalaya. Recommended doses of fertilizers to potato as well as to succeeding vegetable crop are needed to achieve higher yield and net returns as well as sustained soil health.

INTRODUCTION

Sequential cropping is an unique asset to exploit sustainability in food production. Potato based cropping systems have assumed paramount importance to meet the dietary habit of the people of Meghalaya. In the rainfed hilly areas of Meghalaya, potato-vegetables are the widely followed cropping sequences. Potato is a major crop during summer season while vegetable crops such as cabbage, radish, cauliflower *etc.* are preferred during autumn season for assured returns. Nutrient management on cropping system basis is more efficient and judicious than on sole crop basis, the residual effects of fertilizer applied to one crop are fully exploited by succeeding crop. Keeping these considerations in view the present investigation was undertaken to find out nutrient management schedule for potato-vegetable crop sequences at Shillong.

MATERIALS AND METHODS

Field experiment was conducted during summer (March-July) and autumn (August-December) season of 1999 and 2000 at the Central Potato Research Station, Shillong. The soil of the experimental field was sandy loam in texture with pH 5.2. The soil fertility was medium in available nitrogen and potash and low in available phosphorous. The experiment was laid out in split plot design with four replications on the same site without changing the randomization of the treatments. The treatments consisted of two cropping systems *viz.* potato (summer)-radish (autumn) and potato (summer)-cabbage (autumn) in main plots and six fertilizer schedules in sub plots (*viz.* full recommended dose of NPK to potato+100% recommended dose to autumn crop (F1), full recommended dose of NPK to potato+75% recommended dose of NPK to autumn crop (F2), full recommended dose of

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NPK to potato+50% recommended dose to autumn crop (F3), full recommended dose of NPK to potato+25% recommended dose of NPK to autumn crop (F4), full recommended dose of NPK to potato and no NPK to autumn crop (F5), full recommended dose of NPK to potato+125% recommended dose of NPK to autumn crop (F6).

After harvest of potato crop, individual plots were prepared for autumn crops without changing the layout. The potato cultivar Kufri Jyoti was planted at spacing of 60 X 20 cm with seed rate of 25 q/ha on 7th and 13th April during 1999 and 2000, respectively. Autumn crops were planted/sown on 26th and 27th July during 1999 and 2000, respectively. Recommended agronomic practices and need based cultural operations and plant protection measures were followed. The total rainfall recorded during summer and autumn seasons of 1999 and 2000 was 1861 mm and 813 mm and 1573 mm and 792 mm, respectively.

By and large the weather condition remained favourable for growing the summer and autumn crops in both the years. Crop yields were recorded and economics of production was worked out for each treatment at prevailing market prices of inputs and outputs to arrive at net return. For the sake of comparison, yields of component crops in the crop sequences were converted into potato equivalent yield (PEY) on price basis (1). To study the changes in soil-fertility after 2 cycles of each treatment, soil samples were analysed for available N, P and K by standard procedures.

RESULTS AND DISCUSSION

Crop emergence/ plant stand: Plant stand of potato crop was not influenced significantly by different fertilizer schedules (Table-1). However, plant stand of succeeding autumn crop (*i.e.* cabbage & radish) was influenced significantly during both years by various schedules. Highest germination percentage was recorded in fertilizer schedule F6 where 125% of full recommended dose of NPK was applied to subsequent autumn crop, while lowest germination percentage of autumn crop was observed in fertilizer schedule F5 where no NPK was applied to autumn crop.

Yield of crops & potato equivalent yield: The treatments had no significant effect on potato yield indicating uniformity of the experimental site (Table 1). Fertilizer schedule consisting of 125% of recommended doses of NPK (F6) recorded highest radish and cabbage yield, but was at par with fertilizer schedule F1 consisting of 100% of recommended dose of NPK.

Adoption of the potato-radish sequence gave significantly higher potato equivalent yield during both the years over potato-cabbage sequence. Among different fertilizer schedules, though fertilizer schedule F6 recorded highest potato equivalent yield but it was at par with F1 while F1 treatment gave significantly higher PEY than all other fertilizer schedules tested during experimentation. F1 was closely followed by F2 and lowest PEY was obtained in F5, during both the years (Table 2).

Economic analysis: The net return (Rs.21984/ ha) and benefit: cost ratio (0.39) were higher in potato-radish sequence than potato-cabbage

Table 1. Effect of fertilizer schedules on germination and yield of potato, radish and cabbage

Fertilizer schedule	*Crop emeregence/Crop stand (%)*								*Yield (t/ha)*							
	1999				*2000*				*1999*				*2000*			
	Potato	*Radish*	*Potato*	*Cabbage*	*Potato*	*Radish*	*Potato*	*Cabbage*	*Potato*	*Radish*	*Potato*	*Cabbage*	*Potato*	*Radish*	*Potato*	*Cabbage*
F1	92.53	89.50	92.55	89.40	87.53	88.45	87.55	87.45	13.11	16.44 (8.22)	13.07	9.77 (7.33)	12.95	16.96 (8.48)	13.10	9.87 (7.40)
F2	92.50	87.48	92.63	87.38	87.55	86.35	87.55	86.35	13.10	15.30 (7.65)	13.02	9.03 (6.77)	12.90	15.60 (7.80)	13.05	8.91 (6.68)
F3	92.60	85.48	92.50	85.38	87.48	84.25	87.55	83.35	12.99	13.80 (6.90)	12.90	7.79 (5.84)	13.00	13.58 (6.79)	12.90	7 64 (5.73)
F4	92.48	80.50	92.65	80.40	87.50	79.75	87.58	80.38	12.95	9.50 (4.75)	12.95	4.93 (3.70)	12.95	9.20 (4.60)	12.95	4.73 (3.55)
F5	92.55	75.50	92.56	75.40	87.48	74.25	87.53	78.38	13.00	4.40 (2.20)	12.90	1.69 (1.27)	12.90	4.20 (2.10)	12.90	1.33 (1.06)
F6	92.55	91.53	92.50	91.43	87.50	90.80	87.60	89.48	13.10	16.70 (8.35)	12.99	10.05 (7.54)	12.60	17.56 (8.78)	13.00	10.31 (7.73)
CD(P=0.05)	NS	2.17	NS	2.69	NS	1.98	NS	2.13	-	-	-	-	-	-	-	-

Figures in parentheses indicate potato equivalent yield

Table 2. Effect of different treatments on potato equivalent yield, net return and benefit/cost (B:C) ratio

Treatments	Potato equivalent yield (t/ha)		Net return (Rs/ha) pooled	B:C ratio pooled
	1999	2000		
Cropping system				
Potato – radish	19.42	19.36	21984	0.39
Potato – cabbage	18.33	18.35	15988	0.28
CD (P=0.05)	0.27	0.13	-	-
Fertilizer Schedule				
F1	20.96	20.97	26422	0.46
F2	20.26	20.22	24120	0.42
F3	19.32	19.23	20819	0.37
F4	17.17	17.02	12717	0.23
F5	14.56	14.48	3455	0.06
F6	20.99	21.20	26383	0.45
CD (P=0.05)	0.17	0.25	1145	-

sequence, however, land utilization efficiency (LUE) was higher in potato-cabbage (56.31) cropping sequence and lower in potato-radish (53.29%) sequence owing to longer duration of cabbage. Potato-radish system also recorded high production efficiency (Table 3) both in terms of kg/ha/day (94.29) and Rs/ha/day (112.74). The higher net return in potato-radish sequence was mainly because of higher yield and lower cost of cultivation than other sequence.

Table 3. Effect of cropping system on land use efficiency and production efficiency

Cropping system	*Land use efficiency*	*Production efficiency (kg/ha/day) (%)*	*Production efficiency (Rs/ha/day)*
Potato-radish	53.29	94.29	112.74
Potato-cabbage	56.31	89.37	77.61

Among all the fertilizer schedules, F1 resulted in highest net return (Rs.26422/ha) and B:C ratio (0.46). The net return and benefit:cost ratio was not satisfactory in fertilizer schedule F5 (Rs. 3455/ha and 0.06). It is interesting to note that net return and benefit: cost ratio was reduced in both the cropping systems when the autumn crop was fertilized with 125% of NPK of the recommended dose. This was mainly due to higher fertilizer price and cheaper market price of produce than F1 sequence.

Impact on soil fertility: The change in soil fertility status was assessed after completion of two cycles of cropping sequences (Table 4). It is evident that both the crop sequences recorded almost similar values at final stage as compared to initial values and fertility status was maintained in both the crop sequences.

There was a net loss (-) in soil N under control plots and with lower level of N, whereas a positive balance was observed at 75%, 100% and 125% recommended doses of NPK due to residual build up. The maximum available N was recorded with 125% NPK

Table 4. Changes in soil-fertility as influenced by different treatments

Treatments	*Available soil nutrients (kg/ha)*			
	pH	*N*	P_2O_5	K_2O
Cropping system				
Potato – radish	5.2	137.31	20.62	169.4
Potato – cabbage	5.2	137.23	20.38	169.3
CD (P=0.05)	NS	NS	NS	NS
Fertilizer schedule				
F1	5.3	142.2	22.2	176.2
F2	5.2	139.8	21.3	174.7
F3	5.2	135.1	20.0	167.7
F4	5.1	133.7	19.1	161.8
F5	5.2	129.4	17.7	156.6
F6	5.2	144.4	22.7	178.8
CD (P=0.05)	NS	11.3	2.7	10.6
Initial soil fertility	5.2	140.0	21.0	175.0

dose. The available P after 2 years was found to decrease at lower levels of P_2O_5 and control. However, gain in phosphorus in soil was observed when higher rates of (75%, 100% & 125%) recommended doses of NPK were

applied. Similar trend was observed in respect of available K after 2 cycles of crop sequence. There was a net loss of K under no K application treatment. The results show that potato-radish was better sequence than potato-cabbage in the hills of Shillong. Both the crops required recommended doses of NPK.

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MS Received: 20.11.2001

J. Indian Potato Assoc. 29 (3 - 4) : 153-154, 2002

SHORT NOTE

NITROGEN AND POTASSIUM INTERACTION EFFECT ON YIELD ATTRIBUTES OF POTATO

Gyanendra Kumar Rai, M.M. Verma[1] and Jagdish Singh[2]

Potato produces more food per unit area and time compared to cereals. Its production depends on the contribution of many factors, among them judicious application of N and K are of vital importance (2, 5). Present investigation was, therefore, an attempt to study the effect of various levels of N and K on growth and yield of potato.

The experiment was conducted during *rabi* season of 1999-2000 at Sheila Dhar Institute of Soil Science, University of Allahabad. Three levels of nitrogen 0 (N_0), 80 (N_1) and 120 (N_2) kg ha^{-1} and four levels of potassium 0 (K_0), 60 (K_1), 80 (K_2) and 100 (K_3) kg ha^{-1} were applied. Treatments were laid in factorial RBD with three replications. Well sprouted tubers of potato cv. Kufri Bahar (25-30g) were planted at 60 x 20 cm spacing. NPK were applied through urea, single super phosphate and muriate of potash, respectively. Full dose of phosphorus (50 kg ha^{-1}) and K to all plots and half dose of N were applied as basal dressing. The remaining half dose of N was top-dressed as per the treatments at the time of earthing up. Other cultural practices were followed as per recommendation. Observations were recorded periodically adopting standard procedure. The haulms were cut manually at 120 days after planting and crop was harvested one week after haulm cutting.

A perusal of data presented in table-1 revealed significant effects of N and K on plant height. However, their interactions were non-significant. Increase in level of N and K from 0-120 kg ha^{-1} and 0-100 kg ha^{-1}, respectively increased the height. The N_2 (120 kg ha^{-1}) treatment was significantly superior to N_1 and N_0 treatments. The maximum mean height of the plant was recorded under K_1 at 30 DAP (24.5 cm) and at 60 and 80 DAP (31.9 and 37.7 cm) at K_3 levels of K application.

It is evident from table-1 that the levels of N and K gradually increased the number of shoots. The maximum number of shoots i.e. 14.0 was observed at K_0 (60 kg ha^{-1}). The N application also had a significant effect on number of shoots (14.9) at N_2 (120 kg ha^{-1}) level. The increase in the doses of N might have resulted in greater cell elongation and leaf area and thus increased crop growth and number of shoots. Interactions were non-significant. The maximum number of shoots (15.7) were observed at K_1N_2 (60 kg K_2O and 120 kg N ha^{-1}) level followed by other treatments.

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Table 1. Effect of nitrogen and potassium level on yield attributes of potato

Treatments	Height (cm)			Number of shoots	Tuber yield (q ha^{-1})
	30 DAP	60 DAP	80 DAP		
N Levels					
N_0	21.4	25.9	30.2	11.5	164
N_1	23.9	30.8	35.3	14.0	199
N_2	26.8	35.9	40.1	14.9	223
CD (0.05)	1.308	1.174	1.280	1.23	4.34
K Levels					
K_0	23.5	28.9	32.1	13.1	175
K_1	24.5	31.1	35.0	14.0	189
K_2	24.4	31.5	35.9	13.2	201
K_3	23.7	31.9	37.7	13.5	217
CD (0.05)	-	1.357	1.478	-	4.99
CD (0.05) (N x K)	-	2.34	2.56	-	8.63

The increase in the height of plant and number of shoots by K application was due to its association with the efficiency of leaf as an assimilator of CO_2 and built up of plant substances. It also enhances the metabolic activities of the plant and brings about better growth. The rapid increase in height of plant, number of shoots in early stages of plant growth was due to availability of more nutrients for sustaining the plant (6).

Results presented in table-1 clearly indicated that the various level of N and K significantly increased the tuber yield. The highest yield (231 q ha^{-1}) was recorded at K_3N_2 and was significantly higher than control (K_0N_0). The interaction effect of levels was significant. The increase in yield due to better supply of nutrients through increasing levels of K application, in particular, created the most favourable and luxuriant vegetative growth, which correspondingly increased the yield of tubers as reported by Sharma and Arora (4). The increase in yield with N in presence of 100 kg K showed that utilization of K for plant growth was associated with concomitant supply of N. Elagabaly (1) reported that N is able to increase root cation exchange capacity which in turn helps the plant to absorb other nutrients from the soil. The increase in yield due to split application of N might be attributed to better utilization of N as per requirement during various stages of vegetative growth. Sharma (3) has shown that nitrogen being a limiting nutrient in potato production has a great influence on tuber yield and quality.

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MS Received: 21.08.2002

J. Indian Potato Assoc. 29 (3 - 4) : 155-156, 2002

SHORT NOTE

NEW RECORD OF A PAINTED BUG , *BAGRADA CRUCIFERARUM* KIRKALDY (PENTATOMIDAE : HOMOPTERA) ON POTATO IN SATPURA PLATEAU OF MADHYA PRADESH

S.R. Dharpure[1]

Bagrada cruciferarum has been reported as a serious pest of cruciferous and cucurbitaceous crops (2, 3). This insect was found feeding on potato crop during the course of survey of potato pests around Chhindwara, M.P. The pest incidence was first recorded at experimental farm of Zonal Agricultural Research Station, Chhindwara in the third week of November 1997 on variety Kufri Badshah and subsequently it was also observed in Gurayya, Ranikamath and Kundali Kala villages on variety K. Badshah, K. Jawahar, and K. Sutlej. The pest was regularly observed in the following years during November to February. The infested branches showed characteristic withering symptoms due to sap feeding. On such branches invariably 1-2 nymphs or adults were found at their juncture. Damage was recorded by counting the withered branches /10 m^2 in the randomly selected 10 plots in the field. Population count was recorded by actual counting of the pest on the withered branches in the selected plot.

Table 1. Damage and population of *B. cruciferarum* on potato cv. K. Badshah at Chhindwara during 1997-98 and 1998-99*

Month	Week	1997-98		1998-99	
		No of withered branches/10M	Population of B.c./ withered branch	No. of withered branches/10M	Population of B.c./ withered branch
Nov.	III	1.0	1.0	0.0	0.0
Nov.	IV	1.0	1.0	0.0	0.0
Dec.	I	1.0	1.6	1.0	1.1
Dec.	II	1.5	1.6	1.0	1.1
Dec.	III	2.0	1.8	2.2	1.5
Dec.	IV	4.0	1.6	3.0	1.5
Jan.	I	5.0	1.8	3.5	1.5
Jan.	II	5.5	1.8	4.0	1.6
Jan.	III	5.0	1.5	4.0	1.6
Jan.	IV	5.0	1.1	4.0	1.2
Feb.	I	5.0	1.0	4.0	1.0
Feb.	II	5.0	0.6	4.0	0.5

*Average of 10 random plots of 10 M each, B.c. = *Bagrada cruciferarum*

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The damage in 10 m^2 area and population count per branch recorded at the research farm of Zonal Agricultural Research Station, Chhindwara is presented in table 1.

A perusal to the data presented in table1 reveals that the pest was more active on potato plants between 3rd week of November to the 2nd week of February during 1997-98 where as from December 1st week to February 2nd week in 1998-99. The population of this pest declined fast after last week of January and no pest population was observed beyond second week of February during both the years. Maximum activity and damage was recorded during last week of December to third week of January.

Incidence of *Bagrada cruciferarum* on potato has not been reported so far (1). Occurrence of this pest on potato may be attributed to changing scenario of pests of potato due to the changing cropping pattern of the area. *B. cruciferarum* is the major pest of cruciferous crops like cauliflower, cabbage and mustard which are extensively grown in the area and may pose serious threat to potato crop in near future, hence needs special attention.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the encouragements of Dr. S.M.Paul Khurana, Project Coordianator (Potato), C.P.R.I. Shimla for preparation of this manuscript.

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MS Received: 5.12.2001

J. Indian Potato Assoc. 29 (3 - 4) : 157-158, 2002

SHORT NOTE

ON-FARM EVALUATION OF TPS DERIVED TRANSPLANTS AND SEEDLING TUBERS IN SATPURA ZONE

D.N. Nandekar[1]

Research on true potato seed (TPS) includes many important aspects such as breeding, evaluation of parental lines, true seed production and agronomical studies on seedling transplants and seedling tubers as propagating material. TPS produced seedling as propagating materials can be used successfully in areas where farmers are well aware of horticultural practices being applied for vegetable production, temperatures are moderate at transplanting and irrigation is easily available (1). However, for those areas where labour availability is a problem and climatic conditions are unfavorable for transplanted seedlings, the seedling tubers developed from TPS during the previous season can be used as planting material in the following season.

During two successive crop seasons (1997-98 to 1998-99) five hybrid TPS populations, viz. HPS-1/13, HPS-11/13, HPS-7/67, HPS-1/13 and TPS C-3 were sown in nursery beds to raise seedlings in four villages namely Chandangaon, Kundhalikala, Ranikamat and Guraiya in Satpura zone of Madhya Pradesh. Four-week-old seedlings of each progeny were transplanted in RBD with four replications. Bare rooted seedlings were transplanted manually at 50x10 cm inter and intra row spacing in plots of 5 m x 3 m at each location. Seedling tubers of same families produced in previous season were also planted in RBD on the same day as transplanted trial. Seedling tubers of >40 g, 20-40 g and 10-20 g size were planted at 60 cm x 20 cm, 60 cm x 15 cm and 60cm x 10cm spacings respectively with each having four replications. Pre-planting NPK fertilizers were applied both for seedlings and

Table 1. Total and marketable yield (q/ha) of seedling tubers and seedlings of TPS populations at different locations

Treatments	*Location wise yield (q/ha)*							
	Chandangaon		*Kundhalikala*		*Ranikamat*		*Guraiya*	
	Total yield	*Marketable yield*	*Total yield*	*Marketable yield*	*Total yield*	*Marketable yield*	*Total yield*	*Marketable yield*
Seedling tubers	227.87	187.99	217.70	183.30	231.71	186.75	228.78	186.22
Seedlings	134.74	88.52	142.88	100.73	140.54	96.12	134.56	90.42
L.S.D.(0.05)	31.25	29.50	35.70	32.45	40.20	36.70	37.30	34.60

Mean of two suceessive seasons and five TPS populations

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seedling tubers propagated crops at the rate of 80:100:100 kg per ha. Additional 40kg N/ ha was applied to transplanted trial in two equal split doses, once to the crop raised from seeding tubers at the time of planting and other at the time of first earthing up. Both seedling and tuber propagated trials were dehaulmed at 90 days of field planting. Total tuber yield and marketable yield (tubers >20g) were recorded at harvest. 'T' test – was applied to compare the means of two types of crops over two season (1997-98 and 1998-1999). Mean maximum and minimum temperatures were 25.92°C and 12.70°C respectively during crop seasons.

The mean total and marketable tuber yield of first year seedling tubers was higher as compared to crop raised through seedling transplants at all locations. The growth of plants from seedling tubers was much faster than those from transplants. This is in confirmation with previous studies of Rowell *et al* (2). At the time of transplanting in the month of November the night temperatures were low at all allocations and, therefore, the growth of seedlings in the field was significantly slow for two or three weeks. The seedlings took longer time to resume the normal growth. Thomson (3) had compared seedlings and first clonal generation crop of hybrid and open pollination TPS families and reported the differences in yield of tuber propagated and seedling populations to be non significant at two locations of test. However, the average tuber size from tuber propagated plants was significantly larger than that from seedling transplants. The seedling-propagated crops in the present study produced more number of smaller size tubers compared to seedling tubers, which affected the proportion of marketable size tubers.

The major constraints for seedling transplanted crop in Satpura area perhaps can be overcome by modifying the cultural and local management practices. In general any cultural practice, which could help in early recovery of seedlings from transplanting shock and promote rapid growth, is likely to result in larger total and marketable yields. Studies in this direction need to be undertaken.

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MS Received: 7.01.2002

J. Indian Potato Assoc. 29 (3 - 4) : 159-161, 2002

SHORT NOTE

ROOM TEMPERATURE STORAGE OF SOME ADVANCED POTATO HYBRIDS AND VARIETIES IN THE PLAINS OF GUJARAT

R.N. Patel, V.H. Kanbi, C.K. Patel, N.H. Patel and S.M. Chaudhari[1]

Till now potato breeders developed high yielding and disease resistant potato varieties to feed the millions. This has brought a revolution in the country resulting in self sufficiency in potato and more recently also some to spare (export). This has opened up possibility of export of potatoes both for table and for seeds, not only to our neighbouring countries but also to South Asian and Middle East countries. Further the country's major produce is available for consumption after January in the plains, when temperatures start rising gradually. Flooding of market with fresh potatoes results in sharp decline in their prices and financial losses to the farmers. The potatoes are, therefore, to be kept in ordinary stores by farmers for a few months and sold in the market when the prices are more remunerative. This necessitates breeding varieties having better keeping quality to withstand the rigour of storage while being kept in ambient temperature in the country stores.

Potato is an important crop in Gujarat state. The state produces more than 7 lac tonnes of potatoes from nearly 30,000 ha. area with an average productivity of nearly 22-23 tonnes /ha. The state has vast potential to export potatoes. In view of the above, 11 advanced hybrids being evaluated in All India Coordinated Potato Improvement Project along with 3 high yielding medium duration varieties suitable for sub-tropical conditions of Gujarat state, were evaluated for their storage behaviour under ordinary storage at ambient temperature for four months after their harvest in February.

Storage behaviour of hybrids/varieties was studied from March to June during the year 1999 to 2001. Five kg clean, healthy and uniform size tubers of each culture from the harvest of 90 days crop were kept in Hessian cloth bags at room temperature on 1st March. The ambient maximum temperature during the four months of storage ranged from 32.9°C to 40.9°C, while the minimum ranged from 12.7 to 27.4°C. The range of minimum and maximum relative humidity varied from 80 to 83%. At the end of 120 days of storage, number and weight of healthy and rotted tubers was recorded to work out percentages of rotting both by number and weight. The tubers were also examined for sprouting and per cent sprouting from tubers having one or more

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sprouts of more than 2mm long along with sprout weight after desprouting in gm/kg of tubers was recorded. The physiological weight loss was calculated by weighing five randomly marked tubers from each replication both at the start and at the end of storage, while percent total weight loss was calculated by weighing the stored tubers at the end of experiment. The data obtained during the three years of experimentation were pooled and analyzed statistically.

The data on per cent sprouting, rottage (by number and weight) sprout weight, physiological and total weight loss after 4 months of storage at room temperature is presented in table 1. The per cent sprouting in the hybrids/varieties varied from 1.20 in hybrid JW-160 to 45.11 in hybrid JX-90.

Hybrid MS/89-60 also showed very low sprouting (5.56%) during the four months of storage. Among the varieties minimum sprouting was observed in cv. Kufri Badshah (8.27). Two of the hybrids, viz. JW-160 and MS/89-60 possess comparatively longer dormancy, which is supported by the lower sprout weight (0.08 and 0.90 gm /kg) observed in these hybrids. Among varieties, K. Badshah showed least sprout weight (0.46 gm /kg) compared to 5.16gm/kg in cv. Kufri Pukhraj and 2.86 in cv. Kufri Sutlej. Similar, results for the sprouting and the sprout weight in the two hybrids were reported by Singh *et al.* (4) from Modipuram and Kang *et. al.* (3) from Jalandhar in North-western plains of India. Longer dormancy is a desirable attribute in any hybrid/variety as it prevents physiological weight loss during storage.

Variation in rotting (both by number and weight) was also observed in the hybrid/ varieties stored at room temperature. It was minimum in hybrid JW-160 (6.69 and 5.31) and maximum in cv. Kufri Sutlej (42.28 and 35.55). A wide range of variation in these characters among the Indian varieties and advanced potato hybrids has also been reported earlier (1, 3, 4, 5). Among varieties

Table 1. Storage behaviour of advanced potato genotypes at ambient temperature after 120 days of storage

Hybrid/ variety	*% Sprouting*	*% Rottage (by number)*	*% Rottage (by weight)*	*Sprout wt. (gm)*	*Physiol wt. loss (gm)*	*% Total wt. loss*	*%Dry matter*	*Tuber yield q/ha.*
MS/89-60	05.56	23.63	21.40	0.90	10.11	33.53	18.41	335
MS/90-542	18.73	30.74	18.71	1.39	10.56	37.76	17.50	331
JW-96	16.86	10.37	06.24	0.70	08.33	18.38	15.50	345
JX-90	45.11	24.21	12.13	7.49	13.94	31.54	16.34	369
JW-160	01.20	06.69	05.31	0.08	08.73	17.07	17.47	328
JX-23	18.15	30.86	26.12	2.28	12.64	41.66	17.71	332
JX-161	22.32	10.00	07.77	3.90	14.11	21.85	17.04	383
JX-216	25.20	20.70	15.87	2.62	12.62	31.69	18.59	376
JX-214	38.58	11.91	07.97	4.09	13.12	23.88	15.86	320
JX-576	40.88	19.11	12.52	6.18	12.71	32.06	16.33	353
85-P-670	17.58	26.14	25.40	2.10	11.94	41.36	16.45	323
K. Sutlej	21.42	42.28	35.55	2.86	14.92	54.49	18.96	307
K. Pukhraj	32.86	18.41	12.78	5.16	11.92	29.96	18.03	381
K. Badshah	08.27	08.93	08.08	0.46	11.75	22.83	17.95	343
S Em ±	08.50	05.42	05.30	1.56	01.10	05.49	—	—
C.D (0.05)	24.7	15.75	15.41	NS	03.21	15.98	—	—
C. V. %	39.36	37.63	31.04	50.30	12.76	16.67	—	—

the losses due to rottage were minimum in cv. Kufri Badshah (8.93 and 8.08 %), indicating its good keeping quality under ambient temperature conditions of sub-tropical Gujarat state. Both physiological weight loss and total weight loss were also minimum in hybrids JW-160 while being very high in cv. Kufri Sutlej. The results of present study clearly established that hybrid JW-160 is a better keeper among all the hybrids evaluated for storage behaviour while Kufri Badshah possesses better shelf life.

Fresh potatoes in abundance are available in the major markets of the country from January to March, following harvest of the main crop in the plains. The wholesale price remain low during this period (2) and selling of produce in the market immediately after harvest results in poor financial gains to the farmers. Farmers who can afford, therefore, tend to keep the produce in the country store under room temperature and sell it when the prices become attractive in the market.

Potato being a perishable crop, shelf life of tubers play an important role and cultivation of varieties which show least sprouting and better keeping quality is desirable and preferred. Based on the storage behaviour of the hybrids/varieties in the present sudy, cultivation of hybrid JW-160 which is under advanced stage of evaluation in the All India Coordinated Potato Improvement Project will be desirable and advantageous along with potato cv. Kufri Badshah. Not only the produce of these culture can be kept for three to four months in the ordinary stores without much deterioration and released at the appropriate time in the market but their cultivation will also be suitable for exporting potatoes from Gujarat state in the years to come.

ACKNOWLEDGEMENTS

Authors are thankful to Dr. SM Paul Khurana, Director, CPRI & Project Coordinator, AICPIP, Shimla and Dr. SK Pandey, Head, Crop Improvement, CPRI, Shimla for giving valuable suggestions for improvement of the MS. Sincere thanks are due to the authorities of GAU for the facilities and ICAR, New Delhi for funds.

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MS Received: 19.04.2002

J. Indian Potato Assoc. 29 (3 - 4) : 163-164, 2002

SHORT NOTE

CORRELATION AND PATH ANALYSIS OF SOME ECONOMIC CHARACTERS IN POTATO

P.B. Patel*[1], N.H. Patel and R.N. Patel[2]

Yield in potato, as in other crops, is a very complex character and is generally dependent on sub-characters, which are simple in inheritance. Besides yield, tuber dry matter is important for processing varieties. The present investigation was designed to furnish the information on the nature of the association among different yield attributes, tuber dry matter and some morphological characters.

A random set of 20 genotypes were planted in randomized block design with three replications in each of four different artificially created environments by combination of fertility levels (220-110-220 and 165-82.5- 165 Kg NPK/ha) and sowing dates (15th November and 5th December) at Potato Research Station, Gujarat Agricultural University, Deesa during *rabi* season of 1998-99. Each plot had four rows of 2 metre length and inter and intra row spacings were 50 x 15 cm. Observations were recorded on five competitive plants from each plot. Data on number of stems per plant, number of leaves per plant, and plant height were recorded at 75 days after planting. Whereas the tuber yield, number of tubers per plant, average weight of tuber, fresh weight of tops per plant, harvest index, days to maturity and tuber dry matter were recorded at harvest (100 days after planting). Tuber dry matter was estimated by using 100 g of tuber tissue chopped and oven drying at 105^{0}C for 18 hours to ensure complete drying. The dried material was weighed and dry matter was converted into percent fresh weight. Correlations and path coefficient analysis was done by following method of Dewey and Lu (1).

In general values of genotypic correlations were higher than the corresponding phenotypic correlation. Tuber yield per plant was positively and significantly associated with fresh weight of tops per plant (r = 0.47), number of stems per plant (r = 0.47) and plant height (r = 0.49). Tuber dry matter had significant correlation with number of leaves per plant (r = 0.57) and number of tubers per plant (r = 0.48). Number of tubers per plant depicted negative correlation with average weight of tubers (r = -0.63).

Path coefficient analysis revealed that number of tubers per plant and average weight of tubers had strong positive direct effect on tuber yield. It suggests good scope of improvement of tuber yield by selecting plant types bearing a higher number of tubers per plant with higher average weight of tubers.

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High negative indirect effect was exhibited by number of tubers per plant on average weight of tubers. Positive direct effect of leaves per plant, plant height and fresh weight of tops per plant on yield was low but its correlation with yield was high because of higher indirect effect through number of tubers per plant (2). The dry matter content had positive direct effect on tuber yield and also showed high positive indirect effect through number of tubers per plant (2).

Results thus indicate that, for increasing tuber yield, selection should be based on both number of tubers and average tuber weight. However, for increasing both tuber yield and tuber dry matter, selection should be based on number of tubers only, as an increase in tuber size may result in a decrease in tuber dry matter.

ACKNOWLEDGEMENTS

Authors are thankful to Dr. SK Pandey, Head, Crop Improvement, CPRI, Shimla for giving valuable suggestions for improvement of the MS. Sincere thanks are due to the authorities of GAU for the facilities.

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MS Received: 26.05.2002

J. Indian Potato Assoc. 29 (3 - 4) : 165-166, 2002

SHORT NOTE

RESPONSE OF POTATO TO NPK FERTILIZATION IN *TERAI* SOILS OF WEST BENGAL

S.B. Goswami[1]

Potato (*Solanum tuberosum* L.) is a popular commercial crop in *Terai* agro-climate of West Bengal capitalizing on its long winter (October - March) and light textured soil condition. This region contributes 30% of the total potato production of the state (7.5-8.0 million tones). The nutrient requirement of potato depends on planting time and soil fertility (1, 2, 3, 4). In the present investigation attempt has been made to study the production potential of late potato at varying levels of NPK fertilizations in these soils.

The experiment was conducted during *rabi* season of 1996 at the BCKV, North Bengal Campus, Cooch Behar. The soil was sandy loam in texture and acidic in soil reaction (pH-5.7) with organic carbon -0.54%, available P_2O_5 -37 kg ha^{-1} and K_2O - 150 kg ha^{-1} . The experiment was laid out in split plot design with 3 levels of N (75, 100 & 100 kg ha^{-1}), 2 levels of P (75 and 100 kg P_2O_5 ha^{-1}) and 3 levels of K (75, 100 and 125 kg K_2O ha^{-1}) and was replicated thrice in plot size of 5m x 3m. The well sprouted seed tubers of cv. Kufri Jyoti (20-25 g) were planted at a spacing of 50 cm x 20 cm on 3rd January, 1996.

The half-N and full dose of P and K were applied as basal and rest half N was given at earthing up (stolonization starts at 45 DAP). Crop received one irrigation at peak bulking stage (60 DAP). The crop was adequately protected against pests and diseases. Crop was harvested on 4th April. Tuber yield was recorded and cost benefit ratio worked out on the basis of rupee invested on N, P and K doses (all other inputs being same in all treatments).

Crop growth: Potato crop emergence from the sprouted seed tubers was affected by the soil thermal climate during Ist week of January due to temperature fall (Table 1) in *terai* agro-climate. At 30 days after planting emergence was in the range of 74 to 76% and was not affected by NPK levels. The number of tubers and its weight per hill were significantly influenced by NPK doses (Table 2). The higher doses of N up to 125 kg ha^{-1}, P_2O_5 dose up to 100 kg ha^{-1} and K_2O dose upto 100 kg ha^{-1} increased the number of tubers and their weight significantly, whereas, the higher dose of potassium 125 kg ha^{-1} decreased the tuber number per hill but increased the tuber size and yield per plant. Verma and Grewal (5) reported that K- application increased the tuber yield significantly mainly by increasing the size of the tubers.

Tuber yield : Potato crop planted in January showed its limited yield potential (15.0 to

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Table 1. Meteorological parameters during crop growth

Month	Temperature (° C)		Relative humidity (%)		Rainfall (mm)	BRS* (hr day^{-1})
	Max.	Min.	Max.	Min.		
January	23.2	8.2	88	57	16.6	7.1
February	24.6	10.4	87	52	26.5	7.5
March	29.2	15.3	83	46	30.5	7.5
April	31.4	19.2	83	57	120.1	6.8

*BRS- bright sunshine

Table 2. Effect of NPK levels on late planted potato in terai soil

Treatments	Tubers hill^{-1}	Tuber weight hill^{-1} (g)	Tuber bulking rate (q^{-1}ha^{-1}day^{-1})	Potato yield (t ha^{-1})	B:C ratio (Rs.Kg^{-1})
N (kg ha^{-1})					
75	5.7	193	2.5	15.0	52.0
100	6.3	238	3.0	17.9	46.0
125	6.7	266	3.2	19.0	39.2
CD(P=0.05)	0.32	26.8	0.14	0.85	—
P_2O_5 (kg ha^{-1})					
75	6.3	219	2.7	16.4	17.5
100	6.9	246	3.0	18.3	14.6
CD(P=0.05)	0.34	17.2	0.12	0.74	—
K_2O (kg ha^{-1})					
75	7.2	205	2.7	16.5	44.0
100	6.7	231	2.8	17.1	34.3
125	6.0	260	3.0	18.3	29.2
CD(P=0.05)	0.21	5.23	0.20	1.23	—

Interaction effects N, P and K were not found significant

19.0 t ha^{-1}) but responded significantly to different levels of NPK. Application of 125 kg N + 100 kg P_2O_5 + 125 kg K_2O ha^{-1} recorded the highest yield. The tuber yield corresponding to yield parameters ($Y = -0.041 + 0.044\ x_1 + 0.0018\ x_2 + 5.776\ x_3$**, $R^2 = 0.9998$**) like number of tubers (x_1), tuber weight per hill (x_2) and tuber bulking rate (x_3), was influenced by different levels of fertilizers. The interaction effects of N, P and K were not significant due to short growing season. Benefit-cost ratio in terms of money invested for one kilogram of fertilizers achieved high in nitrogenous fertilizers followed by potassium fertilizer. Higher doses of fertilizers decreased the benefit-cost ratio of the crop.

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MS Received: 3.05.2002

J. Indian Potato Assoc. 29 (3 - 4) : 167-169, 2002

SHORT NOTE

EFFECT OF DIFFERENT CONCENTRATIONS OF THIOUREA ON EMERGENCE AND TUBER YIELD IN POTATO CV. KUFRI JYOTI

S.P. Uniyal and A.C. Mishra[1]

Potato (*Solanum tuberosum* L.) is an important crop of Uttaranchal hills. It covers a large agricultural area (20924 hectares) during summer season. The planting of this crop in mid hills is done in first fortnight of March. Farmers of higher hills use their own old tubers stored in ordinary stores or houses as planting material but in mid hills they are dependent on availability of freshly treated tubers. Therefore, use of suitable dormancy breaking chemicals at appropriate concentration and time period becomes necessary. Dormancy breaking influence of biochemicals like gibberellic acids, ethylene chlorohydrin, carbon disulphide, rindite, thiourea, sodium thiocyanate etc. is well-documented (8, 9, 10). Besides, breaking of dormancy, these chemicals also influence the plant growth and tuber yield (1, 2, 3, 4, 5, 6, 7). Keeping in view the above facts, the present study was also conducted to see the effect of thiourea on tuber yield of popularly used cv. Kufri Jyoti in mid hills of Uttaranchal.

In this experiment, freshly harvested tubers of potato cv. Kufri Jyoti were treated with four concentrations of thiourea (0.5%, 1.0%, 1.5% and 2.0%). These were kept at 15°C for different time periods (1/2 hour and 1 hour) and stored either covering in 5-6 cm layer of dried pine needles locally called *piltu* or spread uncovered in dark room. These treatments were given in all possible combinations (Table 1). Old sprouted tubers for control plot were covered in *piltu* without treating with thiourea. After 30 days, tubers were taken out to plant in field in randomised block design with three replications. Tubers were planted at an inter and intra-row spacings of 60 x 20 cm in plot of 6.0 m^2 along with application of NPK @ 100:80:80 kg/ha. The experiment was conducted under complete rainfed conditions at the Hill Campus, Ranichauri (2000 m altitude), Uttaranchal and the plots were mulched after one month of planting.

Analysis of variance indicated that all the treatments were significantly different for various tuber yield characters. Treatment with thiourea in a concentration range of 0.5-1.0% for half to one hour in inverse relation to each other was the most effective in increasing the tuber yield per plant in potato. Ramanujam *et al.* (8) have also recommended soaking of tubers of *Darjeeling Red Round* in 1% thiourea for 1 hour. Higher concentrations also showed

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Table 1. Effect of different concentrations of thiourea on performance of potato cv. Kufri Jyoti

S. No.	Treatments	Sprout length (mm)	Emergence (%)	No. of tubers per plant	Tuber weight (g)	Tuber yield per plant (g)
1.	0.5%T+1/2hr+Piltu	6.43	90.00	4.67	84.52	392.67
2	0.5%T+1/2hr-Piltu	6.71	90.00	3.96	88.79	392.00
3.	0.5%T+1hr+Piltu	8.23	93.33	3.86	88.89	342.67
4.	0.5%T+1hr-Piltu	4.32	100.00	4.50	99.56	440.00
5	1.0%T+1/2hr+Piltu	12.11	100.00	4.00	111.59	451.96
6	1.0%T+1/2hr-Piltu	6.56	86.67	3.57	107.52	383.47
7.	1.0%T+1hr+Piltu	14.72	93.33	3.07	97.06	290.09
8.	1.0%T+1hr-Piltu	4.80	96.48	3.00	124.14	370.18
9	1.5%T+1/2hr+Piltu	15.00	93.33	3.67	83.70	290.33
10.	1.5%T+1/2hr-Piltu	6.90	100.00	3.57	97.13	340.03
11.	1.5%T+1hr+Piltu	15.20	86.67	2.92	84.21	240.25
12.	1.5%T+1hr-Piltu	6.60	93.33	3.11	92.24	250.20
13.	2.0%T+1/2hr+Piltu	16.63	100.00	4.00	98.29	391.89
14.	2.0%T+1/2hr-Piltu	9.77	96.48	3.17	84.48	260.10
15.	2.0%T+1hr+Piltu	10.10	93.33	4.42	92.56	411.73
16	2.0%T+1hr-Piltu	7.64	95.61	4.58	77.73	348.33
17.	Control	5.14	90.00	4.40	80.63	348.65
	C.V.	3.20	3.39	8.45	4.85	10.78
	S.E.(m)	0.17	1.84	0.19	2.62	21.76
	C.D.	0.49	5.31	0.53	7.56	62.78

T=Thiourea, hr=hour, *Piltu*=Dried pine needle covering, Control=Old and sprouted tubers

beneficial effects on tuber yield. Most of the treatments increased tuber yield per plant compared to control, indicating that thiourea had some beneficial effect on tuber yield, besides breaking of dormancy. Similar results were also observed by Bhatia *et al.* (3, 4, 5).

Maximum tuber weight was observed in treatment with thiourea at 1.0% for 1.0 hour followed by thiourea at 1.0 % for half an hour with *piltu* covering. Latter was also promising for percentage emergence. Treatment with lowest concentration of thiourea (0.5%) for lowest time period (1/2 hour) with covering the tubers in *piltu* was the best for number of tubers per plant. However, treatment with higher concentrations of thiourea along with covering inside the *piltu* exhibited longer sprouts than those with lower concentrations. But the tubers bearing longer sprouts were not promising for number of tubers per plant, tuber weight and tuber yield per plant in successive planting. Such type of uncorrelative response might be due to the fact that the longer sprouts are prone to more damages in operations during planting, resulting in weaker plants from new sprouts. Therefore, sprouts of medium length achieved from treatment with thiourea at comparatively lower concentrations are desirable for higher tuber yield and related characters. Additional effect of *piltu* covering in promoting the sprout length and tuber yield characters was, probably through modifying micro-climate inside the heap resulting in increased reducing sugar level and sprout length (11).

Thus, it appeared that treatment with 1% thiourea for half an hour along with covering of treated tubers in *piltu* can be a potential method to overcome the dormancy in potato cv. Kufri Jyoti in Uttaranchal hills.

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MS Received: 2.09.2002

J. Indian Potato Assoc. 29 (3 - 4) : 171-173, 2002

SHORT NOTE

PERFORMANCE OF POTATO HYBRIDS/VARIETIES IN THE SALINE SOILS OF NORTH BIHAR

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Potato is an important cash crop for *rabi* season in Bihar which falls under the main potato growing belt of northern India. Nearly 2 lakh hectare land in Bihar suffers from the problem of soil salinity mainly in the North. The pH of soil ranges between 8.2 to 9.5 due to the presence of large quantities of soluble salts of calcium, magnesium and sodium and the situation is getting worse due to indiscriminate use of ground water, water management practices etc. Soil salinity, therefore, is one of the factors contributing for the abysmally low productivity of 9.3 t/ha of potato in Bihar. Considering the above, the present study was conducted to identify some potato hybrids/varieties that can do well under the saline conditions of North Bihar.

Field trials were conducted for two years during crop seasons of 1996-97 and 1997-98 at the experimental farms of Tirhut College of Agriculture, Dholi, Muzzaffarpur in North Bihar. The sandy loam soils of experimental field had pH 8.25, available $CaCO_3$ 37.5%, organic carbon 0.36% with chemical conductivity of 0.32% m mhos/cm, thus being saline. Eight advanced potato hybrids/ varieties from Central Potato Research Instt. were planted in a randomized block design with three replicates on plot size of 2.0 x 3.0 m each with distance of 60 cm between rows and 20 cm between plants. The crop was raised following the normal package of practices for the region. Data on plant emergence was recorded 30 days after planting and on number of stems/hill from 5 randomly selected plants/plots. The haulms were cut 90 days after planting and plots harvested after 10 days and the data were recorded on tuber weight per plant along with grade wise and total tuber yield per plot. The data was statistically analyzed as per the standard statistical method.

The data on per cent germination, average number of stems, tuber number, tuber weight, grade-wise and total tuber yield (Table 1) revealed that average germination ranged from 15% in MS/89-279 to 63% in Kufri Pukhraj and number of stems/plant from 3 (Kufri Lalima, JV-62 & MS/89-279) to 6 (Kufri Pukhraj). Compared to normal crop in normal soil where 98-100% germination and average number of stems ranged from 6-8, there was a drastic reduction both in emergence and number of stems in different hybrids/varieties

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evaluated. This may be the result of adverse effect of soil salinity. Similar reduction in germination and vegetative growth was also observed by Mangal *et al.* (6) in potato varieties/hybrids. They attributed it to the harmful effects of soluble salts like Ca, Mg and Na which in association with chlorides and sulphates interfere with the uptake of water, leading to stress and building up of ions to toxic levels in various plant parts. The decrease in stems/hill is also in consonance with the studies of Bernstein (2) and Yadava *et al.* (8) who were of the view that decline in growth and branches/plant may be the effect of increase in osmotic pressure due to high salt concentration and its toxic effects.

The average number of tubers per plant varied from only 4 in MS/89-269 to the highest 13 in Kufri Pukhraj. Similarly average tuber weight varied from 105 to 158 g per plant. The medium sized tubers (40-60 g) were the maximum in number (51-66%) forming major component of yield followed by small sized tubers (Table 1). Number of large sized (60-100g) tubers was the least indicating harmful effect of salts on tuber bulking. There were significant differences in yield which ranged from 106.7 q/ha in hybrid MS/89-279 to maximum 163.3 q/ha in cv. Kufri Pukhraj. The hybrids/varieties used in this study showed a potential of 20 -35 t/ha in general in other parts of Indo-Gangetic region (1). The low average weight and tuber number, a direct outcome of the saline soil conditions in North Bihar, confirms the findings of Paliwal and Yadav (7) who reported a decrease in tuber weight and number with increase in soil salinity. Bliski *et al.* (3) and Harden (4) also reported a significant reduction in yield under saline conditions in pot/field experiments. Potato variety Kufri Pukhraj also proved superior over other hybrids and the presently recommended variety, Kufri Lalima, for the region. Variety Kufri Pukhraj was released in 1998 (5) for entire northern plains and plateau regions of the country. Considering the average productivity of 9.3 t/ha of Bihar state, introduction of Kufri Pukhraj in North Bihar under saline conditions appears to have a great potential. The field resistance to late blight in Kufri Pukhraj, would also be an added advantage.

Table 1. Performance of potato hybrids/varieties in saline soils of North Bihar (1996-98)

Varieties/ hybrids	*Percent emergence*	*Stem/ hill*	*Tubers/ Plant*	*Tuber wt/ Plant (g)*	*Tuber yield q/ha*	*% yield of different sizes of tuber*			*Late blight resistance*
						Large 60-100 g	*Medium 40-60 g*	*Small 20-40 g*	
MS/82-717	52	4	8	135	118.3	17	59	24	Resistant
MS/85-163	58	4	9	140	124.2	23	60	17	Resistant
MS/89-279	15	3	4	105	106.7	11	54	35	Resistant
83-P-12	59	4	8	145	122.5	25	59	16	Resistant
JV-62	48	3	9	152	128.0	17	53	30	Susceptible
JEB/A-26	47	4	11	145	133.3	27	51	22	Resistant
K. Pukhraj	63	6	13	158	163.3	15	66	19	Resistant
K. Lalima	32	3	9	130	103.3	22	52	26	Susceptible
SE ±	2.83	0.62	1.04	6.42	7.50	4.37	4.42	3.67	
CD(0.05)	6.07	1.32	2.24	13.76	16.10	9.39	9.48	7.63	
CV%	7.41	19.48	14.44	5.66	7.38	27.26	11.81	6.42	

Kufri Pukhraj has high yields potential (>25 t/ha) starting from 75 days onward (5) and it appears, from the present data, to be the most suitable variety for cultivation in North Bihar. It can also be inter-cropped with winter maize, sugarcane and tobacco as practiced in Bihar. Besides, in view of the susceptibility of Kufri Lalima to late blight and its low yields, Kufri Pukhraj showed promise for replacement of the Kufri Lalima in North Bihar. The variety can also be used as a parent for breeding salt tolerant potato cultivars.

ACKNOWLEDGEMENTS

Authors thank ICAR for providing financial assistance through AICRP-potato and to the authorities of RAU, Dholi, Pusa for providing the necessary facilities.

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MS Received: 5.12.2002

J. Indian Potato Assoc. 29 (3 - 4) : 175-176, 2002

SHORT NOTE

GENETIC DIVERGENCE AMONG ADVANCED HYBRIDS AND VARIETIES OF POTATO*

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Parent selection is crucial step in hybrid breeding programme in potato. Crosses involving genetically diverse parents are likely to produce heterotic effect (1). In such crosses more variability could be expected in segregating generation. The present study was undertaken to identify genetically divergent genotypes with desirable traits for future breeding programmes.

Thirty eight genotypes of potato including eleven released varieties (Table 1) were planted in three replications during *rabi* (1999-2000 and 2000-2001) at Pantnagar in a randomized block design (30 plants/plot). Data were recorded on five plants in each plot for 15 agro-morphological characters. D^2 values (2) were calculated in all possible 1406 combinations and genotypes were grouped into clusters as per Rao (3), using software SPAR 1 (IASRI, New Delhi).

The analysis of variance revealed adequate variability among genotypes for characters studied. Genotypes could be grouped into 13 different clusters in both the years but pooled analysis resulted in 15 clusters (Table 1). Distribution of genotypes into different clusters in different years was not same. It may be due to genotype x year interaction which was found significant for all the traits (except days to 50% emergence). Hence it was thought desirable to select the parents based on their performance and genetic divergence over years. Eleven Indian varieties were distributed in different clusters indicating considerable genetic diversity among them (Table 1). The D^2 values ranged from 59.49 (between Kufri Chipsona-1 and 85-P-11) to 1564.45 (between JP-100 and JW-96). Cluster XV (JP-100) and cluster X (Kufri Pukhraj, JW-96 and JX-23) had maximum intercluster distance (1302.93) followed by 1285.46 between cluster XV and cluster XIV (Kufri Ashoka) and 1234.44,

Table 1. Composition of cluster based on D^2 statistics (pooled over two years)

Cluster	*Genotypes*
I	Kufri Chipsona-1, Kufri Sutlej, 85-P-11, JX-249
II	Kufri Anand, Kufri Jyoti, Kufri Badshah, MS/92-3128
III	85-P-127, 85-P-670, 85-P-718, Kufri Bahar, JX-576
IV	AB-667, MF-1, JX-1, JX-123
V	JW-23, MS/92-1090, MS/91-1325
VI	JX-235, JX-216, JX-371
VII	Kufri Lalima, TPS I/17
VIII	Kufri Jawahar, JX-44
IX	Kufri Chipsona-2, JTH/C-107, TPS 1/13
X	Kufri Pukhraj, JW-96, JX-23
XI	JV-67
XII	JX-115
XIII	TPS C-3
XIV	Kufri Ashoka
XV	JP-100

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

and 1234.44, between clusters XV and VI (JX-235, JX-371, JX-216). Cluster VII (Kufri Lalima and TPS I/7) was also very diverse to cluster XIV (Kufri Ashoka) with intercluster distance of 1029.94. Therefore, crosses between genotypes in these clusters would be more heterotic.

Maximum mean values for leaf area and number of tubers per plant occurred in cluster VI. Cluster X had highest cluster mean for shoot girth, tuber diameter, tuber volume, tuber weight and tuber yield per plant and cluster XV had highest values of days to 50% emergence and tuber dry matter content. Presence of important tuber yield and quality characters in highly diverse cluster combinations suggested that heterosis for these traits could be procured by selecting the parents form these clusters.

Based on mean performance for various characters and genetic distance between genotypes crosses, viz. JP-100 x Kufri Pukhraj, JP-100 x JW-96, JP-100 x JX-23, JP-100 x Kufri Ashoka, JP-100 x JX-235, JP-100 x JX-216 and JP-100 x JX-371 were identified as promising as these are likely to result in progenies with heterotic performance for tuber yield and its components.

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MS Received: 15-07-2002

J. Indian Potato Assoc. 29 (2 - 4) : 177-180, 2002

SHORT NOTE

COMPARATIVE GROWTH PERFORMANCE AND YIELD OF POTATO CULTIVARS IN MID - WEST PLAINS OF UTTAR PRADESH

Manoj Raghav[1]

Out of several factors which effect the production of a particular cultivar, the importance of growth analysis as potential device to give an insight into the physiological basis of yield is well known (10). However, little work has been done on growth analysis of potato varieties (3, 5). The information on potato cultivars planted during autumn season in mid-western plains of Uttar Pradesh is not adequate. Therefore, the present study was conducted during autumn season to study the dry matter accumulation, relative growth rate, yield attributes and yield of potato cultivars belonging to different maturity groups.

The field experiments were carried out with eight potato cultivars, viz. PS/M75, Kufri Ashoka, Kufri, Jawahar, Kufri Chandramukhi, MS/82-638, Kufri Pukhraj, Kufri Sutlej and Kufri Badshah on sandy loam soil at G.B. Pant University of Agriculture and Technology, Research Station, Nagina (Bijnor) during 1995-96 and 1996-97 to study their comparative growth, dry matter accumulation and yield attributes at different growth stages. Uniform sized tubers of the same physiological age were selected and planted at a spacing of 20 cm in rows and 60 cm apart in a randomized complete block design with three replication; each replication had 675 plants. Recommended agronomical practices were followed during the course of investigation. Data were recorded on plant height, number and weight of tubers after 30, 60 and 90 days of planting and yield/ha at harvest. Samples of leaves, stem, roots and tubers were taken after 60 days of planting for determination of dry matter accumulation. The samples were dried at 65°C and dry weight was taken. Means of five plants uprooted at random from each cultivars in each replication were recorded for various characters under study.

Table 1 showed that cv. Kufri Sutlej had significantly taller plants than others at 30 days stage, but at par with cvs. Kufri Ashoka and Kufri Badshah in both the years indicating that this variety had fast growing habit. But at 60 and 90 days maximum plant height was recorded in cv. Kufri Badshah; however at 60 days stage it was statistically at par with cvs. Kufri Jawahar, MS/82-638 and Kufri Chandramukhi in 1995-96 and 1996-97, except Kufri Chandramukhi. This was probably due to prolonged vegetative growth in cv. Kufri Badshah since it was a long duration cultivar. Similar results were obtained by Singh (8) in potato.

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Table 1. Effect of cultivars on plant height and number of tubers

Cultivar	30 DAP*				60 DAP				90 DAP			
	Plant height cm		Number of tubers		Plant height (cm)		Number of tubers		Plant height cm		Number of tubers	
	95-96	96-97	95-96	96-97	95-96	96-97	95-96	96-97	95-96	96-97	95-96	96-97
PS/M-75	21.1	21.4	11.0	12.0	39.0	39.6	7.0	21.2	37.0	36.7	11.5	27.5
Kufri Ashoka	24.4	25.2	7.2	7.5	44.8	44.3	6.7	18.0	41.9	40.1	8.5	29.0
Kufri Jawahar	17.5	19.0	4.0	5.0	39.6	39.2	8.5	15.5	41.9	40.3	12.5	12.0
Kufri Chandramukhi	23.2	24.2	8.0	8.0	51.8	46.2	8.2	18.2	46.5	44.3	7.5	26.0
M.S./82-63882-638	21.7	20.5	2.7	8.5	52.1	50.1	8.2	19.0	55.1	54.3	7.0	22.5
Kufri Pukhraj	19.7	19.9	5.2	4.7	49.2	49.6	8.2	17.2	43.7	42.4	12.0	17.2
Kufri Sutlej	29.3	27.5	8.7	10.1	51.8	50.6	6.5	17.7	46.3	45.8	6.0	22.5
Kufri Badshah	23.7	27.2	5.2	4.5	55.7	55.7	7.2	19.7	63.5	63.3	9.7	28.5
C.D. at 0.05	5.5	3.1	NS	2.4	8.4	2.0	NS	NS	17.6	3.3	3.6	NS

* DAP= Days after planting

At 30 days stage maximum number of tubers were found in cv. PS/M-75 which was a par with cv. Kufri Sutlej in 1996-97. At 90 days stage maximum number of tubers were recorded in cv. Kufri Jawahar which was at par with cvs. Kufri Pukhraj, PS/M-75 and Kufri Badshah. Weight of tubers were found significant for all the three stages, except for 60 and 90 days in 1995-96 (Table 2). At 30 days stage maximum weight of tuber was found in cv. Kufri Chandramukhi which was at par with cvs. Kufri Sutlej and Kufri Ashoka in 1995-96 whereas, in 1996-97 it was in cv. Kufri Sutlej which was at par with PS/M-75 and MS/82-638 which may be attributed to genetic architecture of the variety. Our results are in agreement with Dayal (1). At 60 days stage maximum tuber weight was recorded in PS/M-75 which was at par with cvs. MS/82-638, Kufri Sutlej, Kufri Badshah and Kufri Ashoka in 1996-97, however in 1995-96, the maximum tuber weight was recorded in cv. Kufri Chandramukhi which was closely followed by MS/82-638, although the

Table 2. Effect of cultivars on tuber weight and yield of potato

Cultivars	Tuber weight (g)							
	30 DAP*		60 DAP		90 DAP		Tuber yield (q/ha)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
PS/M-75	7.0	18.7	199.0	134.5	625.0	195.0	283.1	303.9
Kufri Ashoka	24.0	8.2	185.5	95.5	450.0	150.5	260.0	289.5
Kufri Jawahar	4.2	6.2	211.5	76.2	672.0	128.5	241.7	255.0
Kufri Chandramukhi	25.5	4.7	252.5	50.0	645.0	120.5	194.8	183.1
MS/82-638	3.0	18.7	251.5	120.0	568.0	147.0	203.1	246.1
Kufri Pukhraj	9.5	7.2	192.0	53.5	560.0	257.0.	242.1	258.7
Kufri Sutlej	25.0	23.7	229.0	100.5	415.0	104.0	206.9	197.1
Kufri Badshah	3.2	11.2	194.5	104.5	688.5	136.0	246.1	208.0
C.D. at 0.05	7.2	8.5	NS	41.6	NS	80.6	52.4	57.3

* DAP Days after planting

Table 3. Effect of cultivars on dry matter content (%) of leaves, stems, roots and tubers of potato

Cultivar	Leaves		Stems		Roots		Tubers	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
PS/M-75	13.2	13.4	3.0	2.9	1.7	1.5	89.1	79.5
Kufri Ashoka	12.6	12.5	2.9	2.7	2.3	2.5	82.7	81.7
Kufri Jawahar	13.6	13.3	3.7	3.9	2.4	2.1	79.0	80.5
Kufri Chandramukhi	11.3	10.7	2.8	2.6	1.9	1.8	80.0	86.7
MS/82-638	15.2	14.9	3.9	4.1	3.2	3.3	75.1	76.5
Kufri Pukhraj	14.5	14.7	4.0	4.3	3.4	3.4	76.5	71.0
Kufri Sutlej	13.9	13.5	2.4	2.5	2.7	2.5	81.7	81.5
Kufri Badshah	16.2	17.5	4.3	4.5	3.5	3.6	92.7	95.4
CD at 0.05	0.9	1.3	0.7	0.5	0.4	0.5	2.1	4.7

differences were non - significant. At 90 days stage a non-significant difference was found in 1995-96 but in 1996-97 it was found maximum in cv. Kufri Pukhraj, but at par with PS/M-75. Similar results have also been reported by Panda (2) Singh *et al.* (7) and Sinha *et al.* (9). Tuber yield (q/ha) was found significant in both the years i.e., 1995-96 and 1996-97 (Table 2). Highest tuber yield was found in cv. PS/M-75 and the lowest in cv. Kufri Chandramukhi during both the years. In 1995-96, cv. PS/M-75 was found to be at par with cvs. Kufri Ashoka, Kufri Badshah, Kufri Pukhraj and Kufri Jawahar, whereas in 1996-97 it was found to be at par with cvs. Kufri Ashoka, Kufri Pukhraj and Kufri Jawahar. This might be because PS/M-75 had more number and weight of tubers than other cultivars thus resulting in higher tuber yield. Salman (4) reported that it could be possible to differentiate seedlings and/or individuals on the basis of their specific cropping capacities.

The dry matter produced by different parts of the cultivars is presented in table 3. The maximum dry matter of leaves was recorded in cv. Kufri Badshah (16.2% and 17.5%) which was statistically higher than rest of the cultivars and followed by cv. MS/82-638 (15.2% and 14.9%) where as minimum was found 121 cv. Kufri Chandramukhi (11.3% and 10.7%) in both the years. Statistically higher proportion of dry matter of stem was found in cv. Kufri Badshah (4.3% and 4.5%) but at par with cvs. Kufri Pukhraj, Kufri Jawahar and MS/82-638 in 1995-96 and cv. Kufri Pukhraj and MS/82-638 in 1996-97, where as minimum was recorded with cv. Kufri Sutlej in both the years of experimentation. In case of roots the dry matter proportion was found maximum with cv. Kufri Badshah (3.5% and 3.6%) which was statistically at par with cvs. Kufri Pukhraj and MS/82-638 in both the years. Highest proportion of dry matter in tubers was recorded in cv. Kufri Badshah (92.7% and 95.4%) which was statistically higher than rest of the cultivar and minimum was recorded in cv. MS/82-638 in 1995-96 and cv. Kufri Pukhraj in 1996-97. The cv. Kufri Badshah had more proportion of dry matter content in all the parts as compared to other cultivars. The reason for this is very obvious that cv. Kufri Badshah had faster growth rate and

accumulated more biomass. Our results are in agreement with Singh *et al.* (6).

From the results, it can be concluded that cvs. PS/M-75 and Kufri Ashoka can give better tuber yield under mid-western plains of Uttar Pradesh.

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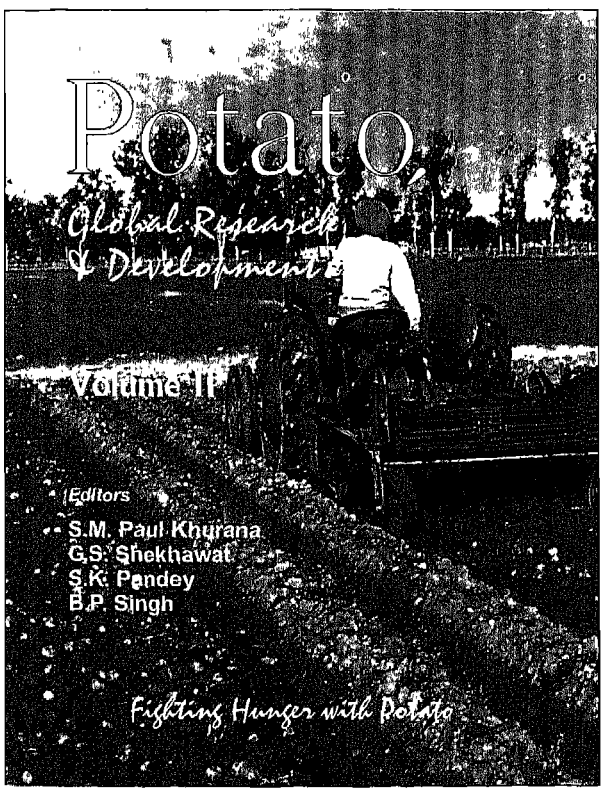
MS Received: 17-12-1998

J. Indian Potato Assoc. 29 (3 - 4) : 181-182, 2002

BOOK REVIEW

Potato, Global Research & Development (Volume-II)

(Khurana, S.M. Paul; Shekhawat, G.S., Pandey, S.K. and Singh, B.P.) 2002
Indian Potato Association, Central Potato Research Institute, Shimla - 171 001, India.
xix + 735-1304 pp., size 28x 22 cm, Hardback, **ISBN: 81-9004 19-0-10.**
Price : India and SAARC Countries INR 1500, Other Countries US $ 100.00



Potato is one of the most important food crops in the developing countries as well as in the developed countries. Its role in ensuring food and nutritional security in the world is widely recognized. As a short duration crop, potato fits well in intensive cropping systems and plays a pivotal role in enhancing employment and farm incomes.

Like Vol. I of the same title (published in 2000), the second volume of the Proceedings of the "Global Conference on Potato" held in New Delhi, India, during Dec. 6-11, 1999, have two sections. The first one deals with Crop production, Cropping systems and Crop modelling covering 45 articles on wide ranging aspects of Agro-techniques, potato based cropping systems, integrated nutrient and water management, crop modelling and mechanization. The other section focuses on potato Storage, Processing and Marketing. It contains 50 articles in all which provide a deep insight into the utilization patterns, farmers' share in consumer rupee, income elasticity of demand, import-export scenario, processing trends, key role of storage in marketing, and economics of storage. The problems of crop gluts have been critically examined. Besides, the recommendations covering (i) issues requiring international attention, and (ii) issues requiring research, are the high-lights that should be useful to the planners, researchers and the industry for exploiting the potential of the potato crop for underpinning food security in the world.

The book provides keynote addresses, lead

lectures and research papers in priority areas. All reviews/papers are supported by a selected relevant bibliography. The volume has an author index but not the subject index. As a convenient reference to the readers, Contents and Author Index of Volume I have also been reproduced. I find the book a very useful source of information on potato crop and recommend this book not only for libraries alone but for individual researchers as well.

Dr SS Johl.
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ACKNOWLEDGEMENT TO THE REFEREES (2000-2002)

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