Indian Journal of Agronomy **59** (4): 646–650 (December 2014)

Research Paper

Effect of integrated nutrient management on production of seed tubers from true potato (*Solanum tuberosum*) seed

S.K. YADAV[1], A.K. SRIVASTAVA[2] AND T.K. BAG[3]

ICAR - CPRI - Central Potato Research Station, 5th Mile, Upper Shillong, Meghalaya, Shillong 793 009

Received : April 2014; Revised accepted : October 2014

ABSTRACT

A field experiment was conducted during autumn seasons of 2011 and 2012 at Central Potato Research Station, Shillong, to study the effect of integrated nutrient management on production of seed tubers of potato (*Solanum tuberosum* L.) from true potato seed. There were 6 treatments of integrated nutrient management, viz. 100% recommended dose of fertilizers (RDF 120 kg N +52.8 kg P + 50 kg K/ha), 75% RDF and 25% recommended dose of nitrogen (RDN) through farmyard manure (FYM), 50% RDF and 50% RDN through FYM, 25% RDF and 75% RDN through FYM, 100% RDN through FYM and control (without application of fertilizer and manure). Integrated use of synthetic fertilizers and organic manures showed the significant impact on growth and yield attributes of potato. Highest average number (984.2 × 10^3/ha) and yield of tubers (12.4 t/ha) were recorded with application of 75% RDF through fertilizers and 25% RDN through FYM which was significantly superior over rest of treatments. However, the lowest tuber numbers (478.3 × 10^3/ha) and tuber yield (3.3 t/ha) were observed in control plot (no application of any nutrients). Similarly, the maximum net returns were with application of 75% RDF and 25% RDN through FYM. The application of 100% RDN through FYM on nitrogen basis significantly improved soil-fertility status over 100% RDF through fertilizers and control plot but remained at par with other integrated nutrient sources. Application of 75% RDF through synthetic fertilizers and 25% RDN through FYM was more remunerative for sustainable production of potato.

Key word **:** FYM, INM, Organic manure, Potato, True potato seed, Tuber yield

Potato production system based on the seed tubers has several disadvantages such as low multiplication rates, high storage and transportation costs as well as more pressure of pest and disease transmission risk due to vegetative propagation (Chujoy and Cabello, 2007; Dubey *et al*., 2010). Besides, the cost of healthy planting material is higher in north-eastern hills region, accounting 50–60% of the total production cost. In such a situation, true potato seed (TPS) provides better and low-priced planting material within potato systems where agroecological conditions for seed tuber systems and steady supply of quality tubers from a formal seed programme are most constrained. In such condition, farmers prefer to grow the potato crop for quality seed purpose through true potato seed, although, its actual productivity is very low compared to its potential yield. Further, profitability of farming community also jeopardizes due to inadequate and imbalance fertilizer application, consequently farmers are not able to harness the full yield potential of crops. These evidences indicate that the use of synthetic fertilizer in combination with organic manures could be a key factor for achieving and maintaining high level of seed potato production in NEH region. Hence a field experiment was carried out to study the effect of integrated nutrient management on producing seed tubers from true potato seed (TPS).

[1]Corresponding author Email: sanjaybhu05@rediffmail.com
[1&2]Scientist; [3]Principal Scientist and Head, Central Potato Research Station, Central Potato Research Institute, 5th Mile, Upper Shillong, Meghalaya, Shillong 793 009

MATERIALS AND METHODS

A field experiment was conducted during the autumn season of 2011 and 2012 at Central Potato Research Station, Shillong. The geographical co-ordinates of experimental field are (25°54' N, 91°84' E and 1,738 m above mean sea-level), Meghalaya. The soil was sandy loam with pH 5.13, moderately fertile, being high in organic carbon (1.48%), and medium in available nitrogen (304.5 kg/ha), low in available phosphorus (14.2 kg/ha) and high in available potassium (293.0 kg/ha). The experiment was laid out in randomized block design with 4 replications. There was 6 treatments, viz.100% recommended dose of

fertilizer (RDF) through synthetic fertilizers, 75% RDF and 25% recommended dose of nitrogen (RDN) through FYM, 50% RDF and 50% RDN through FYM, 25% RDF and 75% RDN through FYM, 100% RDN through FYM and control (without application of fertilizer and manure). The recommended dose of N, P_2O_5, and K_2O was taken as 120, 120 and 60 kg/ha for the crop. Nitrogen, phosphorus and potassium were applied in the form of urea, single superphosphate and muriate of potash respectively. Half of N and whole of P and K were applied at the transplanting of the seedlings. Remaining nitrogen was applied as per the treatments at the time of earthing up. Well-decomposed farmyard manure (0.53% N, 0.29% P and 0.61% K) collected from a nearby farm was applied into the plots as per the treatments. The FYM was applied according to the treatments to replace the recommended doses of nitrogen in the experiment as per the treatments. The price of potato was taken as ₹15,000/t for calculating total returns, net returns and benefit: cost ratio. With a view to avoid the mixing of soil in different treatments, individual plots were thoroughly prepared by manual labour. Cultivation practices were followed as per standard recommendation of crop. Improved TPS population '92 PT 27' was used as potato variety in this experiment.

The nursery plot was ploughed twice to convert the upper layer of soil into fine tilth. The field was levelled properly and beds were prepared carefully by incorporating sufficient quantity of well-rotten farmyard manure (2 kg/m^2). About 120 g TPS (60 m^2 areas) are sufficient to produce seedling for transplanting 1 ha areas. Provide 10 cm high border around nursery bed using bricks. Prepared a substrate by mixing soil and well-decomposed FYM in 1:1 proportion. Fertilizers @ 4–5 g N, 6–8 g P_2O_5 and 10 g K_2O/m^2 added of nursery area and mixed with well decomposed FYM in 1:1 proportion. Seeds were sown on the bed @ 2 g/m^2 in 0.5 cm deep furrows drawn 10 cm apart across the width of the bed. After sowing beds were given light and frequent water application through water cane/sprinkler/sprayer at the beginning to maintain moisture for seedling growth. Two light irrigations were also given at sowing and 10 days after sowing (DAS) to maintain growth a thin layer of FYM was given to cover the seed. The beds were covered with a thin layer of paddy straw on the same day to maintain congenial moisture and temperature condition. Paddy straw was removed after seed germination (10 DAS). Shading of the nursery area may be done for 15 days after sowing if day temperature is > 30°C. Apply 0.1% spray of urea (1 g urea in 1 litre water) at alternate days to the seedlings starting at 2-leaf stage until transplanting at 4–5 leaf stage (achieved 20–25 after days TPS sowing). Seedlings were transplanted during the last week of August in the net plot of 2 m × 2 m with spacing 50 cm × 10 cm and harvested in the first week of December. The earthing up was done 30 days after transplanting to provide loose soils around the plants for proper development of tubers at the stolon tips. Weeding was also done during earthing up with the help of a small spade. Four sprayings of Mancozeb and 1 spraying of Curzate (cymoxanil 8% + mancozeb 64%) were done for controlling late blight of potato. Soil was analysed at initial stage and after completion of the studies to monitor the changes in nutrient status (Soil pH, organic carbon and available nitrogen, phosphorus and potassium contents) as per the standard methods. Growth attributes of potato were recorded during the maximum vegetative growth stage. Data of both years were pooled and analysed as per standard procedure with 5% probability level.

RESULTS AND DISCUSSION

Growth attributes

Significantly higher values of plant height (68%), number of shoots (43%) and leaf-area index/plant were found with application of 75% RDF through synthetic fertilizers + 25% RDN through FYM than the control (Table 1). The prominent variation among growth attributes was shown on leaf-area index than plant height and number of shoots

Table 1. Effect of integrated nutrient management on growth and yield attributes of potato (pooled data of 2 years)

Treatment	Plant height (cm)	Shoots/ plant (No)	Leaf area index	Tubers/ plant (No)	Yield/ plant (g)	Average tuber weight (g)
100% RDF	36.1	1.7	2.9	4.7	43.7	9.3
75% RDF and 25% N through FYM	38.4	1.7	3.2	5.8	71.1	12.4
50% RDF and 50% N through FYM	38.0	1.4	3.2	5.5	58.4	10.8
25% RDF and 75% N through FYM	31.5	1.4	2.6	5.4	43.5	8.2
100% RDN through FYM	31.3	1.4	2.4	4.7	38.5	8.2
Control	22.8	1.2	2.1	2.9	19.1	6.6
SEm±	1.7	0.1	0.2	0.2	1.7	0.4
CD (P=0.05)	5.2	0.3	0.5	0.8	5.4	1.3

RDF, Recommended dose of fertilizer; FYM, farmyard manure

due to different treatments. The lowest value of growth attributes was obtained under control (no application of any nutrients). Applications of 100% RDF through FYM on nitrogen basis were not capable to enhance the growth attributes similar to other treatments of integration of RDF with FYM. The rate of mineralization of organic manure might be slow in this region due to low temperature in autumn season resulted poor availability of nutrients to the crop.

Yield attributes

Generally yield is denoted as the product of number of tubers and its respective weight per unit area. Highest average number of tubers and weight/plant were recorded with integration of 75% RDF + 25% RDF through FYM on nitrogen basis which were significantly superior to 100% RDF through FYM and control, but remained at par with rest of treatments (Table 1). Number of tubers was not much affected than weight of tubers per plant due to integration of nutrient sources during the investigation. The treatment receiving 100% RDF through FYM on nitrogen basis recorded almost similar number of tubers, however lower weight/plant was recorded as compared to other treatments except the control. This might be due to application of fertilizers in combination with organic manure which increased the nutrient-use efficiency through modification of soil physical condition, and resulted in higher total uptake of nutrients because of better root penetration leading to better absorption of nutrients and moisture (Yadav *et al.,* 2013a). Kushwah *et al.* (2005) were of similar view and reported that manures have sufficient residual effect on soil nutrient supply system. They also supply micro-nutrients in addition to major plant nutrients.

Economic yield

Application of recommended dose of fertilizers through inorganic sources recorded slightly lower number of tubers and potato tuber yield than the rest of integrated treatments (Table 2). However, application of 75% recommended dose of fertilizers through synthetic fertilizers in combination with 25% RDN through FYM significantly improved the productivity with respect to number of tubers (984.2 × 10^3/ha). Similarly, pooled data (Table 3) showed the maximum tuber yield associated with integration of 75% RDF through inorganic sources in combination with 25% of RDN through organic sources under investigation. The 100% recommended dose of fertilizers through synthetic fertilizers might faced water stress problem at subsequent stage of crop growth (early cessation of rainfall in the last week of October) due to poor water-holding capacity of soil and more susceptibility to late blight were major reasons for lower productivity than integrated treatment. Further, those plots having higher proportion of farmyard manure increased the water holding capacity of soil by improving the physical environment of soil, consequently retained more available water for longer period to the crop. With nutrition point of view, it was observed that increase in tuber yield due to integration of synthetic fertilizers and farmyard manure might regulated supply of nutrients to potato crop through readily available nutrients from synthetic fertilizers at initial stage and later stages through mineralization of organic manure into available form of nutrients for crop (Sarkar *et al*., 2011; Kumar *et al*., 2011). Similarly, Narayan *et al*. (2013) also reported that integrated use of inorganic and organic sources of nutrients significantly improved the yield of potato.

Economics

All the nutrient treatments provided higher net returns and benefit: cost ratio than the control (Table 2). The highest cost of cultivation incurred (₹50.3 × 10^3/ha) with application of 100% recommended dose of nitrogen through FYM followed by the application of 25% RDF in combi-

Table 2. Effect of integrated nutrient management on productivity and economics of potato (pooled data of 2 years)

Treatment	Tubers/ha (×10^3)	Tuber yield (t/ha)	Economics (×10^3 ₹/ha)		
			Cost of cultivation	Net returns	Benefit: cost ratio
100% RDF	841.7	7.65	39.9	74.8	1.9
75% RDF and 25% N through FYM	984.2	12.40	42.2	143.8	3.4
50% RDF and 50% N through FYM	949.4	10.16	44.7	107.7	2.4
25% RDF and 75% N through FYM	950.8	7.62	47.0	67.3	1.4
100% RDN through FYM	818.5	6.85	50.3	52.5	1.0
Control	478.3	3.30	34.6	14.9	0.4
SEm±	32.2	0.35			
CD (P=0.05)	101.3	1.18			

RDF, Recommended dose of fertilizer; FYM, farmyard manure

Table 3. Effect of integrated nutrient management on fertility status of soil

Treatment	pH	Organic carbon (%)	Available nutrients (kg/ha)			Actual gain /loss (kg/ha)*			
			N	P	K	% OC	N	P	K
100% RDF	5.0	1.7	296.0	15.4	302.5	–0.2	–9.0	0.9	4.5
75% RDF and 25% N through FYM	5.1	2.0	312.5	16.6	306.0	0.1	7.5	2.1	8.0
50% RDF and 50% N through FYM	5.1	2.1	318.5	17.1	308.3	0.3	13.5	2.6	10.3
25% RDF and 75% N through FYM	5.2	2.7	326.0	18.2	311.3	0.8	21.0	3.7	13.3
100% RDN through FYM	5.2	2.75	344.0	19.0	316.0	0.9	39.0	4.5	18.0
Control	5.1	1.73	253.5	13.6	285.5	–0.2	–51.5	–0.9	–12.5
SE±	0.1	0.1	2.10	0.33	1.99				
CD (P=0.05)	NS	0.2	6.50	1.1	6.3				
Initial status	5.1	1.9	305.0	14.5	298.0				

RDF, Recommended dose of fertilizer; FYM, farmyard manure

* Actual gain/loss = (Final value of available nutrients after harvest of crop–initial value of available nutrients)

nation with 75% RDN through organic manure (₹46.9 × 10^3/ha). The quantity of FYM required to meet the entire recommended dose of nitrogen in large quantity, resulted in higher cost of cultivation. Therefore, treatments having higher proportion of FYM showed the more cost of cultivation. Based on pooled data of 2 years the maximum net returns and benefit: cost ratio were recorded with 75% of RDF and 25% RDN through organic manure treatment because of higher value of crop produce under investigation.

Soil fertility

Nutrient treatments had no significant effect on soil pH (Table 3). However, slight improvement was recorded due to application of organic manure than the inorganic treatment (RDF). Fertility status of soil was highly influenced by the nutrient–management treatments, which differed significantly for organic carbon content and available status of major nutrients (N, P and K) over the initial values. At the end of 2-year cycle, the organic carbon and available nitrogen, phosphorus and potassium contents of the experimental soil were found to increase over the initial values in all the manurial treatments. Application of fertilizers in combination with farmyard manure significantly improved the soil available nutrients status and the highest values were found with the 100% RDN through farmyard manure. Increase in available nitrogen may be attributed to higher microbial activity in the manurial treatments which favoured the conversion of the organically bound nitrogen to inorganic form. Similar increase in available nitrogen in soil due to addition of organics was observed by Yadav *et al.* (2013b). The soil-available P was slightly improved due to addition of organic manure over the initial soil value. The organic manures, on decomposition, solubilize insoluble organic P fractions through release of various organic acids, thus resulting in a significant improvement in available P status of soil (Chadha, *et al.*, 2006). All the manurial treatments increased the available potassium content in soil. This increase in available potassium content in soil due to addition of organic manures might be attributed to the direct addition of potassium in the available K pool in soil and release of K due to interaction of organic matter with clay (Yadav *et al.* 2013c).

Balance sheet of fertility status after 2 years of field experimentation showed a negative fertility balance with application of 100% RDF through synthetic fertilizers, especially for organic carbon and available nitrogen (Table 3). However, maximum improvement in fertility was noticed with application of 100% RDN through FYM. This was might be due to the poor rate of mineralization of organic matter in the soil accompanied by the lower temperature. Further poor uptake of nutrients by potato crop due to lower availability of mineralized nutrients through farmyard manure, resulted in higher positive balance in the soil after the harvest of the crop. Similar increase in available nutrients in soil due to addition of organic manure was observed by Yadav *et al*. (2013d).

Thus, it may be concluded that conjoint use of 75% recommended dose of fertilizers through synthetic fertilizers and remaining 25% recommended dose of fertilizers through farmyard manure based on nitrogen basis increased the productivity, profitability, reduced the use of chemical fertilizers and also enriched the fertility status of soil for sustainable production of seed tubers produced from true potato seed.

REFERENCES

Chadha, S., Rana, S.S., Rameshwar and Chaudhary D.R. 2006. Effect of split application of N, K and FYM on the productivity of seed potatoes in cold desert region of H.P. *Potato Journal* **34**(1-2): 94–96.

Chujoy, E. and Cabello, R. 2007. The canon of potato science: 29, True potato seed (TPS). *Potato Research* **50**: 323–25.

Dubey, Shantanu Kumar, Sah, Uma and Gupta, V.K. 2010. True Potato Seed (TPS) vis-a-vis Seed Potato: A Study from the

North Eastern Region of India. *Journal of Community Mobilization and Sustainable Development* **5**(2): 1–6.

Kumar, M., Baishya, L.K., Ghosh, D.C. and Gupta, V.K. 2011. Yield and quality of potato (*Solanum tuberosum*) tubers as influenced by nutrients sources under rained conditions of Meghalaya. *Indian Journal of Agronomy* **56**(3): 260–66.

Kushwah, V.S., Singh, S.P. and Lal, S.S. 2005. Effect of manures and fertilizers on potato (*Solanum tuberosum*) production. *Potato Journal* **32**(3–4): 157–58.

Narayan, Sumati, Kanth, Raihana, H., Narayan, Raj, Khan, Farooq, A., Singh, Parmeet and Rehman, Shabir U. 2013. Effect of integrated nutrient management practices on yield of potato. *Potato Journal* **40**(1): 84–86.

Sarkar, A., Sarkar, S. and Zaman, A. 2011. Growth and yield of potato as influenced by combination of organic manures and inorganic fertilizers. *Potato Journal* **38**(1): 78–80.

Yadav, S.K., Singh, Yogeshwar, Kumar, R.P., Yadav, M.K. and Singh, Kalyan. 2013a. Effect of organic nitrogen sources on yield, quality and nutrient uptake of rice (*Oryza sativa*) under different cropping system. *Vegetos-An International Journal of Plant Research* **26**(1): 58–66.

Yadav, S.K., Babu, Subhash., Singh, Yogeshwar, Yadav, M.K., Yadav, G.S., Pal, Suresh, Singh, Raghavendra and Singh, Kalyan. 2013b. Effect of organic nutrient sources on yield, nutrient uptake and soil biological properties of rice (*Oryza sativa*) cropping sequence. *Indian Journal of Agronomy* **58**(3): 70–75.

Yadav, S.K., Babu, Subhash, Yadav, M.K., Singh, Kalyan, Yadav, G.S. and Pal, Suresh. 2013c. A review of organic farming for sustainable agriculture in Northern India. *International Journal of Agronomy*, Vol. 2013, Article ID 718145, 8 pages, 2013. doi:10.1155/2013/718145.

Yadav, S.K., Babu, Subhash, Singh, Y., Yadav, G.S., Singh, Kalyan, Singh, Raghavendra and Singh, Harvir. 2013d. Effect of organic nitrogen sources and biofertilizers on production potential and energy budgeting of rice (*Oryza sativa*)-based cropping systems. *Indian Journal of Agronomy* **58**(4): 459–64.