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YIELD, RESPONSE AND NUTRIENT UPTAKE BY POTATO AS INFLUENCED BY SOIL FERTILITY AND INTEGRATED PLANT NUTRITION SYSTEM ON ULTISOLS

A. Gayathri, A. Vadivel, R. Santhi* and P. Murugesa Boopathi

Department of Soil Science and Agricultural Chemistry,
Tamil Nadu Agricultural University, Coimbatore-641 003, India

ABSTRACT

Following the inductive cum targeted yield concept, a field experiment was conducted during 2002-03 to study the effect of soil fertility and Integrated Plant Nutrition System (IPNS) on the yield of potato (var. Kufri Thenmalai) in Typic Haplohumult soils of Tamil Nadu. The treatments consisted of five levels of N, four levels of P_2O_5, three levels of K_2O, two levels of FYM and two levels of Azospirillum (Azo). Marked fertility build up due to fertilizer addition at graded levels was recorded to the tune of 18.5, 103.3 and 8.2 per cent, respectively for $KMnO_4$-N, Bray-P and NH_4OAC-K in $N_2P_2K_2$ (strip IV) over $N_0P_0K_0$ (Strip I). Response to fertilizer nutrients was recorded in terms of yield and total uptake. The highest tuber yield of 56.43 t ha^{-1} was recorded by the application of 225 kg N, 300 kg P_2O_5 and 300 kg K_2O ha^{-1} along with the application of FYM @15 t ha^{-1} and Azospirillum @ 2 kg ha^{-1}. Application of 300 kg N, 200 kg P_2O_5 and 300 kg K_2O ha^{-1} has recorded 336.99, 147.95 and 300.24 kg ha^{-1} of total N, P and K uptake respectively.

INTRODUCTION

Soil testing is a scientific tool to evaluate soil fertility by predicting the probability of getting profitable crop response to recommended fertiliser applications under specific soil crop conditions which may further be improved by the application of soil amendments (Biswas, 2002). The pre-requisite to develop a quantitative and significant relationship between crop yield and soil test values is to have a wide range in the soil test values and the resultant yields. In any crop, the response to applied nutrients mainly depends on fertility status of the soil. Soil test based fertiliser recommendation plays a vital role in ensuring balanced nutrition to crops and also avoids over or under usage of inorganic fertilizer. Fertilizer schedules should therefore be based on magnitude of crop response to applied nutrients at different soil fertility levels. Based on this concept, soil test crop response studies were undertaken in different parts of India for different crops (Subba Rao and Sanjay Srivastava, 2000). Potato being one of the major vegetable crops of Tamil Nadu, this study was undertaken on Ultisols of Nigiris district preferably in hilly zone.

MATERIAL AND METHODS

Soil test crop response studies on potato (var.Kufri Thenmalai) was carried out during 2002-03. The soil was sandy clay loam (Typic Haplohumult), pH 4.3, E.C.0.08 dS m^{-1} and non-calcareous. The soil had 352,425 and 550 kg ha^{-1} of $KMnO_4$ - N, Bray-P and NH_4OAc - K, respectively before the start of the gradient experiment.

A gradient experiment was conducted following the Inductive concept (Ramamoorthy *et al.*, 19672). The experimental field was divided into four equal strips *viz.*, $N_0P_0K_0$ (Strip I), $N_{1/2}P_{1/2}K_{1/2}$ (Strip II), $N_1P_1K_1$ (Strip III) and $N_2P_2K_2$ (Strip IV) and fertiliser N, P_2O_5 and K_2O were applied at graded levels to each one of the strips ($N_1P_1K_1$ - 120:250:100 kg ha^{-1} respectively). The gradient crop of potato (var. Kufri Jothi) was grown and harvested at maturity.

After the creation of fertility gradients, each strip was divided into 24 plots to accommodate 24 treatments and thus making a total of 96 plots in all the four strips. Complex field experiment with potato (var. Kufri Thenmalai) was conducted by adopting

* Corresponding author-Present address : Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore-641003. E-mail: santhitnau@yahoo.co.in

fractional factorial design. The treatments consisted of N (0, 75, 150, 225 and 300 kg ha^{-1}), P_2O_5 (0,100,200 and 300 kg ha^{-1}), K_2O (0, 100,200 and 300 kg ha^{-1}), FYM (0 and 15 t ha^{-1}) and *Azospirillum* (0 and 2 kg ha^{-1}). The sources of N, P_2O_5 and K_2O were urea, single super phosphate and muriate of potash.

The initial surface samples from all the plots were analysed for alkaline $KMnO_4$-N (Subbiah and Asija, 1956), Bray-P (Bray and Kurtz, 1945) and NH_4OAc-K (Hanway and Heidal, 1952). Tuber yields were recorded treatment-wise. Tuber and halum samples were analysed for N, P and K contents (Piper, 1966) and total N, P and K uptake were computed. The response of potato to fertilizer nutrients was also computed.

RESULTS AND DISCUSSION

The data on range in soil test values, tuber yield and total N, P and K uptake and also the mean values in the experimental field from control and treated plots showed that the operational range has been obtained in the case of soil available N, P and K (Table 1). Crop yield is a function of soil fertility under optimal levels of other production factors that has been substantiated by the results recorded in the present study. Thus, marked fertility built up due to fertiliser addition at graded levels to create fertility gradient was evident from the crop response data also. Almost in all type of soils, the fertility variations were developed by the application of graded doses of NPK fertilisers (Subba Rao and Sanjay Srivastava, 2001).

i) Pre-sowing soil analysis : The range and mean values of pre-sowing soil available nutrients in treated plots are furnished in Table 1. For alkaline $KMnO_4$-N, the range was from 334-362, 384-417, 402-417 and 409-433 kg ha^{-1} with mean values of 352, 398, 409 and 417 kg ha^{-1}, respectively in S I - S IV. With regard to Bray-P, the range recorded was from 415 - 445, 581-607, 738 - 762 and 840 - 894 kg ha^{-1} with mean values of 429,592, 749 and 872 kg ha^{-1}, respectively in S I - S IV. With reference to NH_4OAc-K, the range was 576- 610,578 - 635, 594 - 661 and 601- 679 kg ha^{-1} with mean values of 589,598, 614 and 637 kg ha^{-1}, respectively in S I - S IV. Likewise the range and mean values of control plots are also reported in Table 1.

ii) Tuber yield and nutrient uptake : Fresh tuber yield of potato was recorded in all the four strips. Using the total N, P and K contents and the dry matter yield of tubers and haulm, the total N, P and K uptake values were computed (Table 1). The fresh yield of tuber in treated plots ranged from 23.25-53.47, 31.31-56.43, 35.81-55.03 and 36.56-55.47 t ha^{-1} with mean yield of 40.07, 43.25, 45.08 and 46.23 t ha^{-1} in S I, S II, S III and S IV, respectively.

The maximum yield in treated plots was recorded in fertility strip II (56.43 t ha^{-1}) with the application of 225 kg N, 300 kg P_2O_5 and 300 kg K_2O ha^{-1} along with the application of FYM @15 t ha^{-1} and *Azospirillum* @ 2 kg ha^{-1} followed by 55.55 t ha^{-1} in fertility strip IV with the application of N, P_2O_5 and K_2O @ 300, 200 and 200 kg ha^{-1}, respectively along with FYM @ 15 t ha^{-1} and *Azospirillum* @ 2 kg ha^{-1} (Table 2). The favourable influence of organics, inorganic and biofertilisers on chemical, physical and biological properties of soil under IPNS would have resulted in such maximum tuber yields of potato. Findings of Dixit (1997) and Gupta *et al.* (1999) corroborate with the findings recorded in the present study. The minimum yields were obtained from the absolute control plots of strip I (13.75 t ha^{-1}). This emphasizes the importance of balanced use of all the three-macro nutrients for getting higher yields of potato.

The uptake of N in treated plots recorded a range of 108.98 - 350.09, 140.00-390.57, 166.84-354.09 and 180.93-372.78 kg ha^{-1} with mean values of 242.00, 278.00, 290.00 and 304.00 kg ha^{-1} in strips S I, SII, SIII and S IV, respectively. The P uptake ranged from 80.70-168.20, 91.00-171.60, 101.82-202.32 and

Table 1. Range and mean values of available nutrients in the pre-sowing surface soil, yield and uptake of potato

Parameters (kg ha^{-1})	Control plots (kg ha^{-1})		Treated plots (kg ha^{-1})	
	Range	Mean	Range	Mean
$N_0P_0K_0$				
Alk.$KMnO_4$-N	320.00 - 333.00	327.00	334.00 - 362.00	352.00
Bray-P	410.00 - 414.00	412.00	415.00 - 445.00	429.00
NH_4OAc-K	562.00 - 569.00	566.00	576.00 - 610.00	589.00
Tuber yield (t ha^{-1})	13.75 - 16.56	15.31	23.25 - 53.47	40.07
N uptake	45.15 - 71.07	59.39	108.98 - 350.09	242.00
P uptake	55.60 - 70.16	63.76	80.70 - 168.20	118.00
K uptake	89.53 - 106.85	99.16	149.75 - 300.13	223.00
$N_{1/2}P_{1/2}K_{1/2}$				
Alk.$KMnO_4$-N	370.00 - 379.00	374.00	384.00 - 417.00	398.00
Bray-P	572.00 - 578.00	575.00	581.00 - 607.00	592.00
NH_4OAc-K	569.00 - 570.00	569.33	578.00 - 635.00	598.00
Tuber yield (t ha^{-1})	14.12 - 17.65	16.04	31.31 - 56.43	43.25
N uptake	46.5 - 78.07	64.71	140.00 - 390.57	278.00
P uptake	64.96 - 75.12	70.36	91.00 - 171.60	132.00
K uptake	90.16 - 124.25	108.88	159.00 - 304.47	237.00
$N_1P_1K_1$				
Alk.$KMnO_4$-N	387.00 - 397.00	392.00	402.00 - 417.00	409.00
Bray-P	730.00 - 735.00	732.00	738.00 - 762.00	749.00
NH_4OAc-K	579.00 - 587.00	582.00	594.00 - 661.00	614.00
Tuber yield (t ha^{-1})	14.53 - 18.59	17.18	35.81 - 55.03	45.08
N uptake	49.92 - 89.32	75.55	166.84 - 354.00	290.00
P uptake	67.2 - 89.76	80.72	101.82 - 202.32	133.00
K uptake	101.11 - 133.56	121.74	195.42 - 312.57	254.00
$N_2P_2K_2$				
Alk.$KMnO_4$-N	401.00 - 407.00	404.00	409.00 - 433.00	417.00
Bray-P	832.00 - 838.00	835.00	840.00 - 894.00	872.00
NH_4OAc-K	589.00 - 595.00	592.00	601.00 - 679.00	637.00
Tuber yield (t ha^{-1})	15.31 - 20.62	18.54	36.56 - 55.47	46.23
N uptake	52.10 - 102.30	84.14	180.93 - 372.78	304.00
P uptake	80.08 - 94.44	87.13	110.78 - 194.14	141.00
K uptake	98.59 - 140.1	125.20	202.30 - 322.08	267.00

110.78-194.14 kg ha^{-1} with mean values of 118, 132, 133 and 141 kg ha^{-1} in strips S I, SII, SIII and S IV, respectively. Regarding the uptake of K, the range was 149.75-300.13, 159.00-304.47, 195.42-312.57 and 202.30-322.08 kg ha^{-1} with mean values 223, 237, 254 and 267 kg ha-1 in S I, SII, SIII and S IV, respectively.

iii) Response of potato to fertiliser nutrients : The response for N increased with increased levels of N (Table 3) .The increased uptake could be due to higher availability of nutrients and increased absorptive area, which resulted in higher tuber yield. Similar results were reported by Sud *et al.* (1991) and Abdul Khalak and Kumaraswamy (1993).

Increase in P fertilizer levels resulted in increased tuber yield and total P uptake upto 200 kg P_2O_5 ha^{-1}, beyond that there was slow decline in total P uptake and tuber yield and this may be due to limited impact of higher dose

Table 2. Effect of pre-sowing soil fertility status and treatments on Tuber yield of potato

Particulars	Strip	STVs (kg ha^{-1})			Fertiliser doses (kg ha^{-1})			Yield
		$KMnO_4$-N	Olsen-P	NH_4OAc-K	N	P_2O	K_2O	(t ha^{-1})
Maximum yield	$N_0P_0K_0$	362	427	581	300	200	200	53.47
Minimum yield	$N_0P_0K_0$	320	414	562	0	0	0	13.75
Maximum yield	$N_{1/2}P_{1/2}K_{1/2}$	398	605	620	225	300	300	56.43
Minimum yield	$N_{1/2}P_{1/2}K_{1/2}$	373	572	569	0	0	0	14.12
Maximum yield	$N_1P_1K_1$	421	748	620	300	200	200	55.03
Minimum yield	$N_1P_1K_1$	387	730	587	0	0	0	14.53
Maximum yield	$N_2P_2K_2$	432	891	645	300	200	200	55.55
Minimum yield	$N_2P_2K_2$	401	837	592	0	0	0	15.31

Table 3. Response of potato to different levels of fertiliser nutrients

Nitrogen	Uptake	Yield
0	70.94	16.77
75	149.34	31.73
150	226.14	38.13
225	289.46	44.50
300	336.99	48.95
Phosphorus	Uptake	Yield
0	75.49	16.77
100	102.32	35.75
200	147.95	45.75
300	134.02	45.69
Potassium	Uptake	Yield
0	113.74	16.77
100	241.69	38.19
200	279.16	46.32
300	321.63	51.84

of P when N and K are sufficiently replenished in the soil. This result is in line with the findings of Jaggi *et al.* (1988) and Nikunja Ch.Deka and Tapan Ch. Dutta (1996).

The tuber yield and total K uptake increased with increase in K levels from 100 to 300 kg ha^{-1}. The higher uptake could be due to increased availability of nutrients and increased absorptive area. The results confirm the findings of Maity and Arora (1980) and Krishnappa (1990).

The results emanated in the present study have clearly revealed that soil fertility and IPNS had profound influence on the tuber yields, response and nutrient uptake pattern of potato.

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