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Integrated use of FYM and inorganic sources of nutrients in potato-radish crop sequence

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Abstract Field experiments were conducted during 2005-06 and 2006-2007 at Central Potato Research Institute, Shimla on brown mid hill soils to investigate the role of FYM on phosphorus and potassium economy in potato-radish crop sequence under rainfed conditions. Eight manurial treatments consisted of different combinations of FYM and inorganic sources of phosphorus and potassium to potato crop whereas, succeeding radish crop received only N. The application of recommended dose of N along with 50% PK from inorganic fertilizers and rest from FYM (on K basis) in potato resulted in the highest concentration of nitrogen, phosphorus and potassium in leaves which consequently enhanced yields of potato (319 q/ha). This treatment also gave highest yield of following crop radish (192.9 q/ha). Therefore, for the higher productivity and better return of the potato-radish system, 25 to 50% of the recommended dose of P and K fertilizers can be replaced with FYM in the mid hills soils of Himachal Pradesh.

Introduction

Potato is one of the most important crops in the summer season in mid hill of Himachal Pradesh. Development of remunerative potato based cropping systems along with system based manurial schedule is required to ensure stability of crop area, production and good returns to the farmers. Fertilizers constitute 15-20% costs of cultivation of potato. Fertilizer costs are rising every year, therefore, it is important to maximize use of locally available organic nutrient sources to maintain soil fertility and productivity. The use of inorganic fertilizer in conjunction with organic manures is essential for getting sustainable and profitable yield of potato based system in the mid hills of HP. Since, the application of inorganic fertilizers alone could not sustain the soil fertility and productivity under cropping sequences, the only way to realize the potential yield of crops on sustained basis is through the use of various sources of nutrients in integrated manner to make the system productivity profitable.

The problem of high fixation of applied phosphorus to unavailable form in acidic mid hills soils can partly be mitigated through use of FYM due to its buffering nature, which releases part of unavailable native P. However, low mineralization rate of these organic matters due to prevailing low temperature during crop growth period generally fails to satisfy the nitrogen requirement (Trehan *et al*, 2008). Therefore, recommended dose of N was applied to all the treatments except 100% organic treatment and absolute control. Since, organic sources have more residual effect than inorganic, succeeding crop is less likely to suffer due to lack of phosphorus and potassium. Potato-radish is one of the important emerging cropping systems in north western hills (Singh *et al*, 2008). However, the information on nutrient management in radish, based on residual effect of integrated nutrient sources in potato is not available. Keeping these points in view, field studies were conducted during 2005-06 and 2006-2007 on slightly acidic soil in mid hills of Shimla to investigate the role of integration of FYM and inorganic sources of nutrients on performance of potato and to evaluate these combinations with respect to subsequent radish crop.

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Materials and Methods

Field experiment was conducted at Central Potato Research Institute, Shimla in mid hills of Himachal Pradesh on potato-radish crop sequence during 2005-06 and 2006-2007. The soil was sandy loam, having pH 6.18, medium in organic carbon (0.94%), total N (0.314%), high in Bray P (116.2 kg/ha) and NH_4OAc-K (316.12 kg/ha). During both the years potato planting was done in second week of April, radish was planted in first week of October after harvesting of potato and harvested after 65 days. The eight manurial treatments to potato were control, 100% N, 100% NPK, 100% N+ 75% PK (inorganic) + 25% PK from FYM (7.5 t/ha), 100% N + 50% PK (inorganic) + 50% from FYM, 100% N + 25% PK (inorganic)+75% PK from FYM, 100% N+ 100% PK from FYM and 100% PK from FYM. Treatments were replicated 5 times in a randomized block design. The succeeding radish crop was given nitrogen only at the rate of 100 kg /ha through calcium ammonium nitrate. Net plot size was 2.5 X 2.5 m with spacing 50 X 25 cm for potato and 25 X 10 cm for radish.

Nitrogen dose to potato was applied in two splits *i.e.* 1/2 at planting and 1/2 at earthing up while whole PK and FYM were applied in furrows at planting time. P and K were applied as single super phosphate and muriate of potash in all the plots as per treatments. Half of N to radish was applied at planting and remaining 1/2 at 30 days after planting. Leaf samples (4th from top) of potato crop were taken at different critical stages of crop growth and analyzed for total NPK. At maturity, crop was harvested and tuber and radish yields were recorded. Both the crops were raised as par the recommended package of practices. Leaves, tubers and haulms samples were analysed for NPK content following all standard procedures. Data were pooled over the years and analysed following standard statistical procedure. For working out potato equivalent yield (PEY), price of potato and radish was taken as Rs. 1200 and 1000/q, respectively.

Results and Discussion

Potato and radish yield: Application of organic and inorganic sources of nutrients along with N significantly increased yield of tubers and haulms as compared to control (Table 1). Integration of organic and inorganic

Table 1: Effect of PK application from inorganic and organic on performance of potato and radish and percent yield response of the system

Treatments	Potato		Radish		PEY (q/ha)	Net return (Rs/ha)	B:C ratio	Potato yield response (%)	Radish yield response (%)	Yield response of the system (%)
	Tuber yield (q/ha)	Haulm yield (q/ha)	Radish yield (q/ha)	Root/ Shoot ratio						
Control	147	13.30	88.8	2.75	215	59,350	0.74	-	-	-
N	232	21.27	106.3	1.56	314	116,605	1.34	57.82	20.21	45.25
N + 100% (I)	280	18.95	165.8	1.64	408	176,109	1.98	90.48	86.81	89.25
N + 75% (I) + 25% (O)	271	18.15	173.5	1.23	404	174,308	1.97	84.35	95.27	88.00
N + 50% (I) + 50% (O)	319	18.26	192.9	1.15	467	215,382	2.44	117.01	113.10	115.70
N + 25% (I) + 75% (O)	261	17.45	142.7	1.46	371	152,756	1.73	77.55	60.73	71.93
N + 100% (O)	263	17.45	141.8	2.20	372	153,755	1.75	78.91	59.72	72.49
100 (% O)	253	9.26	144.8	1.65	364	155,475	1.91	72.11	63.10	69.10
CD (P=0.05)	34	2.43	46.9	0.55	-	-	-	-	-	-

N= 100%, I = (% PK from inorganic fertilizers), O = (% PK from FYM on K basis) PEY=Potato equivalent yield (q/ha)

Table 2: Effect of PK application from inorganic and organic on total nutrients uptake by the system (kg/ha)

Treatments	Total nutrients uptake potato (kg/ha)			Total nutrients uptake radish (kg/ha)			Total nutrients uptake by the system (kg/ha)		
	N	P	K	N	P	K	N	P	K
Control	53.9	13.22	68.7	18.30	2.52	26.94	72.2	15.74	95.6
N	105.0	20.34	120.9	25.09	3.22	37.05	130.1	23.56	157.9
N+100% (I)	110.2	24.78	131.6	41.93	6.17	65.92	152.1	30.95	197.5
N+75% (I)+25% (O)	116.7	24.85	147.1	50.60	6.59	67.17	167.3	31.44	214.3
N+50% (I)+50% (O)	127.2	27.10	151.6	64.28	7.62	83.12	191.4	34.72	234.7
N+25% (I)+75% (O)	111.3	23.38	135.3	44.83	5.42	60.89	156.2	28.8	196.2
N+100% (O)	110.1	22.84	137.6	35.67	5.20	56.68	145.7	28.04	194.3
100 (% O)	81.2	20.60	100.8	40.62	5.64	60.13	121.9	26.24	161.0
CD (P=0.005)	12.5	2.34	17.7	5.33	0.68	8.46	21.9	3.64	25.9

N= 100%, I = (% PK from inorganic fertilizers), O = (% PK from FYM on K basis)

sources at equal proportion (application of 50% PK each from inorganic fertilizers and FYM along with 100% recommended dose of N) gave the highest tuber yield (319 q/ha) which was significantly higher than all other treatments. The increase in total yield was 13.9% higher over recommended NPK through fertilizers. Application of 100% PK through FYM also increased yield significantly by 78.9% to 263 q/ha compared to control. Whereas, this treatment gave only 6.1% less tuber yield as compared to recommended dose of fertilizers. Other treatments, where 25, 75 or 100% of PK were applied through organic sources were better than control, but were inferior to 50% replacement and at par among treatments. Nitrogen application had more positive influence on haulm yield and the highest haulms yield (21.27 q/ha) was obtained with 100% recommended dose N only followed by recommended doses of NPK and equal proportion of PK from fertilizer and FYM (18.95 and 18.26 q/ha). This may be due to more partitioning of dry matter to tubers as a result of balance nutrition in the treatment receiving FYM application (Minhas and Sood, 1994 and Sud *et al.*, 2005).

The residual effect of integration of nutrient sources in potato on radish yield was similar to that of tuber yield. Radish yield (192.9 q/ha) was also higher in the treatment where inorganic and organic sources were applied in equal proportion followed by 75% PK from fertilizers and remaining 25% from FYM and recommended dose of NPK. In other treatments, where inorganic and organic P and K were not in equal proportion, radish yield decreased. This was possibly due to the fact that at this proportion, availability of residual P and K was maximum to radish. Maximum root/shoot ratio was observed in control (2.75) followed by recommended dose of N and PK from FYM, whereas, integrated use of organic and inorganic source of nutrients gave less root/ shoot ratio compared to other treatments. It was clear that application of inorganic and organic PK in equal proportion along with recommended dose of N resulted into balanced root and shoot growth.

Crop duration in hills is longer than plains and for increased duration of nutrients supply, right proportion of inorganic and organic source is required to meet nutrients supply throughout the crop growth. At this proportion inorganic sources maintained the availability of nutrients at a rate at which crop did not suffer stress. At the same time organic sources maintained the balance nutrition to crop for a longer duration. This equal proportion also favored mineralization of organic source at desirable rate to maintain supply of nutrients not only to potato but also the subsequent radish crop.

Potato equivalent yield and percent yield response of system: Similarly, highest potato equivalent yield (467 q/ha), net return (Rs 2,15,382/ha), B: C ratio (2.44) and percent yield response (115.70%) of system was obtained with application of 100% recommended dose of N along with 50% PK each from inorganic and organic source. Per cent yield response of both the crops (117.01 and 113.10% for potato and radish, respectively) were higher in this treatment followed by 100% recommended dose of N along with 75% PK from inorganic fertilizers and 25% PK from FYM (84.35 and 95.27%) and 100% NPK through fertilizer (90.48 and 86.81%). Percent increase of response of potato and radish where recommended dose of NPK was applied by fertilizer over 100% organic treatment was 18.37 and 23.71%, whereas, the response further improved with integration of inorganic and organic nutrients in equal proportion, which was 44.9 and 50% for potato and radish, respectively. Consequently, the system's response also followed similar pattern.

The symptoms of deficiency particularly of P became more prominent in the second year of experimentation in plots receiving no fertilizers and plots with integrated treatments appeared better than plots receiving only inorganic or organic sources of nutrients. Thus, the integration of organic and inorganic sources of fertilizers gave sustainable yield of both the crop.

Table 3: Effect of PK application from inorganic and organic sources on per cent Recovery of nutrients (kg/ha)

Treatments	% Recovery based on control			% Recovery based on only N fertilized plots		
	N	P	K	N	P	K
Control	28.96	-	-	-	-	-
N	39.97	15.21	101.85	11.02	7.39	39.58
N+100% (I)	43.47	19.03	118.61	17.00	9.55	56.34
N+75% (I)+25% (O)	50.21	29.20	139.05	25.82	17.17	76.78
N+50% (I)+50% (O)	32.76	27.49	100.53	10.17	11.03	38.26
N+25% (I)+75% (O)	26.74	41.00	98.61	5.68	14.93	36.34
N+100% (O)	32.04	35.00	65.31	-5.32	8.93	3.04

I = (% PK from inorganic fertilizers), O = (% PK from FYM on K basis)

***Nutrients concentration in leaves at different growth stages, nutrients uptake and recovery*:** There was marked effect of nutrient application on N, P and K concentration at different growth stages (Fig 1 and 2). Leaf content of the nutrients at tuber initiation (45 DAP) and tuber bulking (60 DAP) was highest in treatment where PK was applied with inorganic and organic sources in equal proportion followed by 75% PK through inorganic fertilizers and 25% through FYM. In the treatment with 100% inorganic or 100% organic PK application, NPK content decreased marginally. This may be due to increase in favorable condition or micro climate of root zone by the application of organic and inorganic sources of the nutrients. This also resulted in higher nutrient uptake and yield of potato.

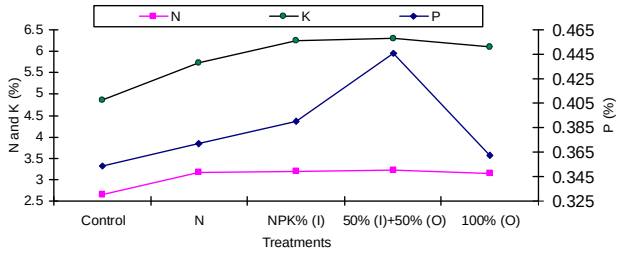

Fig. 1: Effect of PK application from inorganic and organic fertilizers on leaf composition at tuber initiation stage

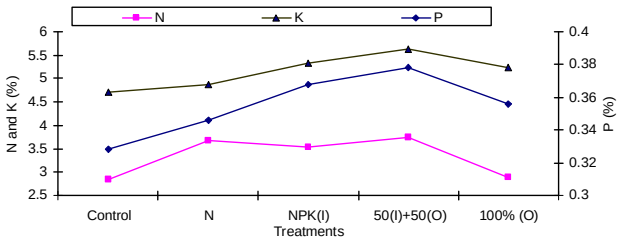

Fig. 2: Effect of PK application from inorganic and organic on leaf composition at early tuber bulking stage

Application of nutrients significantly influenced N, P and K uptake by potato, radish and the system and the trend was similar with that of tuber yield (Table 2). The highest NPK uptake (127.15, 27.10 and 151.57 kg/ha, respectively) by potato and by radish (64.28, 7.62 and 83.12 kg/ha, respectively) was in treatment receiving 50% PK each from inorganic and organic sources. The percent increase in N, P and K uptake by potato and radish was 15.38, 9.36 and 15.20%, and 53.30, 23.50 and 26.09%, respectively, compared to recommended dose of NPK application through fertilizers. Since the uptake of N, P and K by both the crops was highest under this treatment, the total NPK uptake by the system was also highest under treatment receiving 50% PK each from inorganic and organic sources, followed by 75% PK from inorganic and 25% from organic (167.28, 31.44 and 214.25 kg/ha) and 100% NPK through fertilizers (152.13, 30.95 and 167.49 kg/ha). Percent increase in NPK uptake by the system was 25.83, 12.18 and 18.83% when equal proportion from inorganic and organic nutrients were applied compared to inorganic application of NPK through fertilizers. Whereas, whole PK through FYM along with recommended dose of N through fertilizer decreased total uptake of NPK by the system by 4.21, 9.40 and 1.64% as compared to recommended dose of NPK through fertilizer. However, by the application of FYM without N application, the total NPK uptake decreased by 19.90, 13.92 and 18.50% as compared to recommended dose of NPK. Results indicate that availability of nutrients increased in the presence of FYM and there was no need to apply P and K fertilizer to succeeding radish crop (Minhas and Sood, 1994).

N, P and K recovery by potato and radish crop were significantly influenced by the various combinations of P and K applied through inorganic fertilizers and FYM (Table 3). The highest recovery was observed when equal proportions of both organic and inorganic nutrients were applied. Percent recovery of N, P and K in this treatment was 50.21, 29.20 and 139.05% based on control and 28.50, 17.17 and 76.78% based on N fertilized plots followed by 100% recommended dose of N along with 75% PK from inorganic fertilizers and 25% PK from FYM and 100% NPK through fertilizer.

Results showed the importance of integrated use of organic and inorganic fertilizers on the potato crop in Shimla hills where the crop is grown during summer months. Application of recommended dose of N along with 50% PK from inorganic fertilizers and rest 50% from FYM gave sustainable yields of potato and higher nutrient use efficiency in mid hills of Shimla. This proportion of inorganic fertilizer and FYM also proved the best for growing radish on residual fertility.

सारांश

असिंचित दशा में आलू + मूली के फसल क्रम में गोबर की खाद का प्रयोग फास्फोरस तथा पोटाश की मात्रा को कम करने हेतु क्रमशः सन् 2005–06 तथा सन् 2006–07 में केन्द्रीय आलू अनुसंधान संस्थान शिमला में परिक्षण किया गया था। परीक्षणों के आधार पर यह पाया गया कि नत्रजन की पूरी संस्तुति मात्रा तथा 50 प्रतिशत फास्फोरस एवं पोटाश की पूर्ति अकार्बनिक उर्वरक के द्वारा एवं 50 प्रतिशत उक्त तत्वों की पूर्ति गोबर की खाद द्वारा की गयी तो पत्तियों में सबसे अधिक नत्रजन, फास्फोरस तथा पोटाश की सान्द्रता पायी गयी जिसके कारण आलू की सबसे अधिक उपज 319 कु. प्रति है. पायी गयी थी। उक्त परिक्षण द्वारा मूली की भी सबसे अधिक उपज (192.9 कु./हे.) पायी। इसलिए हिमाचल प्रदेश मध्य पहाड़ियों में आलू उगाने के लिए आलू + मूली के फसल चक्र में 25 से 50 प्रतिशत फास्फोरस तथा पोटाश तत्वों की पूर्ति गोबर की खाद से हो सकती है।

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