Indian Journal of Agronomy **59** (1): 116–121 (March 2014)

Review/Overview

Effect of planting dates and integrated nutrient management on productivity and profitability of potato (*Solanum tuberosum*) in Kashmir valley

S. NARAYAN[1], RAIHANA HABIB KANTH[2], R. NARAYAN[3], F.A. KHAN[4], AMAL SAXENA[5] AND TAHIR HUSSAIN[6]

Sher-e- Kashmir University of Agricultural Science and Technology of Kashmir, Shalimar, Srinagar, Jammu and Kashmir 190 025

Received : July 2013; Revised accepted : December 2013

ABSTRACT

A field experiment was conducted during the rainy (*kharif*) seasons of 2008 and 2009 at Shalimar, Srinagar in a split plot design having 3 dates in the main plots and 6 sources of nutrients through the combinations of organic and inorganic fertilizers in the sub-plots with 3 replications, to find out their effect on productivity and profitability of potato (*Solanum tuberosum* L.). Among the dates, planting on 25 March recorded significantly higher tuber yield (35.7t/ha) and benefit: cost ratio (1.89) than that sown on 10 March and 11 April during both the years. Plant height, number of shoots, shoot dry matter, leaf-area index (LAI) and number of tubers/hill (11.48) were also the highest in 25 March planting as compared to the other planting dates. Application of 75% of full recommended dose of fertilizers (RDF) (120:75:75 NPK/ha) + 8 t/ha vermicompost + pre-sowing tuber treatment with *Azotobacter* and phosphorus-solubilizing bacteria proved significantly superior in terms of number of tubers hill, harvest index, tuber yield (32.7 t/ha) and benefit: cost ratio (1.75) of potato over rest of the treatments during both years.

Key words : Biofertrilizer, Integrated nutrient management. Organic manure, Potato, Planting dates, Vegetable production

Potato is one of the important crops of the world and is consumed by over people across the globe both as food and as vegetable. The post green revolution has witnessed substantial increase in production of food but at the cost of soil health and environmental pollution. Potato, being a heavy feeder of nutrients, requires high amount of nitrogen, phosphorus and potassium. Chemical fertilizers are the main source of nutrient to the potato crop. However, continuous cropping and dependence on chemical fertilizers has resulted in nutritional imbalance, depletion of soil organic matter, soil erosion, low availability of water, contamination of food and water, adverse affect on biodiversity as well as on human health. Considering the higher cost of fertilizers and their harmful effects, it is necessary to find out an alternative that besides improving the productivity and quality of potato should also be eco-friendly to the environment. Supplying of nutrients through the organic source can be opted for avoiding the hazardous effects of fertilizers and maintaining sustainability. As no single source is capable of supplying all the nutrients in required quantity, integrated use of inorganic and organic sources of plant nutrients is a must to supply balanced nutrients to the crop (Arora, 2008). Thus a combined use of organic manures with reduced dose of chemical fertilizer would not only pave the way for higher yields but also help to maintain the soil health and reduce pollutions. Bio-fertilizers like phosphorus solubilizing bacteria and *Azotobacter*, also play a major role in supplementing the crop nutrients through nitrogen fixation and solubilisation of fixed forms of phosphorus in soil (Bharadwaj and Gaur, 1970). Since potato requires specific climatic condition for its better growth and quality and crop-growth period in Kashmir valley is restricted, it is also essential to find out a suitable planting time of potato for harnessing better yields under temperate conditions. Since ample work has not been done under Kashmir valley, the present study was planned to find out the appropriate combination of nutrient sources and suitable planting time of potato in Kashmir valley.

MATERIALS AND METHODS

The study was carried out at Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir,

[1]**Corresponding author Email:** sumatinarayan@gmail.com
[1,2,5]Associate Professor (Agronomy); [4]Associate Professor (Plant Physiology); [6]Professor (Agricultural Statistic), [3]Senior Scientist (Vegetable Science), Central Institute for Temperate Horticulture, Srinagar

Shalimar (Srinagar) during the rainy seasons (*kharif*) of 2008 and 2009. The experimental site lies at 34^0.08' N and 74^0.83' E with an altitude of 1,587 meters above mean sea-level. The mean maximum and minimum temperatures and relative humidity during the cropping season were just about 25 and 11°C and 77 and 52% respectively. The total annual rainfall and sunshine length during the cropping season of 2008 and 2009 were 344.3 and 331.4 mm and 1,213.0 and 1,283.3 hours respectively. The soil of the plot was silty clay loam having bulk density of 1.30 mg/mm^3 with neutral pH (6.89), rich in organic carbon (0.89%), low in available N (231.48 kg/ha) and medium in available P (20.83 kg/ha) and K (170.01 kg/ha) (Table 1).

The experiment was laid out in a split-plot design with 3 replications on a net plot size of 3.6 × 3.6 m. The main plot consisted of 3 dates of planting, viz 10 March, 25 March and 11 April, while different combinations of nutrient sources, viz recommended doses of nutrients (160, 100 and 100 kg/ha of N, P and K) through fertilizers (RDF), 75% RDF + 20 t FYM/ha, 75% RDF + 8 t vermicompost/ha, 75% RDF + *Azotobacter* + phosphorus-solubilizing bacteria 75% RDF + 20 t FYM/ha + *Azotobacter* + phosphorus solubilising bacteria and 75% RDF + 8 t vermicompost/ha + *Azotobacter* + phosphorus solubilising bacteria constituted the sub-plot. Disease-free, medium-size potato tubers (40–50 g) of Shalimar 'Potato 1', which matures in 115–125 days having 40–50 g/tuber weight and ready-to-sprout were planted at the spacing of 20 cm from plant to plant and 60 cm from row-to-row. Half dose of nitrogen and full dose of other fertilizers and manures were given basal, while remaining nitrogen was applied at the time of earthing. Treatments of potato tuber with *Azotobacter* and phosphorus-solubilizing bacteria were done by dipping of tubers into 10% jaggery-biofertilizers solution for 15 minutes. Observations on growth yield and tuber quality were recorded. Data of both the years were pooled and relative economics of potato production under different treatments was also computed considering the local price of input and output. The data recorded were statistically analysed according to RCB design with split plot arrangements (Snedecor and Cochran, 1980)

RESULTS AND DISCUSSION

Growth attributes

Planting of potato on 11 April resulted in the highest plant height as well as number of shoots and they were followed by planting on 25 March and 10 March comparable results. Chandran *et al*. (2005) also reported similar results. The highest LAI was recorded with 25 March planting followed by 10 March planting. Planting on 11 April recorded significantly the highest dry matter followed by 25 March planting. Increase in plant height under 11 April planting might be attributed to the warmer average temperatures (25.79/11.81°C) as compared to 25 March (23.95/9.93°C) and 10 March (22.37/7.80°C) planting (Abbas *et al*., 1995). Elevated temperature increased endogenous gibberellins (Moshe *et al*., 1989) that is known for intermodal elongation and plant eight. A lower LAI of 10 March planting might be due to the lower growing degree day (GDD) and sunshine hours, received during the period; whereas, decreased LAI in 11 April planting may be attributed to the high light intensity. Improved shoot dry weight in later planting may be taken as the product of shoot length and number as well as owing to better photosynthetic rate under warmer temperatures.

Tuber dry-matter pattern was comparable with those of leaf area index, as the highest tuber dry weight was recorded with 25 March planting followed by that in 10 March planting. Our findings confirm those of Chandran *et al*. (2005) and Ravikant and Chandha (2009). The obvious reason for higher tuber dry matter in 25 March planting is the availability of greater LAI which resulted in more assimilate production and subsequent supply to the tubers. Further there was a significant variation among the dates of sowing so far as tubers/plant are concerned and the highest number of tubers/plant was obtained in 25 March planting pursued by 10 March planting. This can be attributed to improved nutrient uptake and cell-division activity due to suitable soil temperature (Chen and Setter, 2003).

Integration of different organic and inorganic nutrients revealed that 75% of RDF + 8 t vermicompost/ha + *Azotobacter* + phosphorus-solubilizing bacteria (PSB) re-

Table 1. Physico-chemical properties of soil of experimental field

Properties	Measured value	Properties	Measured value
Coarse Sand (%)	0.9	pH	6.80
Fine Sand (%)	14.20	EC (dS/m) at 25°C	0.28
Silt (%)	50.00	CEC (C mole/kg)	11.94
Clay (%)	34.90	Organic carbon (%)	0.91
Textural class	Silty clay loam	Available N (kg/ha)	232.9
Bulk density (g/cm^3)	1.25	Available P_2O_5 (kg/ha)	21.1
		Available K_2O (kg/ha)	170.5

corded the highest shoot growth in terms of plant height, shoot no., LAI and shoot dry weight followed by 75% of RDF + 20 t FYM/ha + *Azotobacter* + PSB, whereas the lowest shoot growth (plant height, number, shoot and shoot dry weight) were recorded with 75% of RDF + *Azotobacter* + PSB proceeded by 100% RDF. The variations in shoot growth may be accredited to the varying physico-chemical characteristics of the soil (Shashibala *et al*., 2011; Selvamani *et al*., 2011), which might have resulted in an altered root growth and thus availability of nutrients to the plant. Further, 75% of RDF + 8 t vermicompost/ha + *Azotobacter* + PSB produced the highest tuber dry weight and number of tubers followed by 75% of RDF + 20 t FYM/ha + *Azotobacter* + PSB against the minimum tuber dry weight and number of tubers under 75% of RDF + *Azotobacter* + PSB second by full RDF supplied through fertilizers. The improved tuber dry weight as well as number of tubers under certain INM practices may be attributed to the improved water and nutrient uptake by the plant chiefly due to improved physico-chemical conditions of the soil in presence of organic manures as well as soil microflora. Biofertlizers are also known to produce some bioinoculants which might have caused the cell division and thus increased number and growth of tubers (Balachandar, 2012).

Yield attributes and yield

The highest biological yield was recorded in 25 March planting followed by that in 10 March and 11 April planting (Table 3). The trend of variation in harvest index also followed the similar way as in case of biological yield, but harvest index of 10 and 25 March planting remained at par. A better harvest index in 25 March planting is indicative of a shift in the conversion of complex carbohydrate into simpler form and their mobilization towards the increased sink capacity, i.e. tuber. Constructive dominance of common growth and yield related parameters under 25 March planting ultimately reflected in terms of tuber yield, as this particular date of planting resulted in the highest tuber yield preceded by 10 March planting against the minimum tuber yield in 11 April planting.

The crop receiving 75% RDF + 8 t vermicompost/ha + *Azotobacter* + PSB showed the highest biological and tuber yield followed by 75% RDF + 20 t FYM/ha + *Azotobacter* + PSB as compared to the second lowest values of biological yield and tuber yield in 100% RDF. However, harvest index did not follow the trend and maximum was recorded with 75% RDF + 8 t vermicompost/ha compared to the minimum harvest index of with 75% RDF + *Azotobacter* and PSB. The superiority of crop performances under 75% RDF + 8 t vermicompost/ha + *Azotobacter* and PSB could be attributed to the beneficial effect of combined use of organic manures and chemical fertilizers in precise proportions that led to increased nutrient availability through enhanced microbial activity, conversion from unavailable to available forms and improved physical-chemical and biological conditions of soil (Singh and Kushwah, 2006). Mohapatra *et al*. (2008) and Zaman *et al*. (2008) also reported similar type of findings.

Interaction of planting date and nutrient management (Table 4) also signified that 25 March planting with nutrient application as 75% RDF + 8 t vermicompost/ha + *Azo-*

Table 2. Effect of planting dates and nutrient management practices on growth attributes of potato (pooled data of 2 years)

Treatment	Plant height (cm)	Shoots/ plant	Leaf-area index	Shoot dry weight (g/plant)	Tuber dry weight (g/plant)	Number of tubers/ plant)
Date of planting						
10 March	54.2	6.2	5.4	27.9	52.4	8.8
25 March	58.9	5.3	6.1	34.9	67.1	11.5
11 April	102.3	6.4	4.8	43.3	46.6	5.9
SEm±	0.24	0.06	0.13	0.18	0.26	0.31
CD (P=0.05)	0.95	0.20	0.51	0.72	1.03	1.21
Nutrient management						
RDF (160:100:100 N, P and K kg/ha)	70.2	5.7	5.1	31.1	53.4	8.0
75% RDF + 20 t/ha FYM	70.7	5.9	5.4	34.0	54.9	8.6
75% RDF + 8 t/ha VC	72.3	6.1	5.3	36.7	56.4	9.1
75% RDF + *Azotobacter* and PSB	69.2	5.1	4.8	27.4	49.1	7.2
75% RDF + 20 t/ha FYM + *Azotobacter* + PSB	73.5	6.3	5.8	39.2	58.1	9.4
75% RDF + 8 t/ha VC + *Azotobacter* and PSB	74.8	6.6	5.9	41.02	60.1	10.2
SEm±	0.22	0.19	0.13	0.16	0.51	0.29
CD (P=0.05)	0.70	0.58	0.41	0.50	0.95	0.83

RDF, Recommended dose of fertilizer; PSB, phoshphorus-solubilizing bacteria; VC, vermicompost *tobacter* and PSB was the best practice for obtaining highest yield of potato followed by 75% RDF + 20 t FYM/ha + *Azotobacter* + PSB against the minimum tuber yield with 11 April planting and 100 RDF.

Economics

Maximum benefit: cost ratio and net returns/ha were obtained with 25 March planting (Table 3). However, in case of nutrient management practices, the maximum benefit: cost ratio and net returns were evidenced with 75% RDF + 8 t/ha vermicompost/ha + *Azotobacter* and PSB. The results are in conformity with the findings of Sasani *et al.* (2003).

Tuber quality and grade

Quality analysis of tuber (Table 5) revealed that planting of potato on 25 March gave the highest total soluble sold (TSS), vitamin C and nitrogen content against the minimum TSS, vitamin C and nitrogen content recorded with 11 April planting. However, reverse trend was recorded with regard to specific gravity. Grading of tubers showed that 25 March planting resulted in the highest numbers of A, B and C grades of tubers followed by 10 March planting that given rise 1.91, 3.69 and 3.13 tubers/ plant under A, B, and C grades respectively. Comparable results were also obtained by Narayan *et al.* (2013).

Different nutrient management practices showed that 75% RDF + 8 t vermicompost/ha + *Azotobacter* and PSB produced minimum specific gravity of tubers followed by 75% RDF + 20 t FYM/ha + *Azotobacter* + PSB and 75% RDF + 20 t FYM/ha in opposed to the maximum value (1.05) in 100% RDF. Treatment of 75% RDF + 8 t vermicompost/ha + *Azotobacter* and PSB recorded the highest TSS, vitamin C and nitrogen content, whereas

Table 3. Effect of date of planting and different nutrient management practices on yield and relative economics of potato (pooled data of 2 years)

Treatment	Tuber yield (t/ha)	Biological yield (t/h)	Harvest index (%)	Relative economics of potato on pooled data		
				Cost of cultivation (×10³ ₹/ha	Net returns (×10³ ₹/ha	Benefit: cost ratio (return/ ₹ invested)
Date of planting						
10 March	30.7	43.2	71.2	61.9	91.7	1.48
25 March	35.8	49.9	71.7	61.9	116.9	1.89
11 April	24.9	36.5	68.3	61.9	58.5	0.93
SEm±	0.35	9.10	0.48			
CD (P=0.05)	1.02	3.2	0.98			
Nutrient management						
RDF (160: 100: 100 N, P and K kg/ha)	29.6	42.0	70.5	57.5	82.6	1.43
75% RDF + 20 t/ha FYM	29.7	42.8	70.5	65.4	85.4	1.30
75% RDF + 8 t/ha VC	30.9	43.6	71.0	63.4	91.3	1.44
75% RDF + *Azotobacter* and PSB	27.6	39.6	69.7	55.6	82.5	1.48
75% RDF + 20t/ha FYM+ *Azotobacter* + PSB	31.6	45.0	70.3	65.6	92.6	1.14
75% RDF + 8 t/ha VC + *Azotobacter* and PSB	32.7	46.6	70.3	63.6	99.9	1.57
SEm±	0.27	0.92	0.23			
CD (P=0.05)	0.79	2.63	0.67			

Table 4. Interaction effects of planting dates and nutrient management practices on tuber yield of potato (pooled data of 2 years)

Nutrient management	Tuber yield (t/h)		
	10 March	25 March	11 April
RDF (160: 100: 100 N, P and K kg/ha)	30.2	34.9	23.7
75% RDF + 20 t/ha FYM	30.7	35.6	24.4
75% RDF + 8 t/ha VC	31.1	36.5	25.2
75% RDF + *Azotobacter* and *PSB*	28.7	31.7	22.5
75% RDF + 20 t/ha FYM + *Azotobacter* + PSB	31.5	37.3	26.1
75% RDF + 8 t/ha VC + *Azotobacter* and PSB	32.4	38.5	27.2
SEm±	Date - 0.5; Nutrient - 0.67		
CD (P=0.05)	Date - 1.68; Nutrient - 2.61		

Table 5. Specific gravity, total soluble solids, vitamin C and nitrogen content of tubers as affected by planting dates and nutrition levels (pooled data of 2 years)

Treatment	Specific gravity (g/cc)	Total soluble solids (^{0}B)	Vitamin C (mg/100g)	Nitrogen content (%)	Different grades tubers/plant		
					Grade 'A'	Grade 'B'	Grade 'C'
Date of planting							
10 March	1.03	5.9	14.1	2.08	1.91	3.69	3.13
25 March	1.01	6.2	14.8	2.33	2.57	4.82	4.09
11 April	1.05	4.9	13.6	1.66	1.21	2.61	2.11
SEm±	0.007	0.07	0.06	0.01	0.06	0.11	0.20
CD (P=0.05)	0.023	0.28	0.24	0.06	0.26	0.42	0.27
Nutrient management							
RDF (160: 100: 100 N, P and K kg/ha)	1.05	5.2	13.5	1.94	1.65	3.50	2.85
75% RDF + 20 t/ha FYM	1.02	5.9	13.8	1.97	1.85	3.68	3.10
75% RDF + 8 t/ha VC	1.03	5.8	13.3	2.05	1.96	3.87	3.30
75% RDF + *Azotobacter* and PSB	1.04	5.4	14.0	1.81	1.55	3.10	2.50
75% RDF +20t/ha FYM+ *Azotobacter* + PSB	1.02	5.6	14.6	2.14	2.27	3.95	3.33
75% RDF + 8 t/ha VC + *Azotobacter* and PSB	1.01	5.9	15.8	2.22	2.37	4.13	3.53
SEm±	0.008	0.08	0.07	0.04	0.06	0.11	0.13
CD (P=0.05)	0.023	0.25	0.26	0.12	0.19	0.33	0.38

100% RDF, 75% RDF + 8 t vermicompost/ha and 75% RDF + *Azotobacter* and PSB produced minimum TSS, vitamin C and nitrogen content. Grading of tubers indicate that 75% RDF + 8 t vermicompost/ha + *Azotobacter* and PSB resulted in the highest number of A, B and C grade of tubers followed by 75% RDF + 20 t FYM/ha + *Azotobacter* + PSB, while minimum values of A, B and C grade of tubers were recorded under 75% RDF +*Azotobacter* and PSB. Our results conform the findings of Mubara (2012).

The results lead to conclusion that for realizing higher tuber yields of potato under temperate environment of Kashmir valley, it should be planted during the last week of March with the integrated approach of nutrient management as 75% RDF + 8 t vermicompost/ha + *Azotobacter* and PSB as the said treatment combination recorded the highest tuber production and gross returns along with maximum benefit: cost ratio.

REFERENCES

Abbas, M.L. and James, H.L. 1995. Effect of high temperature on plant growth and carbohydrate metabolism in potato. *Plant Physiology* **109**: 637–43.

Arora, S. 2008. Balanced nutrition for sustainable crop production. *Krishi World (pulse of Indian Agriculture), pp.* 1–5.

Balachandar D. 2012. Biofertilizers–What Next? *Journal of Biofertilizer and Biopesticide* **3**: e108. doi:10.4172/2155-6202.1000e108

Bhardwaj, K.K.R. and Gaur, A.C. 1970. The effect of humic and fulvic acids on the growth and efficiency of nitrogen fixation of *Azotobacter chroococcum. Folia Microbiologica* **15**: 364–67.

Chandran, G.R., Singh, S. and Manorama, K. 2005. Optimum date of planting seed potato crop in the Niligiris. *South Indian Horticulture* **53**(1–6): 139–41.

Chen, C. and Setter, T.L. 2003. Response of potato tuber cell division and growth to shade and elevated CO_2. *Annals of Botany* 91: 373–81.

Ganaie M.A. 2012. 'Effect of Nutrient Management and Plant Density on Growth, Yield and Quality of Potato'. M. Sc. Thesis, Division of Vegetable Science, SKUAST-Kashmir, Srinagar (Unpublished).

Mohapatra, B.K., Maiti, S. and Satapathy, M.R. 2008. Integrated nutrient management in potato (*Solanum tuberosum*)–jute (*Corchorus olitorius*) sequence. *Indian Journal of Agronomy* **53**(3): 205–09.

Moshe, J.P., Michael, D.G., Nigel, E.J.A. and John, R.L. 1989. Effect of temperature on gibberellin (GA) responsiveness and on endogenous GA1 Content of tall and dwarf wheat genotypes. *Plant Physiology* **90**(3): 854–59.

Narayan, S., Kanth, R.H., Khan, F.A., Singh, P. and Rehman, S.U. 2013b. Effect of integrated nutrient management practices on yield of potato. *Potato Journal* **40**(1): 84–86.

Ravikant and Chadha, S. 2009. Effect of planting season and fertility regimes on different potato cultivars. *Potato Journal* **36**(1–2): 68–71.

Sasani, G.V., Pater, C.K., Patel, R.N. and Patel, N.H. 2003. Effect of levels of inorganic fertilizers with and without organic manures on yield of potato in north Gujarat. *Journal of Indian Potato Association* **30**(1): 77–78.

Selvamani, P., Manivannan, K. and Mohan, J. 2011. Impact of organic manures, inorganic fertilizers and biofertilizers on the nutrient concentration in soil at different growth stages of banana cv. Poovan Mysore. *Plant Archives* **11**(1): 165–68.

Shashibala, Chaudhary, V.R. and Shukla, H.S. 2011. Effect of organic manures and biofertilizers with graded dose of NPK on soil and leaf nutrient status of aonla (*Emblica officinalis*

Gaertn.) cv. Banarasi. *Karnataka Journal of Agricultural Sciences* **24**(5): 709–11.

Singh, S.P. and Kushwah, V.S. 2006. Effect of integrated use of organic and inorganic sources of nutrients on potato (*Solanum tuberosum* L.) production. *Indian Journal of Agronomy* **51**(3): 236–38.

Snedecor, G.W. and Cochran, W.G. 1980. *Statistical Methods*. The Iowa State University Press, Ames, U.S.A.

Zaman, A., Patra, S.K., Das, P.P. and Mandal, S.C. 2008. Effect of combined application of organic and inorganic sources of nutrients for potato (*Solanum tuberosum* L.) in Gangetic alluvial soil. In extended summaries, (In:) *Proceeding of the National Symposium on New Paradigms in Agronomic Research*, held during 19–21 November 2008, Gujarat pp. 534–35.