EFFECT OF ORGANIC AND INORGANIC SOURCES OF NITROGEN ON PERFORMANCE OF HYBRID POTATO SEED (HPS II/67) IN CHITWAN

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ABSTRACT

A field experiment was conducted at Meghauli, Chitwan to evaluate the effect of different levels of nitrogen (N) obtained from organic and inorganic sources on ware potato production from the first clonal generation of TPS hybrid (HPS II/67) during September, 2014 to February, 2015. The experiment was laid out in a randomized complete block design (RCBD) with nine treatments and three replications. The treatments consist of three different sources of nitrogen (Biomal, vermicompost and chemical fertilizers) having three different levels (80, 120 and 160 kg N/ha) from each source. Plant height, number of leaves/plant, total biomass/plant, total dry matter/plant and leaf area index were measured at 75 days after planting (DAP). Similarly, days to tuber initiation, number of tubers/plant, number of tubers/plot, tuber yield/plot and total tuber yield (mt/ha) were recorded. Cumulative physiological weight loss, greening percentage and sprouting percentage were observed during storage. B/C ratio of all the treatments were computed and compared. Experimental results revealed highest plant height (42.8cm), no. of leaves (145), biomass (98.9 gm/plant), dry matter (9.17 gm/plant) and leaf area index (3068.5 per plant) were recorded when 160kg N/ha applied through Biomal. The highest tuber yield (47.8 mt/ha) and B/C ratio (2.41) were obtained from Biomal at 160 kg N/ha. From this study, 160 kg N/ha from Biomal is recommended for higher productivity and economic returns for ware potato production from TPS hybrid (HPS II/67) under Meghauli, Chitwan, Nepal. However further study on different levels of N from organic sources is needed under different ecological niches.

Keywords: *bio-fertilizer, seedling tuber, True Potato Seed (TPS)*

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the most important tuber crop, and it is the fourth most widely grown crop globally after wheat, rice and maize. It is an important vegetable crop and a good source of antioxidants (Chen et al., 2007). The productivity of potato from True Potato Seed (TPS) is about 25 mt / ha while from traditional methods it is only 11 mt/ ha (NPDP, 2006). TPS can be utilized to increase the national productivity of potato as the cost of production through TPS can reduce total potato crop production cost almost by 50% (Sadik, 1983). Proper nitrogen management is one of the most important factors required to obtain high yields of good quality potatoes. The productivity of potato in Nepal is lower (5.8 t/ha in 1986 to 8.5 t/ha in 1996) than that of other SAARC countries (Baker, 2004). In Nepal, the low productivity is mainly due to unavailability of quality planting materials, lack of varietal resistance to incidence of late blight, higher cost of seed tuber and viral degeneration of the seed tubers (PDS, 1998). There is an urgent need for sound research to determine appropriate nutrient sources, appropriate doses of nutrients, effect of nitrogen source on improving yields, and quality of the produce. Use of optimum levels and combinations of nutrients depend on the variety as well as location (Adhikari, 2009). The present study focused on comparison of different organic and chemical fertilizers for appropriate nitrogen source and dosage in TPS hybrid potato production. The hypothesis of this study was: there is a significant effect of different sources and doses of nitrogen on the performance of seedling tuber of hybrid potato seed for ware potato production. The objective of this study was to estimate the appropriate level of nitrogen obtained from different sources at Meghauli, Chitwan.

MATERIALS AND METHODS

The experiment was carried out at a farmer's field at Meghauli-7, Chitwan during September, 2014 to May, 2015. Soil samples (0-30cm depth) from the experimental site and fertilizers were analyzed for assessing different physico-chemical properties of the soil (Table 1) and fertilizers (Table 2) before starting the experiment, at the soil testing laboratory of soil management directorate at Hariharbhawan, Lalitpur. Physico-chemical properties of fertilizers are above the minimum standards criteria of fertilizers given by Soil Management Directorate, Hariharbhawan, Lalitpur.

Table 1. Physico-chemical properties of the soil before the field experiment

Details	Mean
pH	6.6 (Near neutral)
Total N (%)	0.13 (Medium)
Available P_2O_5 (kg ha^{-1})	0.1 (Low)
Available K_2O (kg ha^{-1})	35.014 (Low)
Organic matter (%)	2.59 (Medium)
Soil type	Sandy loam (sand-62.3%, silt-33%, clay-4.7%)

The ratings of the nutrients are based on rating chart given by (Khatri Chhetri, 1991) and (Jaishy et al., 2000).

Table 2. Physico-chemical properties of the Bio- fertilizers used in the experiment

Description	Standard quality criteria	Vermicompost	Biomal
Total Nitrogen % (Oven dried basis)	>1.5	1.91	1.61
Total Phosphorus % (Oven dried basis)	>0.5	2.79	4.23
Total Potash % (Oven dried basis)	>1.5	3.34	2.44
Moisture %	≤ 30	27.8	9.34

Source: Soil Management Directorate, 2014

Details of the experimental setup

The experiment was laid out in a Randomized Complete Block Design (RCBD) with nine treatments and three replications. Different organic (Biomal and Vermicompost) and chemical fertilizers (urea, single super phosphates and potassium chloride) were used as sources of nitrogen. Individual plot size was 2.4m x 2.0m (i.e. 4.80 m^2). Healthy seedling tubers were planted in the plot at the geometry of 60 x 20 cm^2. One meter gap between blocks and 0.5 meter between plots were maintained. Thus, there were 40 plants in a plot with 4 rows and 10 plants within a row. Out of 4 rows, one row from each side of the plot was left as border row. Similarly, one column from each side of the plot was left as border. Two rows and eight columns, i.e., altogether 2 X 8 = 16 inner plants of each experimental unit were considered for observing the various growth and yield parameters.

Treatments and their allocation

HPS II/67 clonal progeny of TPS family was used for the experiment as it is recommended for Terai region of Nepal and is popular among the farmers. Well decomposed farmyard manure (FYM) was applied @ of 20 t/ha to all the treatments 2 weeks before planting. Healthy seedling tubers of size 10-12 gm were used as planting material for ware potato production. It was planted in the main field with the spacing of 60 cm between rows and 20 cm plant to plant distance within the row on 23rd October, 2014.

Table 3. Different levels of nutrient inputs used in the experiment

Treatments	Explanation
Bio80	80 kg/ha nitrogen equivalent from Biomal
Bio120	120 kg/ha nitrogen equivalent from Biomal
Bio160	160 kg/ha nitrogen equivalent from Biomal
Vermi80	80 kg/ha nitrogen equivalent from vermicompost
Vermi120	120 kg/ha nitrogen equivalent from vermicompost
Vermi160	160 kg/ha nitrogen equivalent from vermicompost
Chemical80	80 kg/ha nitrogen equivalent from chemical fertilizers
Chemical120	120 kg/ha nitrogen equivalent from chemical fertilizers
Chemical160	160 kg/ha nitrogen equivalent from chemical fertilizers

Nitrogen from different organic (Biomal and vermicompost) and inorganic sources (Urea 46% N) of fertilizes were applied at the rate of 80, 120 and 160 kg/ha. Phosphorus and potassium were applied at the rate of 100 kg/ha and 60 kg/ha in case of chemical treatment through SSP and KCL fertilizers having 16% Phosphorus and 60% Potassium respectively. Half dose of nitrogen, full doses of phosphorous and potassium was incorporated into the soil at the time of tuber planting. The remaining amount of nitrogen was split into two equal parts and each part was top-dressed at 30 and 45 days after planting. All the intercultural operations like weeding, top dressing, irrigation, and earthing-up were done as required. To control late blight disease DM-45 @2.5 gm/liter solution was sprayed regularly for 4 times in the interval of 15 days starting 30 days after sowing. Harvesting was done at 105 DAP when more than 75% haulm turned yellow.

Observations

Observations were recorded at optimum growth stages for vegetative growth characters viz., number of leaves/plant, plant height, biomass/plant, dry matter/plant and leaf area index. Among the yield characters, days to tuber initiation, number of tubers/plant, number of tubers/plot, tuber yield/plot and total tuber yield/ha were recorded. Among post-harvest characters, cumulative physiological weight loss, greening percentage and sprouting percentage were observed.

Statistical analysis

Gen-stat software 15th edition was used for the statistical analysis of the data. Treatment means were compared using Duncan's multiple range test (DMRT) at 5% level of significance.

RESULTS AND DISCUSSION

Effect on growth parameters

The results revealed that different levels of N from organic and chemical fertilizers have significant effect on plant height, number of leaves, plant biomass, total dry matter and leaf area index measured at 75 DAP (Table 4). Among different treatments highest plant height (42.8cm) was attained when 160 kg N/ha applied from Biomal and the lowest (22.8 cm) at 80 kg N/ha applied from vermicompost. The increase in fertility level increased the cell size and enhancement of cell division which ultimately resulted in increased plant height (Barevadia et al., 1978). The present data are in agreement with the data obtained by Rizk et al. (2002) and Paudel (2013) who found that increased dose of nitrogen up to 150 kg N/ha increased the plant height. The highest number of leaves (145) per plant was recorded under 160 kg N/ha from Biomal while the lowest number of leaves (75) was recorded at 80 kg N/ha from Vermicompost. The increase in available N in the root zone consequently increases its absorption which helps the plant tissues to build more leaves. Paudel (2013) also showed that at all the growth stages of crop, the highest number of leaves were recorded at 200 kg N/ha. Similarly, highest biomass (98.9 gm/plant), total dry matter (9.17 gm/plant) and maximum leaf area index (3069 per plant) was produced when 160kg N/ha was applied through Biomal.

Table 4. Effect of different levels of nitrogen obtained from different sources on plant height, no. of leaves, biomass/plant, total dry matter/plant and leaf area index at 75 DAP of seedling tubers for ware potato production, Meghauli, Chitwan

Treatments	Plant height (cm)	No.of leaves	Biomass/plant (gm/plant)	Dry matter (gm/plant)	Leaf area index
Bio80	31.4^{c}	114^{b}	50.9^{cd}	5.87^{bc}	1094^{e}
Bio120	37.0^{b}	111^{b}	78.6^{b}	7.70^{ab}	1401^{d}
Bio160	42.8^{a}	145^{a}	98.9^{a}	9.17^{a}	3069^{a}
Vermi80	22.8^{g}	75.0^{d}	30.4^{e}	4.60^{c}	777^{g}
Vermi120	26.4^{f}	79.7^{cd}	36.0^{e}	5.33^{bc}	1089^{e}
Vermi160	29.0^{e}	81.3^{cd}	51.7^{cd}	6.93^{abc}	1599^{c}
Chemical80	30.0^{d}	76.7^{d}	41.4^{de}	5.70^{bc}	902^{f}
Chemical120	30.8^{d}	83.9^{cd}	58.9^{c}	6.20^{bc}	1352^{d}
Chemical160	33.8^{c}	93.4^{c}	85.5^{b}	8.20^{ab}	2309^{b}
SEM (±)	0.399	4.25	4.13	0.87	23.94
LSD (0.05)	1.19*	12.75*	12.38*	2.61*	71.79*
CV %	2.2	7.7	12.1	22.7	2.7
Grand Mean	32.09	95.5	59.1	6.63	1510.4

*Means followed by the same letter in a column do not differ at 5% level of significance by DMRT. DAP = Days after planting, SEM = Standard Error of Mean, LSD = Least Significant Difference, CV = Coefficient of Variance, * Significant at 5%.*

Effect on yield parameters

The results of this study showed that days to tuber initiation, number of tubers per plant, number of tubers per plot, tuber yield per plot and total yield differed significantly at various levels of nitrogen used from different organic and inorganic sources (Table 5). Days to tuber initiation was shortest (40 DAP) when N was applied at 80 kg/ha from Biomal, which was at par with 120 kg N/ha from Biomal; 80 kg and 120 kg N/ha from chemical fertilizers. Days to tuber initiation was longest (50 DAP) at 160 kg N/ha from chemical fertilizer. Errebhi et al. (1998); Westermann and Kleinkopf (1985); Kleinkopf and Dwelle (1978); and Lauer (1985) also reported that higher N levels at planting delayed tuber initiation and onset of tuber bulking period. Similarly, Paudel (2013) reported that, up to 150 kg nitrogen/ha, earlier tuber initiation takes place in potato, but beyond that, tuber initiation would be delayed.

Increase in the number of tubers per plant was recorded with increasing levels of nitrogen except in the treatment with 160 kg N/ha from chemical fertilizer. The highest number of tubers (8) per plant was observed when seedling tubers were planted at 160 kg N/ha through Biomal which was at par with 80 kg N/ha from Biomal and 120 kg N/ha from chemical fertilizers, and the lowest Number of tubers/plant produced in treatment 80 kg N/ha from vermicompost which was at par with 120 kg N/ha from Biomal; 120 and 160 kg N/ha from vermicompost; and 160 kg N/ha from chemical fertilizer. The highest number of tubers (307) per plot was obtained at 160 kg N/ha from Biomal, which was significantly higher than all the other treatments. Increase in the number of tubers may be attributed to the fact that the supply of nitrogen enhanced cell multiplication, cell elongation and favorable conditions for physiological activities.

Table 5. Effect of different levels of nitrogen obtained from different sources on days to tuber initiation, number of tubers/plants, number of tubers/plot, tuber yield/plot and total tuber yield (mt/ha) of potato produced from seedling tubers at Meghauli, Chitwan

Treatments	Days to tuber initiation	Number of tubers/ plant	Number of tubers/ plot	Tuber yield/ plot (kg)	Yield (mt/ ha)
Bio80	40.0[a]	6.40[ab]	243[ab]	14.4[b]	30.01[b]
Bio120	41.7[a]	5.46[bc]	208[bc]	16.4[b]	34.1[b]
Bio160	48.3[b]	8.060[a]	307[a]	22.9[a]	47.8[a]
Vermi80	48.3[b]	3.53[c]	134[c]	7.080[c]	14.8[c]
Vermi120	50.0[b]	4.46[bc]	170[bc]	7.40[c]	15.4[c]
Vermi160	50.0[b]	4.66[bc]	177[bc]	8.24[c]	17.2[c]
Chemical80	41.7[a]	4.66[bc]	177[bc]	8.76[c]	18.3[c]
Chemical120	43.3[a]	6.46[ab]	246[ab]	13.7[b]	28.6[b]
Chemical160	50.0[b]	5.20[bc]	198[bc]	15.2[b]	31.6[b]
SEM (±)	1.21	0.771	29.3	1.078	2.24
LSD (0.05)	3.63*	2.31*	87.8*	3.23*	6.73*
CV, %	4.6	12.7	12.7	4.3	4.3
Grand Mean	45.93	5.44	206.6	12.68	26.41

*Means followed by the same letter in a column do not differ at 5% level of significance by DMRT. DAP = Days after planting, SEM = Standard Error of Mean, LSD = Least Significant Difference, CV = Coefficient of Variance, * Significant at 5%.*

Singh and Raghav (2000); and Belanger et al. (2002) also found similar results where increasing level of nitrogen led to increased number of tubers. The data revealed that N level from organic and inorganic sources showed highly significant variation in the tuber yield/plot and total yield of tuber/ha. Nitrogen level 160 kg/ha from Biomal produced the highest (22.9 kg) tuber yield per plot, which was statistically superior to all other treatments. The total yield was significantly higher (47.8 mt/ha) when seedling tubers were planted at 160 kg N/ha through Biomal. Increment in the yield of tuber with the increased level of nitrogen application could be attributed to higher amount of photosynthates available for tuber.

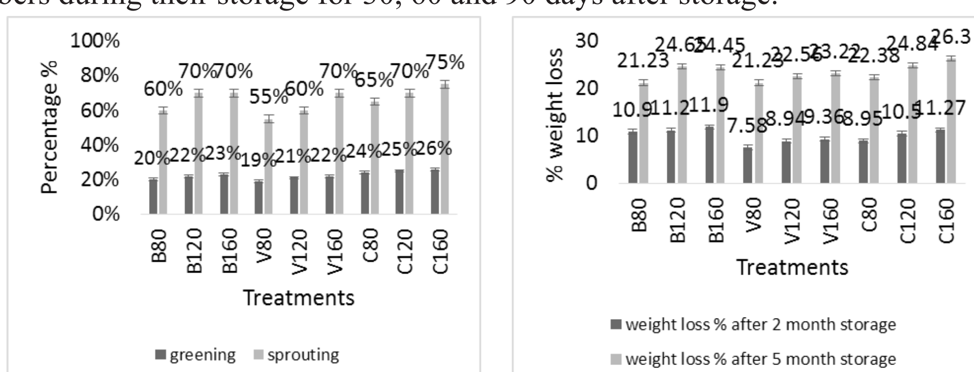
Effect on post harvest quality of potato

Greening percentage and sprouting percentage after 5-month storage at normal room condition

Potato tubers showed varied response to treatments in terms of greening and sprouting during post-harvest storage at room condition for five months (Figure 1). The highest percentage of greening (26%) and sprouting (75%) were found in the potato produced by applying 160 kg N/ha from chemical fertilizer. The lowest percentage of greening (19%) and sprouting (55%) were found in potato produced by applying 80 kg N/ha from Biomal. Paudel (2013) found that the effect of level of nitrogen was non-significant on percentage of green tuber during the storage at 90 days after storage. However, the highest greening percentage (35.17%) was observed at 200 kg N/ha and the lowest (32.58%) at 150 kg N/ha. This study showed that the higher the level of nitrogen applied during potato production, the higher would be the chances of greening and sprouting in potatoes during post-harvest storage.

Percentage weight loss after storage

The results showed that the highest weight loss was found in the treatment 160 kg N/ha applied from chemical fertilizer and the lowest weight loss was found in 80 kg N/ha Biomal and 80 kg N/ha vermicompost. The maximum weight loss of 26.3% and lowest weight loss of 21.23% found after 5 month of post-harvest storage at normal room temperature. Paudel (2013) found non-significant effect of nitrogen on cumulative physiological weight loss of potato tubers during their storage for 30, 60 and 90 days after storage.



(a)

(b)

Figure 1. Greening and sprouting percentage (a), and, percentage weight loss (b) after two and five months of storage at normal room condition, Meghauli VDC, Chitwan

Economic Analysis

In potato cultivation, seed share is very high as compared to other crops and seed tubers alone accounts for 40-70% of the total cost of production (Upadhya, 1994). If tuber numbers per unit weight were more, it would be more economical as in the case of TPS hybrid. Cost incurred in potato production through TPS technology is presented in table 6. The cost of cultivation varied among the treatments due to differences in sources and levels of nitrogen.

Table 6. Benefit Cost (B:C) ratio of potato tubers production at Meghauli, Chitwan, Nepal

Treatments	Yield (ton/ha)	Price (NRs/ ton)	Total Revenue (NRs/ha)	Variable Cost (NRs/ha)			Total cost (NRs/ha)	B:C Ratio
				Fertilizer	Seedling tuber	Common cost		
Bio80	30.01	20000	600200	50000	100000	80000	230000	1.61
Bio120	34.1	20000	682000	75000	100000	80000	255000	1.67
Bio160	47.8	20000	955000	100000	100000	80000	280000	2.41
Vermi80	14.8	20000	295200	40000	100000	80000	220000	0.34
Vermi120	15.4	20000	308200	60000	100000	80000	240000	0.28
Vermi160	17.2	20000	343400	80000	100000	80000	260000	0.32
Chemical80	18.3	20000	365000	20000	100000	80000	200000	0.83
Chemical120	28.6	20000	572000	30000	100000	80000	210000	1.72
Chemical160	31.6	20000	632600	40000	100000	80000	220000	1.88

The cost of cultivation (NRs. 2,80,000/ha) was the highest when 160 kg N was supplied from Biomal and the lowest (NRs. 2,00,000/ha) when 80 kg N was supplied from chemical fertilizer. The variation in the cost of production was mainly due to the differences in the cost of organic and chemical fertilizers according to the treatment combinations. The highest B: C ratio (2.41) was found in the treatment 160 kg N applied from Biomal and the lowest 0.28 in 120 kg N applied using vermicompost. A study conducted in Ardabil, Iran revealed that about 40% of energy was generated by chemical fertilizers, 20% from diesel oil and machinery. About 82% of the total energy inputs used in potato production was indirect (seeds, fertilizers, manure, chemicals, machinery) and 18% was direct (human labor, diesel). Mean potato yield was about 28.45 mt/ha, Cost analysis revealed that total cost of production for one hectare of potato production was 3267.17 $. Benefit–cost ratio was reported as 1.88. (Mohammadi, 2008)

CONCLUSION

From this study, it can be said that increasing levels of nitrogen have significant effect on plant growth and yield attributing parameters of potato. The study revealed significant increase in plant height, number of leaves/plant, total biomass of plant, total dry matter, leaf area index, tuber number per plant and total tuber yield when N was applied at 160 kg/ha from Biomal. Also the B/C ratio was highest (2.41) when potato was produced by applying 160 kg N/ha from Biomal. So, 160 kg N/ha from Biomal is suggested for the higher productivity and the higher economic return for ware potato production from clonal progeny of TPS hybrid (HPS II/67) under Meghauli, Chitwan, Nepal. This study also showed that there is a possibility of increasing the yield of potato by 2 to 3 times through seedling tubers along with effective biofertilizer management. Thus, the production, verification and distribution of effective biofertilizers to the local farmers' is imperative to sustain the production and quality of potatoes. Further study using different levels of biofertilizers on potato production in different ecological niches is needed.

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