Response of Potato to Nitrogen and Potassium Fertilization

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ABSTRACT

This study was carried out to investigate the response of potato cv. Kufri Jyoti to different levels of nitrogen and potash at Agriculture Research Station (ARS), Pakhribas, Dhankuta during 2003/04-2005/06. Four levels of each nitrogen (0, 50, 100, and 150 kg/ha) and potash (0, 30, 60 and 90 kg/ha) having sixteen treatments were allocated in Factorial Randomized Complete Block Design with three replications. Nutrient status of the experimental site was low nitrogen (0.007%), high phosphorous (171 kg/ha), low potash (81 kg/ha), medium organic matter content (1.6%) and moderately acidic soil (pH 4.6) with sandy loam soil texture. Phosphorous and farmyard manure were applied in all the plots at the rate of 100 kg and 20 tons per hectare, respectively. Ground foliage development, stem number per plant and plant height were statistically at par at 100 and 150 kg N. Undersize tuber weight (%) decreased as the level of nitrogen increased. Effect of potassium fertilizer on plant morphological characters, tuber fractions and total tuber number was non-significant. Nitrogen at 100 kg and potassium at 60 kg/ha gave the better yield under on-station condition at Pakhribas. Further research is recommended to conduct the farmer's field condition in order to corroborate the on-station's research results.

Key words: Potato**,** Nitrogen, Potash, Morphological character, tuber yield

INTRODUCTION

Potato serves as an important food crop for high hills people. Besides its contribution in food security, it has also an immense importance to generate the income source for the poor people. Existing production of potato at high hill cannot cope with burgeoning demand of consumption for people of lower hills and terai. Average productivity of potato is quite low at eastern high hills (11.7 t/ha) than central hills (14.3 t/ha) and terai (16.6 t/ha). The area under potato cultivation is 1, 53,534 ha and national average productivity is estimated about 12.6 t/ha (APSD, 2006) which is considered very low as compared to neighboring countries.

Irrational use of available fertilizer is one of the major bottlenecks of potato production at eastern high hills. Intensive cultivation of crop in the same piece of land for several years and decreasing use of manure has resulted in reducing the crop yield. Potato is considered as a heavy feeder crop, and its shallow root habit and rapid growth rate further necessitates a good supply of plant nutrients to obtain higher yield (Pandey, 1991). Use of optimum amount of chemical fertilizer in harmony with the farmyard manure can only achieve the sustainable potato yield for long term.

Nitrogen is an essential constituent of protein and chlorophyll whereas potassium helps in translocation of carbohydrates and enhances plant resistance to withstand stresses against drought and frost (Singh and Raghav, 2000). Potato has more influence on the quality of

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the crop, dry matter content, black spot, damage, blue-discoloration after cooking and storage quality (Beukema and Van Der Zaag, 1990). Nitrogen and potash have indispensable role for successful potato production. Crop response to fertilizer varies from field to field. Hence, amount of nitrogen and potash also varies depending on the purpose of the crop and the soil condition. Meager information is available regarding N and K_2O requirement of potato cv. Kufri Jyoti especially for fresh production. Therefore, present study was carried out to find out the optimum dose of N and K_2O at potato cv. Kufri Jyoti at Agriculture Research Station, Pakhribas Dhankuta.

MATERIALS AND METHODS

This experiment was carried out during 2003/04-2005/06 at Agriculture Research Station, Pakhribas, Dhankuta (1740 masl). Treatments were consist of four levels of nitrogen and (0, 50, 100 and 150 kg/ha) and four levels of potash (0, 30, 60 and 90 kg/ha) i.e. two factor experiments and design was laid out in factorial Randomized Complete Block (RCB) with three replications.

Soil sample was taken block wise up to 15 cm depth from soil surface before planting and analyzed of total nitrogen by Macro-Kjeldahl method (Jackson, 1967), available phosphorous by Olsen's method (Olsen *et al*. 1954)), available potash by Neutral normal ammonium acetate method (Black, 1965), organic matter (Walkey and Black, 1934), pH by Beckman Glass Electrode pH meter (Wright, 1939) and soil texture by hydrometer method. Soil status of the experimental site before planting was identified as very low nitrogen (0.007 %), high phosphorous (171 kg/ha), very low potassium (81kg/ha), medium organic matter content (1.6 %) and moderately acidic soil (4.6 pH). Likewise, after harvesting of potato, N (%), P_2O_5 (kg/ha), K_2o (kg/ha), Organic matter (%) and soil pH were analyzed in treatmentwise to observed the change in soil properties.

Plot size was maintained 7.2 m^2 and bonds of 50 cm were placed in each plot. Farm yard manure was applied at the rate of 20 tons per hectare in all the plots. Phosphorous was used at the rate of 100 kg per hectare in the entire plot. Single super phosphate and di-ammonium phosphate were the source of phosphorous. About third fourth of nitrogen and all amounts of phosphorous, potash, and farm yard manure were applied in furrows at the time of potato planting. Remaining one fourth of nitrogen was given at 45 days after crop emergence. Observations on ground cover, stem number per plant and plant height were recorded as crop morphological characters and tuber size distributions (under size number and weight i.e. < 20g, seed size number and weight i.e. 20-50g, and over size tuber number and weight i.e. >50g), total tuber number, total tuber weight per plot and total yield were recorded as yield characters. Marginal Rate of Return was also calculated to examine the economic use of N and K_2O fertilizer.

RESULTS AND DISCUSSION

Effect on morphological characters

Nitrogen fertilization on potato crop had significant effect on ground foliage development (Table 1). However, potassium had no any significant effect on ground coverage. Application of 150 kg N produced maximum (84.4 %) ground cover followed by the use of 100 kg N (83.6 %) per hectare whereas least development of ground foliage was recorded

at control (68.9 %). Average number of mains stem per plant was also increased as increased level of nitrogen fertilizer but no effect of potash was observed (Table 1). Highest number of main stem per plant was counted at 150 kg N (3.6) followed by the plot where 100 kg N (3.5) was applied. Likewise, nitrogen had significant effect in plant height (Table 1). Plant height was increased as the increasing the levels of nitrogen fertilizer. Maximum (48.0 cm) height was measured at 150 kg N. This result is also supported by Singh and Raghav (2000). With increased level of nitrogen fertilizer, ground foliage was highest and consequently highest plant height was measured at the highest (150 kg) level of nitrogen. This result is in agreement with the findings of Shrestha *et al.* (2004). Response of potassium fertilization was observed less than the nitrogen fertilization which is also reported by Jadhav and Kadam (2005). The interaction effect of N and K on ground coverage, stem number per plant and plant height was insignificantly different.

Table 1. Effect of N and K_2O on ground coverage (%), stem number per plant and plant height (cm) of potato cv. Kufri Jyoti during 2003/04-2005/06.

Treat-ment	Ground coverage (%)			Mean	Stem number/ plant			Mean	Plant height (cm)			Mean
	2003	2004	2005		2003	2004	2005		2003	2004	2005	
Nitrogen (Kg/ha)												
0	65.2	70.2	71.3	68.9	2.7	2.7	3.6	3.0	33.4	34.7	32.9	33.6
50	75.4	75.5	81.5	77.4	3.3	3.1	3.0	3.1	42.6	34.6	51.8	43.0
100	84.6	80.4	85.9	83.6	3.5	3.4	3.6	3.5	47.6	35.8	53.4	45.6
150	85.8	82.4	85.2	84.4	3.6	3.8	3.3	3.6	53.1	41.6	49.4	48.0
F-test	**	**	**	**	**	**	*	**	**	**	**	**
LSD	12.8	10.3	15.5	14.3	0.1	1.1	0.8	0.7	2.1	7.8	10.2	7.3
Potash (Kg/ha)												
0	70.1	70.6	72.3	71.0	3.1	3.3	3.6	3.3	41.9	35.8	45.1	40.9
30	74.5	71.7	80.7	75.6	3.2	3.5	3.2	3.3	43.8	37.3	48.1	43.0
60	80.4	81.2	85.3	82.3	3.4	3.2	3.5	3.4	45.2	37.5	47.7	43.4
90	83.7	84.7	86.6	85.0	3.4	3.0	3.1	3.2	45.8	36.1	46.6	42.8
Mean	77.7	77.1	81.2	78.5	3.3	3.2	3.4	3.3	44.1	36.7	46.9	42.6
F-test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	8.4	10.3	12.7	10.3	3.2	21.8	15.7	15.6	2.9	12.8	13.1	10.6
N x K	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

** = Significant difference at 1% level. * = Significant difference at 5% level. NS = Non-significant

Effect on yield characters

Variation of undersize tuber number was found at the level of nitrogen applied (Table 2). The number of undersize tuber was decreased as the increased level of nitrogen from 50 to 150 kg in 2003 and 2004. Undersize tuber number (%) decreased as the level of nitrogen increased over the years. This result is also reported by Shrestha *et al.* (2004). Minimum (18%) undersize weight of tubers were obtained at 100 kg and 150 kg N/ha. Seed size number (%) was found statistically significant in all the years Seed size tuber number and weight (%) were also increased as the level of increased nitrogen from 50 kg to 150 kg/ha.

Table 2. Effect of N and K_2O on tuber size distribution (undersize number and weight (%), seed size number and weight (%) and over size number and weight (%)) of potato during 2003/04-2005/06

Treatment	Undersize number (%)			Mea	Under size weight (%)			Mean	Seed size number (%)			Mean	Seed size weight (%)			Mean	Over size number (%)			Mea	Over size weight (%)			Mean
	2003	2004	2005	n	2003	2004	2005		2003	2004	2005		2003	2004	2005		2003	2004	2005	n	2003	2004	2005	
Nitrogen (Kg/ha)																								
0	38	67	70	48	16	42	19	26	35	24	39	33	33	35	41	36	29	9	21	20	51	23	42	38
50	40	100	29	56	18	36	11	22	28	29	37	31	27.	39	30	32	31	10	34	25	55	25	59	46
100	38	52	31	40	17	25	12	18	31	35	36	34	33	43	32	36	31	13	32	42	50	32	56	46
150	35	50	29	38	16	26	11	18	35	34	39	36	37	41	33	37	30	15	32	26	47	34	56	46
F-test	**	NS	NS	**	NS	**	**	**	NS	**	**	**	*	*	**	**	**	**	**	*	NS	**	**	**
LSD	4.3	-	-	14.1	-	10.6	9.2	8.8	-	10.1	3.0	3.2	12.9	10.9	11.7	11.6	2.7	4.5	12.7	20.7	-	12.1	14.7	13.9
Potash (Kg/ha)																								
0	37	37	33	36	17	34	14	22	30	47	39	39	31	40	38	36	31	16	28	25	53	27	48	43
30	35	58	31	41	17	32	13	21	33	29	38	33	33	39	34	35	30	13	31	25	51	30	54	45
60	36	56	32	41	16	31	12	20	32	31	37	33	33	40	33	36	32	13	31	25	51	29	55	45
90	41	58	32	44	18	33	13	22	35	30	35	33	34	39	30.	34	28	12	33	24	49	28	56	44
Mean	37	52	32	41	17	32	13	21	33	34	37	35	33	39.	34	35	30	14	31	25	51	28	53	44
F-test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	22.4	19.6	38.4	25.8	25.4	19.7	41.9	26.3	23.3	20.9	22.1	22.4	23.8	16.5	20.7	20.2	21.6	33.0	30.6	29.3	18.8	25.5	16.6	19.5
N x K	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

** = Significant difference at 1% level. *= Significant difference at 5% level. NS = Non-significant

The highest (42%) numbers of over size tubers were obtained at 100 kgN and the lowest (20%) at 0 kg N whereas oversize weight was recorded the same (46%) in the plot where 50, 100 and 150 kg N applied per hectare. Sharma and Arora (1989) have also reported that N decreased the number of small-sized tubers but increased the number of large-sized tubers.

The effect of potash on tuber size distribution was not distinct in all years (Table 2). Potassium effect on undersize tuber number and weight, seed size number and weight, and oversize number and weight was not statistically significant in all the years. The interaction of N and K_2O was also non-significant. But data of over size tuber number revealed that application of potassium at 90 kg/ha, produced highest (33) number of over size tuber. Increased level of potassium also increases the proportion of large size tuber which is also mentioned by Imas and Bansal (1999).

Table 3. Effect of N and K_2O on total tuber number/ plot, total weight (kg/plot) and total yield (t/ha) of potato during 2003/04-2005/06.

Treat-ments	Total number/ plot			Mean	Total weight (kg/ plot)			Mean	Total yield (t/ha)			Mean
	2003	2004	2005		2003	2004	2005		2003	2004	2005	
Nitrogen (Kg/ha)												
0	153	316	183	217	5.9	7.4	7.4	6.9	8.1	10.	10.3	9.6
50	171	392	215	259	6.2	10.6	12.6	9.8	8.6	14.	17.5	13.6
100	203	409	250	287	8.0	13.3	14.6	12.	11.	18.	20.3	16.6
150	178	363	266	269	7.3	12.6	15.1	11.	10.	17.	21.0	16.2
F-test	**	**	**	**	**	**	**	**	**	**	**	**
LSD	36.0	81.1	77.3	66.4	1.2	2.5	3.6	2.6	1.6	3.6	5.1	3.6
Potash (Kg/ha)												
0	172	267	228	222	6.5	10.4	12.2	9.7	9.0	14.	17.0	13.5
30	174	362	237	258	6.6	10.9	12.9	10.	9.1	15.	17.9	14.0
60	195	380	233	269	8.4	11.4	12.6	10.	11.	15.	17.6	15.0
90	164	369	216	250	5.9	11.2	12.0	9.7	8.2	15.	16.6	13.5
Mean	176	344	228	250	6.8	11.0	12.4	10.	9.5	15.	17.3	14.0
F-test	**	NS	NS	NS	**	NS	NS	*	**	NS	NS	*
CV	12.2	13.2	20.3	15.8	10.6	14.2	17.8	16.	10.	14.	17.8	16.0
LSD	30.1	-	-	NS	1.2	-	-	2.6	1.6	-	-	3.2
N x K	NS	NS	NS	NS	NS	NS	NS	NS	NS	15.	NS	NS

** = Significant difference at 1% level. * = Significant difference at 5% level. NS = Non-significant

Total tuber number was statistically significant in different level of nitrogen (Table 3). Results showed that increasing N level up to 100 kg increased the total tuber number per plot and then decreased at 150 kg N. But total tuber number at 50 kg N, 100 kg N and 150 kg N were statistically at par. Nitrogen increased the number as well as the size of tuber which is also mentioned by Sharma and Sharma (1990). Highest (12 kg/plot) weight of potato was harvested at 100 kg N and lowest (6.9 kg/plot) at control plot. With respect to tuber yield, application of 100 kg N per hectare produced significantly highest (16.6 tha^{-1})

yield as compared to other treatments. The increase in tuber yield may be ascribed to higher number of stolons, well developed ground foliage, more plant height and the better assimilation of carbohydrates and their translocation to the tubers which ultimately helped in enlargement of tuber weight.

Potassium had not observed any significant differences on producing the total number of tuber per plot where as significant effect was observed on total weight per plot (Table 3). Highest (10.8 kg) weight per plot was obtained at 60 kg K_2O followed by 30 kg K_2O (10.1 kg) applied plot. Significant effect of potassium fertilizer was also observed in total yield of potato. Use of 60 kg K_2O per hectare gave highest (15 tha^{-1}) yield. Increase in total yield and the yield of large tubers due to K fertilization may stem from the stimulating effect of potassium on photosynthesis, phloem loading and translocation, as well as synthesis of large molecular weight substances within storage organs, contributing to the rapid bulking of the tubers. However, interaction of N and K_2O on total tuber number, total weight and yield was not statistically significant in all the years (Table 3).

Economic analysis

The economic of N and K_2O analysis is presented in Table 4. The maximum (19.5) marginal rate of return was obtained at 50 kg N and use of nitrogen fertilizer seemed more economical upto 100 kg N and then additional increased of nitrogen fertilizer, negative result in marginal rate of return. Likewise, application of potassium beyond 60 kg/ha, marginal rate of return seemed negative. Hence, application of 100 kg N and 60 kg K_2O seemed more profitable along with 100 kg phosphorous and 20 tons farmyard manure.

Table 4. Economic analysis of nitrogen and potassium fertilizer use

Nitrogen (kg/ha)	Value of added nutrient cost (Rs)	Tuber yield (t/ha)	Yield increment (t/ha)	Value of added income potato (Rs)	Marginal Rate of Return (MRR)
0	0	9.6	0	0	0
50	1944	13.6	4	40000	19.5
100	3888	16.6	3	30000	6.7
150	5832	16.2	-0.4	-4000	-3.14
Potash					
0	0	13.5	0	0	0
30	1000	14.0	0.5	5000	4
60	2000	15.0	1.0	10000	4
90	3000	13.5	-1.5	-15000	-4

Effect on soil properties

The effect of different levels of nitrogen and potassium nutrients on soil properties were analyzed after the potato harvest. Nitrogen content in soil in different treatments was not varied so much but phosphorous content remained much higher (267.4 $kgha^{-1}$) at control plot (Table 4). This might be due to the addition of farmyard manure in soil over three year's period. Likewise, potassium content was observed much higher (434.0 $kgha^{-1}$) at 0 level of K_2O. This can be also ascribed by the continuous adding of farm yard manure in

experimental plot during three year's periods. In addition, no any distinct changes were observed on soil organic matter content and soil reaction.

Table 5. Effect of N and K_2O nutrients on soil nutrients status and soil reaction during 2003/04-2004/05

Treatments (N:P_2O_5:K_2O	% N	P_2O_5 (kgha^{-1})	K_2O (kgha^{-1})	OM (%)	pH
0:100:0	0.11	267.4	318.7	0.92	4.4
0:100:30	0.11	202.6	356.1	0.75	4.3
0:100:60	0.11	236.1	364.6	0.94	4.2
0:100:90	0.08	174.2	369.1	0.66	4.3
50:100:0	0.14	244.4	390.2	0.93	4.1
50:100:30	0.13	202.2	379.4	0.72	4.1
50:100:60	0.10	253.1	396.0	0.74	4.1
50:100:90	0.08	174.1	387.0	0.48	4.3
100:100:0	0.11	204.2	411.9	0.76	4.2
100:100:30	0.10	158.3	407.2	0.91	4.0
100:100:60	0.08	217.7	405.4	0.90	4.1
100:100:90	0.09	209.4	430.0	0.88	4.0
150:100:0	0.08	259.3	434.0	0.80	4.3
150:100:30	0.13	258.0	418.0	0.77	4.0
150:100:60	0.07	246.1	421.0	1.73	4.1
150:100:90	0.09	139.0	417.0	1.07	4.2

CONCLUSION

Application of 100 kg N, 60 kg K_2O along with 100 kg phosphorous and 20 tons farmyard manure per hectare is found economically profitable and recommended for better potato production having the soil nutrient status of low nitrogen, high phosphorous, low potash and medium organic matter content at eastern hill. But findings generated from on-station experiment should be verified further in farmer's field condition at eastern hill. Potassium effect on tuber quality, storage quality and cooking quality should be studied further to verify its effect distinctly. In addition, nutrients uptake by potato at different stages of plant growth and its residual status on soil will be more relevant and fruitful study for future.

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