Nepalese Horticulture 2(1) :60-69. 1998.

ORGANIC AND INORGANIC FERTILIZER RESEARCH ON POTATO IN NEPAL : A REVIEW

B. B. Khatri and S. L. Shrestha
Potato Research Programme Nepal Agricultural Research Council Khumaltar

ABSTRACT

To find out the optimum doses of organic and inorganic fertilizers on potato, a series of experiments were conducted in different locations from high hills, mid-hills and terai of Nepal for several years in the past. In general, the application of N, P_2O_5 and K_2O increased the tuber yield and their uptake significantly. In Kathmandu, one of the representative site from mid-hills the optimum doses were found 100:100:60 kg/ha along with 20 tons compost or farm yard manure (FYM) per hectare as a basal dose in furrows. To reduce the cost of production in other locations of the country, few more multi-locational experiments are still to be conducted for the judicious use of manure and fertilizers. Fertilizer dose verification studies carried out in the past at Khumaltar and outside under on-station and on-farm conditions are reviewed and future research needs are presented here. Available report shows that fertilizer study trial was started since 1977. The results presented here are expected to serve as very useful guidelines to the application of fertilizers in potato crop. Now to find out accurate and economic dose of chemical fertilizer in major agro-ecological zones of the country, some more experiments should be carried out in the country.

Additional Key Words: Fertilizer, inorganic, organic, potato, productivity.

INTRODUCTION

Besides the several efforts put by the Nepalese farmers and the governmental institutes, the productivity of most of the crops including potato is declining every year in the country. Intensive cropping year after year in the same piece of land with application of inadequate quantity of manure and fertilizer creates soil quality deterioration, leading to severe nutrient deficiency if not replenished properly, disturbs the nutrient status of the soil and may become non or less productive to a crop.

Potato is grown throughout the country on wide range of soils. In order to get optimum yield from different soils, nutrients are to be supplemented by the use of fertilizer and manure and the soil as a resource of potato production must be maintained if potato production is to be sustained into the 21st century (Stevens and Hammond, 1992).

The main source nutrients for potato crop are soil, organic and inorganic fertilizers. Good production can not be expected without applying organic or inorganic fertilizers in right dose and proper method. Since potato is a heavy feeder crop and the efficiency of fertilizer depends largely on methods used in its application, it needs special care in fertility management. Traditionally, farmers are growing this crop by applying huge amount of farmyard manure but amount applied is decreasing season by season and now becoming insufficient to provide required nutrients. However, farmers even from very remote areas have already started applying chemical fertilizers without knowing soil fertility status of the soil and balanced doses of it.

The use of chemical fertilizer is extremely low in Nepal. During 1991, only 22.0 kg of N, 18.6 kg of P_2O_5 and 3.0 kg of K_2O was estimated applied per hectare (APROSC/JMA, 1995). Experts claim that with the increase in crop intensity and adoption of improved varieties, the net removal of plant nutrients from the soil has far exceeded the rate of replenishment (Pradhan et al., 1992). Soil status differs to each and every location and fertilizer needs of the crop vary with it. Soil type, its nutrient supplying capacity, varieties, cropping systems, sources of nutrients, time and method of their application, nutrient interaction and moisture supply are additional influencing factors to this.

Nutrient management practices need to be improved for sustained and increased productivity (Westermann and Davis, 1992). The use of blank fertilizer recommendations not only results in under utilization of nutrients from fertilizers but also results in considerable leaching losses leading to pollution by soil run-off and ground water. Moreover, their toxicity may affect tuber yield (Grewal and Sud, 1993).

Carson (1992) reports that the majority of Nepalese farmers fallow as the prone method of fertility management ended many years ago and FYM/compost is by far the most important additive used by farmers to manage soil fertility. Farmers surveyed by Tamang (1992) were alert to the possibility that by correct combination of chemical and organic fertilizers they might increase yields without causing the fertility of their soil to decline.

Potato requires a large amount of nutrients. A 20 ton crop is calculated to extract 140:140:190 kg, while the average application of 15 -30 t/ha FYM would supply at the most 35 - 50 : 50-100 :35-70 kg, of N, P_2O_5, K_2O, not enough to support the potential higher yield.

The fertilizer trial conducted at Jobber in 1973 have shown that the variety Pimpernel. did best when it was supplied with NPK 60:60:50 kg and FYM 25 t/ha while Kufri Naveen and Farse responded the dose of NPK 120:120:100 kg and FYM 25 T/ha. At Daman in 1973, the variety Beautex responded best to the dose of NPK 100:145:145 and FYM 10 t/ha. (Khairgoli, 1977).

Fertilizer dose verification studies conducted at Khumaltar and Nigale farms revealed that potassium had the greatest effect on tuber yield while nitrogen had the least on the other hand, with increasing dose of phosphorus the yield declined subsequently. In Jumla condition, it was found that increase in nitrogen and potash application helped decrease dry matter, however, that of phosphorus did not have any effect (PRP, 1997)

Varietal evaluation and recommendations need informations about the varietal response to levels of nutrients. Better management decisions will be made when accurate information is available about the nutritional characters and requirements of each important variety. So, it is important to review past studies on manure and fertilizer use on potato crop, in different varieties and to recommend optimum level of N, P_2O_5 and K_2O fertilizer in high-hills, mid-hills and Terai.

Several works have been done on the aspect of fertilizer management on potato in different research stations and farms in the country but these data are scattered. The increasing interest on potato crop and its potential for increasing production in Nepal requires the accumulated informations on the use of fertilizer and manure in the past from different locations and summarization of the results for the future research needs.

The farmers in command area of LAC have been generally applying 12 - 24 t/ha of buffalo manure (Pradhanang et.al., 1987). In nutritional terms it could supply about 60 - 120 kg N 24-48 kg P_2O_5, and 36 - 72 kg K_2O (Stapith, et al., 1987) however, the availability to the potato crop in the year of application and in succeeding years is still to be studied.

The past results on the use of FYM or compost almost agree on 20 tons/hectare but no such detail experiments were conducted on chemical fertilizer dose in different agro-ecological zones. So, to find out accurate and economic dose of chemical fertilizer in major agro-ecological zones of the country, the new experiment from following years are also proposed.

WORK REVIEW

From the manure and fertilizer trials conducted for three years from 1975 to 1977 at Khumaltar as a representative site from mid-hills, Khairgoli (1977) reported that in 1975, the treatments with 0 kg nitrogen gave significantly lower yield than all other treatments. Nitrogen @ 60 kg/ha produced highest yield (20.47 t/ha followed by 120 and 180 kg). This preliminary results shows that after the certain amount of fertilizer, the yield goes decreasing.

In 1977, Khairgoli further reported that in fertilizer trial conducted at Khumal, yield due to 0-100-100 and 0-100-100+OM were significantly different from other treatments and yield increased successively as the dose of nitrogen increased (Table 1).

Table 1: Effect of N, P_2O_5, K_2O on potato crop at Khumal, 1977

Treatments	Plant height (cm)	Main stems/plant (#)	Yield (kg/plot)	Yield (tons/ha)
A. Nitrogen				
0-100-100	15.28	2.92	3.39	3.46
0-100-100+OM	16.2	3.8	5.19	5.29
60-100-100+OM	25.4	3.52	16.69	17.03
120-100-100+OM	29.92	3.56	19.88	20.28
180-100-100+OM	31.12	3.36	22.4	22.85
CD at 5%			2.23kg/plot	
B. Phosphate				
120-0-100	25.76	3.8	17.92	18.28
120-0-100+OM	27.96	4.64	23.10	23.57
120-60-100+OM	28.08	4.24	24.54	25.04
120-120-100+OM	26.84	4.52	23.51	23.99
120-180-100+OM	26.68	4.04	23.95	24.44
CD at 5%			3.62 kg/plot	
C. Potash				
120-100-0	21.4	3.28	11.3	11.53
120-100-0+OM	22.24	3.8	18.5	18.88
120-100-60+OM	25.84	3.56	22.45	22.9
120-100-120+OM	26.52	3.84	25.47	25.99
120-100-180+OM	31.84	3.4	27.23	27.78
CD at 5%			1.46 kg/plot	

The plant growth in the treatments without nitrogen from chemical fertilizer was remarkably weak and poor. The treatment with 120-0-100 yielded lowest as compared to other treatments which do not show any significant difference at all levels of phosphate. The yield in the treatments without any source of phosphate was remarkably higher than the yield of corresponding treatments in case of nitrogen and potash indicating the presence was more prominent as compared to that of phosphate. All the treatments were significantly different and the yield increased successively as the dose increased.

Farmers field trials conducted at Kathmandu (Khairgoli, 1977) also showed that the yield due to compost only was sufficiently higher though addition of nitrogen and other nutrients increased the yield. Addition of 50 kg N/ha and NPK @ 50:50:100 kg/ha increased the yield by 3 tons and 5 tons per hectare, respectively over the treatment only with compost.

A highly significant response of nitrogen and phosphorus in potato yield was observed at Pakhribas Agriculture Centre (PAC), Under an irrigated conditions, even a small dose of nitrogen increased the potato yield in 1977. In farmers conditions as well as in Pre-production verification trial (PPVT) when 60:30:30 NPK kg/ha fertilizer was used, yield was increased both in local and improved variety (Shrestha, 1987). But under dry soil conditions, application of small doses of nitrogen was not available to the plants in terms of yield (Russel, 1978).

In phosphate response trial conducted during 1976/77 at PAC command area, it was found that the soaking of the sprouted tuber is not a better practice than using fertilizer in the soil. However, the yield of all treatments was very low by reason of premature necrosis of the leaves and senescence of the plants due to early blight disease.

In the same location, variety Kufri Jyoti and local were tested without fertilizer and with low rate of nitrogen and phosphorus in consequences of previous trials under maize crop. The results show that the Kufri Jyoti is more responsive to nitrogen and phosphorus fertilizer. Phosphorus has not shown much effect as nitrogen to increase the yield and also this was no synergistic response when both are applied together (Shrestha, 1987).

In another fertilizer dose trial (Table 2) conducted at Kathmandu valley, results showed that the number of main stems, number of tubers per plant and yield kg/plot were increased with increase of N application upto 160 kg +25 tons of FYM per hectare during three years and decreased onward. Further addition of 40 kg in the dose of N increased plant height only to 15 cm (Khairgoli, 1978).

Table 2. Effect of different doses of nitrogen on yield, stem number and tubers of Kufri Jyoti variety, 1978

Observations	Nitrogen (kg/ha)				
	80	120	160	200	Mean
Main stems per plant (#)	2.72	2.72	2.89	2.64	2.74
Plant height (cm)	36.6	49.6	50.0	65.6	50.54
Tubers per plant (#)	7.93	8.39	8.97	7.79	8.27
Yield per plot (kg)	15.87	17.89	19.54	17.98	17.82

From a trial conducted at Panchkhal valley, Karmacharya (1978) reported that nitrogen applied at the rate of 100 kg/ha gave net increase of 3.175 tones of potatoes when compared with the cost input RS. 547.82/100 kg of nitrogen. The cost of net return 3.175 tones of potato due to the nitrogen is Rs. 3,968.75 (considering 1.75 per kg during that time). The yield increased due to the N (100 kg/ha) and P_2O_5 (100 kg/ha) application is 5.714 tones (Table 3).

Table 3. Cumulative and net increase in yield due to organic and inorganic fertilizer, 1978

SN	Treatments	Yield (t/ha)	Yield increased due to fertilizers	Net increase in yield Due to fertilizer added
1	No fertilizer	3.174	--	--
	N only	6.349	3.175	3.175
2	N and P only	8.830	5.714	2.539
3	N, P,& K	9.523	6.349	0.635
4	N, P,K & oil cake	12.698	9.524	3.175
5				

At Lumle Agriculture Research Centre a fertilizer trial was designed during 1980 (Table 4). The results showed that application of fertilizer @ 100-75-75 kg/ha plus compost @ 15 t/ha gave significantly higher yields (Sthapit et al., 1987) among all tested doses.

Table 4. Fertilizer Trial on potato at Lumle Agriculture Center (1980)

Treatments	Plant stand /plot	Tubers /plant (#)	Tubers grading by size class			Yield (t/ha)	Difference mean & control mean
			OS	SS	US		
0-0-0	39	4.3	8	18	18	3.197	-
25-25-0	40	4.5	11	19	19	3.12	-073^{ns}
50-50-0	40	5.0	12	20	20	4.96	1.767^{ns}
75-75-0	39	5.4	11	19	29	5.093	1.9^{ns}
100-75-75	38	6.4	18	25	25	6.627	3.434^{ns}
0-0-0-+compost	40	4.6	7	21	21	3.4	0.207^{ns}
25-25-0+compost	39	5.9	15	25	25	4.933	1.740^{ns}
50-50-0+compost	49	5.7	15	22	22	5.307	2.114^{ns}
75-75-0+compost	38	5.7	13	26	26	5.4	2.207^{ns}
100-75-75+compost	40	6.5	17	28	28	9.04	5.847*

In a trial from 1985/86 at Kathmandu valley, nitrogen with combination of compost showed a greater influence to increase the plant height, average tuber weight and total yield among the major fertilizer nutrients. The highest yield of 15.56 t/ha (cardinal variety) was recorded in the treatment with 100 kg of N, and 20 tons compost per hectare (NPDP, 1985/86).

The response of 3 varieties to increasing rates of compost and chemical fertilizer was examined during 1987/88 . There was no interaction effect of fertilizer level x variety nor was there a positive response to the highest level of fertilizer (NPDP, 1987/88).

From the trials conducted to find out the optimum dose of N P_2O_5 K_2O fertilizer for potato cultivar Cardinal in Khumaltar during 1985 spring results showed that nitrogen with combination of compost showed a greater influence to increase the plant height, average tuber weight and total yield (Dhital and Khanal, 84/85).

Potash showed some but phosphorus did not show any clear effect on yield. The highest yield of 15.56 t/ha was recorded in the treatment with 100 kg of nitrogen and 20 ton compost per hectare (Table 5).

Table 5. Effect of different doses of fertilizer on yield and number of stems at Khumaltar, 1986

Treatments	Stems /plant (#)	Average Tuber wt (gm)	Yield (kg/plot)	Yield (t/ha)	Increase yield over control (t/ha)
0-0-0	3.6	11.7	2.82	4.90	-
0-50-50	3.6	13.4	3.46	6.02	1.12
100-50-50	3.8	22.0	4.30	7.48	2.58
200-50-50	3.6	20.1	5.30	9.22	4.32
100-0-50	4.0	19.6	5.30	9.22	4.32
100-100-50	4.4	22.6	5.91	10.27	5.37
100-50-0	4.0	16.1	4.10	7.13	2.23
100-50-100	4.7	23.0	8.49	14.76	9.86
50-0-0+20 tons FYM	4.8	20.4	7.15	12.43	7.53
100-0-0+20 tons FYM	4.2	24.0	8.95	15.56	10.66

Jensen (1987) reported from the trials conducted at Agriculture Research Station Pokhara at light brown sandy loam and farmers field and Horticulture Farm Tansen that ammonium sulphate increased the yield of potato about 10%. He further reported that placement of compost together with fertilizer was found to be highly beneficial compared to the general practice of broadcasting.

In Koshi hills, application of FYM or compost in potato is one of the most important practices of the farmer. According to Chand (1987) an average farmer used 39 t/ha of FYM or compost in their potato crop. Farmers were found never cultivating potato without manure.

Fertilizer trials conducted at Khumaltar (1989/90) showed that there were small increases in plant height and ground cover with higher fetter rates and significant increases in yield at higher fertilizer doses. The highest response was from nitrogen and potassium (Table 6).

Table 6. Effect of different doses of fertilizer on plant and yield of Kufri Jyoti at Khumal, 1990

N:P2O5:K2O (kg/ha)	Ground Cover (%)	Plant Height (cm)	Grading (%) wt.			Yield (t/ha)
			US	SS	OS	
0-0-0	30	17.4	11	84	4	8.9
0-30-60	23	20.1	9	90	1	11.7
45-30-60	33	27.1	8	86	6	15.3
90-30-60	33	29.6	7	87	6	16.6
45-0-60	31	20.8	8	88	4	11.7
45-60-60	35	25.7	7	88	5	13.8
45-30-0	32	23.7	8	89	3	12.8
45-30-120	28	27.3	8	92	0	15.9
CV (%)						16.5

Likewise in Jumla (1990), there was a slight, but non significant increase in yield with the higher compost and compost with chemical fertilizer treatments (Table 7).

Table 7. Effect of FYM and chemical fertilizer on potato yield, Jumla 1990

Treatments	Plant Height (cm)	Yield (t/ha)
Control	43.6	16.8
16 t/ha FYM	45.0	16.0
32 t/ha FYM	45.7	17.9
16 t/ha FYM +50:50:0	48.4	18.4
0 FYM+100:100:0	50.9	16.8
CV (%)		11.4

In 1991, Pandey reported that farmers under existing soil fertility management are producting 66% more than that of the natural soil fertility (no fertilizer and manure) treatment (Table 8). This indicates that the farmers are putting their considerable efforts to supply external sources of plant nutritions clearly illustrated by the significant increase in potato yield with the introduction of balanced fertilizers. The yield increment due to lower as well as higher rates over the natural soil fertility was found over 100 and 180 percent, respectively.

Various trials conducted by Fertilizer and Related Input Programme (FRIP) during 1989/90 shows that in most of the cases the potato crop responded well to the application of N P_2O_5 K_2O fertilizers with very high economic benefit (Table 8). It also indicated that the native soil fertility in the country is not rich enough to exploit the full yield potentiality of the high yielding potato varieties and thus the application of plant nutrients from external source is a must for harvesting higher yield (Pandey, 1991).

In Sarlahi Horticultural Station, a fertilizer dose verification trial was conducted with variety Kufri Sindhuri. Partial factorial design was applied with 3 levels of N, P_2O_5, K_2O. With respect to yield treatment 45-30-60, 45-30-0, and 45-30-120 were found better. Fertilizer response was greatest for nitrogen and phosphorus. There were small increase in plant height with higher fertilizer dose.

Table 8. Demonstration results in 66 sites by FRIP, 1991

Treatments Nutrient rate kg/ha)	Yield (g/ha)	Yield increase over control	
		(t/ha)	(%)
0-0-0	7001.8	-	-
Farmers practice	11656.8	4655.0	66.48
40-20-50	14728.8	7727.0	110.36
80-40-100	19790.2	12788.3	182.64

In another trial from Khumaltar with variety Kufri Jyoti, the highest yield were recorded for the treatment 45-30-120, 45-30-60 and 45-0-60, respectively. Fertilizer response was highest for potassium and least for nitrogen. The yield declined when the level of phosphorus is increased. However there was slight increase in plant height and % ground cover with respect to high fertilizer dose but did not have any effect on number of main stems (NPRP, 1990/91).

CIP 720088 and CIP 800947 were tested with different nutrient combinations and compared with variety Kathmandu Local at Khumaltar with 4 combinations of nutrients; NPK 100:100:60, 80:80:60, 40:40:30 and 0:0:0 kg/ha, compost at 20t/ha (PRP, 1992/93). Results

showed that percent ground cover at 50 days after planting was affected by both variety and level of nutrients.

Table 9. Effect of nutrients level on plant and yield characteristics at Khumaltar, 1992/93

Variety	Nutrient Level (N:P:K)	% Gr.Cov 50 DAP	Plt ht Cm	# stem/ plt	LB	# tubers/ plt	Yield t/ha
CIP 720088	100-100-60	67	40.0	2.4	2.4	5.3	16.3
	80-80-60	45	33.3	1.5	1.5	4.3	14.6
	40-40-30	46	27.4	2.3	2.3	4.0	13.8
	0-0-0	27	27.5	2.5	2.5	4.3	12.1
	Mean	46	32.1	2.2	4.5	14.2	26.1
CIP 800947	100-100-60	75	38.4	2.9	5.0	17.5	39.2
	80-80-60	55	32.0	2.7	5.3	13.8	30.2
	40-40-30	46	30.1	2.1	5.0	13.5	21.4
	0-0-0	29	29.7	2.3	3.7	10.4	12.5
	Mean	51	32.6	2.5	4.8	13.8	25.8
KTM Local	100-100-60	91	49.9	3.0	5.3	25.2	29.9
	80-80-60	85	46.5	2.6	5.7	24.2	41.2
	40-40-30	65	41.0	3.1	5.3	18.2	19.5
	0-0-0	40	34.5	3.0	5.0	14.2	12.6
	Mean	70	43.0	2.9	5.3	20.5	25.8
Mean for nutrien t level	100-100-60	78	42.8	2.8	5.2	19.7	35.1
	80-80-60	62	37.2	2.3	5.1	17.5	33.6
	40-40-30	52	32.8	2.5	4.8	15.2	21.7
	0-0-0	32	30.6	2.6	4.3	12.2	13.1
LSD (0.05) Nutrient level mean		48	3.6	Ns	0.5	1.5	8.2

Percent ground cover increased with increasing the level of nutrient irrespective of variety. Similar trend was observed with plant height, Late blight and number of tubers per plant. No. of stems was not affected by nutrient level. Yield increased with increasing nutrient level. All the tested varieties had produced highest yield with high level of fertilizer (Table 9).

In addition to the various studies on organic and inorganic fertilizer doses on potato, the effect of legumes on the production of rice and potato crop were also studied and the results indicated that the potato and rice crops grown after legumes produced more yield and biomass. Faba bean was the most effective grain legume increasing the yields of both potato and rice crops in mid-hill condtions of Nepal (Khatri and Wells, 1998).

CONCLUSION

Although past results from fertilizer dose trials do not give any successful and complete results, however it is clear that increased nutrient levels showed positive effect on vegetative characters and increased the tuber yields and its components up to certain level. The increase was always related to the individual varietal potential. For potato cultivar NPI - 106, 100 - 150 kg of nitrogen + compost 20 t/ha is beneficial for higher yield and economic return when available phosphorus and potassium are present in sufficient quantity in the soil (NPDP, 1983/1984).

Response to fertilizer depends upon the type of soil and its nutrient status. For potato, nitrogen has a prominent role in increasing the production. Next to nitrogen, potash has a remarkable effect followed by phosphate. Potato is a heavy feeder and quick growing crop. Cattle manure or cow dung slurry is not sufficient for supplying nitrogen while these may supply

a greater part of the requirement of phosphate and potash. Use of compost alone may delay the crop maturity due to slow avail ability of nitrogen.

Since there is a variation on nutrient levels in the soil of different agro-ecological zones (high hills, mid hills and terai), fertilizer recommendations should be location specific on potato crop too. In the light of soil fertility as a national issue, the PRP should concentrate future research on increased and efficient fertilizer use and the use of bio-fertilizer and agricultural by-products as organic manure.

REFERENCES CITED

APROSC and (JMA). 1995. Agriculture Projects Service Centre/ John Mellor Associates. Nepal Agriculture Perspective Plan, APROSC, Kathmandu, Nepal.

Carson, B. R. 1992. The land, the farmer and the future. A soil fertility management strategy for Nepal, ICIMOD occasional paper No. 21. Kathmandu Nepal

Dhital, S. P. and S.P. Khanal. Annual Report 84/85. National Potato Development Programme, Khumaltar, Lalitpur, Nepal.

Grewal, J. S. and K. C. Sud.1994. Fertilizer use Efficiency by potato cv. Kufri Jyoti in Shimla Hills, Potato: Present and Future In: Proceedings of the National Symposium held at Modipuram during 1-3, march, 1993. Indian Potato Association, Shimla, India. P. 128-133.

Jensen, P. R. 1987. Technical Report on Fertilization of Potato. FAO Fertilizer Programme, GCPF/NEP/030/NET Field Document 2. Increased Crop Production and Farmers' income in the Hills through Fertilizers and Related Inputs, September 1987.

Joshi, D. 1997. Soil Fertility and Fertilizer Use in Nepal. Soil Science division, Nepal Agriculture Research Council, Khumaltar, Lalitpur, Nepal. Pp 47.

Khairgoli, L. P. 1978. Studies on different methods of fertilizer application in Kufri Jyoti, 1978, Paper presented Collected papers on Potato Production and Research, Horticulture Workshop held on November 12-17, 1978 organized by National Potato Development programme, Khumaltar, Lalitpur, pp. 1-4.

Karmacharya, J. L. 1978. Fertilizer Trial on Potato at Panchkhal; 1977-78. Collected papers on Potato Production and Research, Horticulture Workshop held on November 12-17, 1978 organized by National Potato Development programme, Khumaltar, Lalitpur, pp. 1-3.

Kelly, G. S. 1977. "Potato Trials 1976/77". PAC Technical Paper No. 18, November, 1977.

Khairgoli, L. P. 1977. Report on manure and Fertilizer Trials, Seed potato workshop held on May 25-27, 1977 jointly conducted by National Potato Development Programme Khumaltar and International Potato Center, Nepal Country Programme, pp. 15 – 21.

Khatri, B. B. and G. J. Wells. 1998. The effect of Legumes on the production of rice and potato based cropping systems. In: Proceedings of First National Horticulture Research Workshop, held on 1-2 May, 1996 organized by Nepal Agricultural Research Council (NARC), Khumaltar, Lalitpur, Nepal, pp. 211-214

NPDP. 1983/1984. Annual Report, 1983/84. National Potato Development Programme, Khumaltar, Lalitpur, Nepal.

NPDP. 1985/86. Annual Report, 1985/86. National Potato Development Programme, Khumaltar, Lalitpur, Nepal.

NPDP. 1987/88. Annual Report, 1985/86. National Potato Development Programme, Khumaltar, Lalitpur, Nepal.

NPRP, 1990/91. Research Report. National Potato Research Programme, Khumaltar, Lalitpur, pp 60-61.

NPRP, 1992/93. Research Report. National Potato Research Programme, Khumaltar, Lalitpur