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Effect of different levels of NPK on foliar diseases of potato under different fertility gradient soil in field

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ABSTRACT

A field study was conducted to find out the effect of different combinations of nitrogen, phosphorus and potassium levels against the severity of fungal foliar diseases i.e. late blight, early blight, leaf blotch and diseases complex and yield of potato grown in four different fertility gradient soils (low-S_1, medium-S_2, moderate-S_3 and high-S_4). Maximum yield as well as low disease severity was observed in S_1 at $N_{150}P_{125}K_{100}$ kg ha^{-1}combination, S_3, at $N_{250}P_{125}K_{100}$ kg ha^{-1} combination and at $N_{250}P_{125}K_{125}$kg ha^{-1} combination in S_2 and S_4. This study showed that soil testing plays an important role in management of disease in potato before fertilizer application.

Keywords : Fertility gradients, foliar diseases, NPK dose, potato, yield attributes.

Potato (*Solanum tuberosum*) belonging to the family Solanaceae is an important starchy cheapest food crop in both subtropical and temperate region.In India potato is grown in almost all the states under diverse conditions and 82% of potato are grown in plains during the short winter days from October to March. The state of West Bengal along with UP, Bihar account for 3/4th of area under this crop and 4/5thof the total production. Generally, the nutrient requirement of potato is high because of their high biological yield. So sufficient plant nutrients are needed to be supplied in assumable form to sustain rapid growth and tuberisation for production for sizeable yield. This crop is known to suffer the greatest losses from disease attack (Guchi, 2015). The most commonly occurring and destructive foliar diseases of potato are late blight of potato caused by Phythophthora infestans, early blight caused by Alternaria solani, leaf blotch by Cercospora concors cause maximum loss (Mizubuti *et al*., 2007).

Nutrients are important for growth and development of plants and also micro-organisms, and they are important factors in disease control. It is important to manage nutrient availability through fertilizers or change the soil environment to influence nutrient availability, and in that way to control plant disease in an integrated pest management system. It is known that an understanding of disease interactions with each specific nutrient, the effects on the plant, pathogen and the environment can be effectively modified to improve disease control, enhance production efficiency and increase crop quality (Walters and Bingham, 2007). As the demand for potato production increases, the farmers began to apply fertilizers indiscriminately in order to increase yield in different locations without knowing the fertility status of the soil. But this increase use of fertilizers in different regions predisposed the potato crop towards infection by various diseases in low to severe form. Dey *et al*., 2015 also revealed that integrated use of balanced inorganic fertilizer with organic manure-biofertilizer helps to maintain soil physical health. With regard to the effect of various macro-nutrient levels on the incidence of foliar diseases namely early blight, late blight, leaf blotch of potato very little work has been carried out in India particularly in West Bengal. In view of this scenario field experiments were carried out to find out the effect of different levels of NPK, on the disease incidence vis-a-vis disease severity of early blight, late blight, and leaf blotch including yield and yield parameters in different fertility gradient soils under same prevailing climatic conditions.

MATERIALS AND METHODS

The experiment was conducted during the *Rabi* season at Regional Research Station, Gayeshpur, BCKV, Nadia,West Bengal during 2012-2014. The soil was sandy loam in texture, and the research station situated at 23.05^0 N latitude and 88. 5°E longitude to study the effect of different fertility gradient of soil. The fertility gradient experiment was conducted with maize (var A-de-Cuba) during the kharif season of 2011 by broadcasting maize seeds. 4 fertility gradient strips of area 200 m^2. were separated by one meter irrigation channel. The fertility gradient strips were prepared by the application of four different doses of NPK (kg ha^{-1}) as low S_1 -0:0:0, medium S_2 (50:31:67), moderate S_3 (100:62:134) and high S_4 (200:124:268). The crop was harvested on 8.10.2011, 60 days after sowing. Soil samples collected from 15 cm depth from 4 plots under each treatment were analyzed for pH, Organic Carbon (%), $KMnO_4$ – N, Olsen – O and NH_4OAc – K before land preparation and available mean nutrients of the two years data wereas low (S_1)- pH, 6.3; N, 277.3; P, 9.5; K, 90.3 kg ha^{-1}; in medium (S_2)- pH,6.2; N, 276.4; P, 12.6;

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K, 123.5 kg ha^{-1};in moderate (S_3)- pH, 6.4; N, 275.4; P, 16.2; K, 163.3 kg ha^{-1}; and in high (S_4)- pH, 6.3; N, 290.1; P, 26.3; K, 243.3 kg ha^{-1}. Each of the fertility strips were divided into 16 sub plots each with an area of 5 × 5m. The experiment consisted of 64 plots for 13 treatments including untreated control with 3 replications.

The experiment was conducted in a split plot design composed of 13 different treatments [T_1: $N_0P_0K_0$; T_2:$N_1P_1K_1$; T_3:$N_2P_2K_2$; T_4:$N_3P_2K_2$; T_5:$N_1P_2K_2$; T_6:$N_1P_1K_2$; T_7:$N_1P_2K_1$; T_8:$N_2P_2K_1$; T_9:$N_2P_1K_1$; T_{10}:$N_2P_1K_2$; T_{11}:$N_3P_1K_1$; T_{12}:$N_3P_2K_1$; T_{13}:$N_3P_1K_2$]here N_1=150 kg ha^{-1} N, N_2=200 kg ha^{-1}N, N_3= 250 Kg ha^{-1} N; P_1=100 kg ha^{-1}P_2O_5, P_2= 125 kg ha^{-1}P_2O_5 with K_1=100 kg ha^{-1} K_2O, K_2=125 kg ha^{-1}K_2O preparation keeping three replicates in a split plot design.

The tubers (KufriJyoti) were planted on 30th November in each year 2012-13 and 2013-14 with inter row spacing maintained at 55 × 15cm. All experimental plots were uniformly fertilized. Half N, total P and K were applied as basal dose during final land preparation and the rest half of N was top dressed after the first earthing up to 35 days after planting. Irrigation was applied 5 times and insecticide was sprayed whenever required.

Severity of late blight, early blight and leaf blotch was assessed and recorded on 1-9 scale (Ghosh *et al*., 2009). 10 plants of each replication were selected randomly for data collection and percent disease index (PDI) and percent increase and decrease over control was calculated as per McKinney (1923).

Percent Disease index =

$$\frac{\text{Sum of all numerical ratings} \times 100}{\text{Total no. of leaves observed} \times \text{maximum rating}}$$

The disease severity data were averaged over three replications .From each replication of each plot the potato rows were harvested on 20th-21stMarch in each year. The fresh weight of the tubers per replication per plot was recorded taken in kg per plot then converted to ton per hectare.

The experimental results were statistically interpreted through calculation of ‘Analysis of variance’ by a standard method (Bailey, 2008) and the significance of different treatments was tested by Error mean square by Fisher and Snedicos’s ‘F’ test at probability level 0.05. For determination of critical difference (CD) at 5 per cent level of significant Fisher’s and Yate’s tables were consulted.

RESULTS AND DISCUSSION

Nitrogen @150, 200 and 250 kg ha^{-1}, Phosphorus and Potassium @ 100 and 125 kg ha^{-1} at different combinations showed various degrees of disease severity of foliar diseases late blight, early blight, leaf blotch and their mixed infections (Table 1)

In case of late blight of potato, with increasing N there was a decrease in disease severity in S_1 gradient, and lowest disease severity was observed in low (S_1) $N_{200}P_{125}K_{100}$ (2.36) followed by $N_{150}P_{100}K_{125}$ (2.94). In (S_2) gradient showed a similar trend and the lowest disease severity was observed in $N_{200}P_{125}K_{100}$ (1.35) followed by $N_{250}P_{100}K_{100}$ (1.80) and $N_{200}P_{100}K_{100}$ (1.81), whereas, highest in $N_{200}P_{125}K_{125}$ (4. 34). In moderate (S_3) gradient, it was observed that there was a significant increase in late blight severity and with increase in N, the lowest disease severity was observed in $N_{250}P_{100}K_{125}$ (0.44) and it was observed that maximum level of N, P, and K caused maximum disease severity (Table 1). In high (S_4) gradient, with increase in N there was a significant decrease in disease though maximum reduction in N_{200} level. Here it was observed that K has no effect on disease severity, whereas, with increase in P there was increase in disease severity (Table 1).

In case of early blight the lowest disease was observed in high soil gradient (S_4) $N_{200}P_{125}K_{125}$ (0.77) followed by $N_{150}P_{100}K_{125}$ (0.78), $N_{150}P_{125}K_{125}$ (0.84) which were statistically *at par*. Maximum disease severity was observed in medium (S_2) soil in $N_{150}P_{100}K_{125}$ (7.95) followed by $N_{150}P_{100}K_{100}$ (7.56), $N_{150}P_{100}K_{125}$ (7.25). NPK interaction in different gradients showed that in high (S_4) gradient the minimum disease severity was observed in $N_{150}P_{100}K_{125}$. It was observed that with increase in N level, maximum reduction in disease severity was observed where P and K has no significant effect in reducing the disease severity over untreated control (Table 1).

In case of leaf blotch disease it was observed that in every treatments in each gradient there was a reduction of disease severity in comparison to untreated control (N0P0K0) but differential disease severity was observed in different gradients. In low (S_1) minimum disease severity was observed in $N_{250}P_{100}K_{100}$ (2.99) followed by $N_{250}P_{125}K_{100}$ (3.47). In medium (S_2) gradient minimum severity was observed in $N_{250}P_{100}K_{125}$ (2.56) and maximum in $N_{150}P_{125}K_{100}$ (12.06) and their difference in disease reduction was not statistically significant. In moderate (S_3) gradient showed that in every treatment more than 50 per cent reduction of disease severity was observed in every treatment as compared to untreated control. Maximum reduction was observed in moderate (S_3) $N_{200}P_{100}K_{125}$ (77.67%) and with increasing in N level leaf blotch disease was decreased (Table 1). In high (S4) gradient also increasing N level decreased the disease severity irrespective of P and K levels. Maximum reduction was observed in high (S4) $N_{250}P_{100}K_{100}$(82.26%). Minimum reduction was observed in (S4) $N_{150}P_{125}K_{100}$ (26.93) (Table 1).

Table 1: Effect of different combinations of NPK under different soil fertility gradient on severity of foliar diseases of potato (Pooled data of two years).

Treatment	Late blight		Early blight		Leaf blotch		Multiple disease complex	
	Disease severity	Increase/ de Crease - over control %	Disease severity	Increase/ de Crease - over control %	Disease severity	Increase/ de Crease - over control %	Disease	Increase/ de Crease - over control %
$S_1N_1P_1K_1$	5.78	30.10	6.55	-8.93	8.48	-34.75	20.81	-16.32
$S_1N_1P_1K_2$	2.94	-34.10	1.47	-79.50	3.98	-69.51	8.39	-66.19
$S_1N_1P_2K_1$	3.32	-26.30	4.96	-30.16	10.42	-19.78	18.70	-24.77
$S_1N_1P_2K_2$	4.22	-5.11	3.89	-45.10	6.43	-50.48	14.54	-41.47
$S_1N_2P_1K_1$	5.38	20.89	6.03	-16.19	9.52	-26.75	20.93	-15.83
$S_1N_2P_1K_2$	5.15	15.84	7.25	1.61	7.95	-38.90	20.35	-17.98
$S_1N_2P_2K_1$	2.36	-48.347	4.44	-37.4	7.04	-45.98	13.84	-44.17
$S_1N_2P_2K_2$	4.31	-1.16	3.49	-51.29	9.71	-25.29	17.52	-29.39
$S_1N_3P_1K_1$	3.32	-26.50	2.18	-69.69	2.99	-77.11	8.49	-68.87
$S_1N_3P_1K_2$	3.33	-24.61	3.07	-56.97	3.60	-72.31	10.00	-59.69
$S_1N_3P_2K_1$	4.53	-35.71	4.48	-38.39	3.47	-73.29	12.48	-49.78
$S_1N_3P_2K_2$	3.26	-27	1.70	-76.43	4.77	-63.14	9.73	-61.03
$S_2N_1P_1K_1$	2.68	-38.76	7.56	248.48	9.79	-27.30	19.19	-6.65
$S_2N_1P_1K_2$	3.30	-24.23	7.95	279.65	11.37	-15.49	22.62	10.90
$S_2N_1P_2K_1$	2.33	-46.64	4.63	109.31	12.06	-10.60	19.02	-7.56
$S_2N_1P_2K_2$	2.64	-39.25	3.59	64.13	10.66	-20.94	16.88	-17.54
$S_2N_2P_1K_1$	1.81	-59.28	7.02	221.16	2.82	-79.09	11.65	-43.50
$S_2N_2P_1K_2$	3.25	-22.93	6.83	213.16	11.79	-12.39	21.87	6.95
$S_2N_2P_2K_1$	1.35	-69.63	2.53	8.55	7.00	-48.17	10.87	-47.14
$S_2N_2P_2K_2$	4.34	-1.51	3.22	47.39	6.15	-54.40	13.65	-33.60
$S_2N_3P_1K_1$	1.80	-60.58	6.17	182.91	3.58	-73.47	11.55	-44.20
$S_2N_3P_1K_2$	2.33	-46.19	2.04	-0.05	2.56	-80.99	6.94	-66.07
$S_2N_3P_2K_1$	2.84	-36.85	4.61	121.44	5.89	-56.36	13.33	-34.94
$S_2N_3P_2K_2$	1.85	-58.49	2.12	-6.47	3.07	-77.36	7.03	-66.40
$S_3N_1P_1K_1$	0.49	-80.67	4.53	-21.01	5.86	-50.99	10.88	-47.02
$S_3N_1P_1K_2$	1.01	-62.21	5.56	-2.54	3.68	-69.22	10.24	-50.28
$S_3N_1P_2K_1$	0.85	-70.07	2.14	-60.88	7.82	-34.89	11.02	-46.15
$S_3N_1P_2K_2$	2.56	-3.34	2.62	-52.41	7.24	-40.00	12.42	-39.64
$S_3N_2P_1K_1$	1.10	-59.36	2.60	-55.55	3.01	-75.00	8.71	-67.81
$S_3N_2P_1K_2$	1.10	-58.34	1.90	-67.35	2.70	-77.67	5.70	-72.43
$S_3N_2P_2K_1$	1.14	-57.23	3.99	-31.72	6.15	-48.73	11.27	-45.60
$S_3N_2P_2K_2$	2.63	-0.61	6.09	2.29	4.64	-61.39	13.57	-39.98
$S_3N_3P_1K_1$	1.35	-49.77	2.47	-56.31	3.70	-69.34	7.53	-63.63
$S_3N_3P_1K_2$	0.44	-82.21	5.81	-0.59	3.40	-71.57	9.25	-53.52
$S_3N_3P_2K_1$	1.05	-60.51	2.83	-49.57	3.70	-69.15	6.73	-67.72
$S_3N_3P_2K_2$	4.73	79.08	3.92	-29.73	4.37	-63.38	13.04	-36.67
$S_4N_1P_1K_1$	1.10	40.98	2.12	-35.12	3.32	-51.37	7.81	-30.91
$S_4N_1P_1K_2$	0.67	-11.96	0.78	-76.56	1.52	-77.85	2.97	-73.38
$S_4N_2P_2K_1$	3.64	368.99	2.58	-22.40	5.00	-26.93	11.22	0.71
$S_4N_1P_2K_2$	0.72	-5.84	0.84	-76.52	1.86	-72.78	3.42	-69.58
$S_4N_2P_1K_1$	0.43	-45.38	1.28	-62.55	1.93	-71.80	3.64	-67.70
$S_4N_2P_1K_2$	0.44	-42.34	1.53	-56.30	2.46	-64.09	4.43	-60.70
$S_4N_2P_2K_1$	0.51	-35.05	1.36	-61.51	2.33	65.96	4.20	-62.43
$S_4N_2P_2K_2$	0.63	-17.94	0.77	-78.57	2.68	-60.80	4.08	-63.82
$S_4N_3P_1K_1$	0.53	-29.29	1.50	-58.63	1.20	-82.26	3.24	-71.06

Contd.

Table 1 contd.

Treatment	Late blight		Early blight		Leaf blotch		Multiple disease complex	
	Disease severity	Increase/ de Crease - over control (%)	Disease severity	Increase/ de Crease - over control (%)	Disease severity	Increase/ de Crease - over control (%)	Disease	Increase/ de Crease - over control (%)
$S_4N_3P_1K_2$	1.02	30.24	1.42	-59.28	1.33	-80.61	3.77	-66.27
$S_4N_3P_2K_1$	1.65	117.80	2.37	-30.98	1.67	-75.272	5.69	-49.02
$S_4N_3P_2K_2$	0.60	-24.97	0.94	-72.69	1.55	-77.20	3.08	-72.52
SEm(±)	**0.16**	**12.12**	**0.29**	**$^{-1}$1.70**	**0.23**	**2.22**	**0.44**	**2.76**
LSD(0.05)	**0.45**	**34.38**	**0.82**	**-33.19**	**0.65**	**6.29**	**1.25**	**7.83**

Note: $N_1=_{150}$, $N_2=_{200}$, $N_3=_{250}$ kg $ha^{-1}N$; $P_1=_{100}$, $P_2=_{125}$ $kgha^1$ P_2O_5; $K_1=_{100}$, $K_2=_{125}$ $kgha^{-1}$ K_2O
The NPK gradients in low soils (S_1) = 278.3:9.9:80.3, medium S_2 =290.1:22.9:97.0, moderate (S_3) = 301.8:26.6:213.5, and high (S_4) = 296.0:37.1:282.8

Table 2: Effect of different levels of NPK applied in various combinations to control foliar diseases of potato on tuber yield under different fertility gradient soils.

Treatment	No. of tuber plant^{-1}	% increased (+) or decreased (-) over control	Weight of tubers plant^{-1} (g)	increased/ decreased over control %	Yield t ha^{-1}	increased / decreased over control %
$S_1N_1P_1K_1$	4.33	45.80	183.33	100.93	14.67	218.41
$S_1N_1P_1K_2$	4.33	37.39	210.00	153.78	16.13	249.85
$S_1N_1P_2K_1$	8.00	162.68	441.67	395.19	19.60	325.17
$S_1N_1P_2K_2$	4.67	52.21	241.67	181.56	20.13	337.02
$S_1N_2P_1K_1$	5.00	82.62	350.00	299.07	17.60	281.51
$S_1N_2P_1K_2$	6.33	108.05	395.00	365.78	17.67	283.04
$S_1N_2P_2K_1$	4.67	47.65	183.33	113.35	15.57	235.40
$S_1N_2P_2K_2$	5.67	83.69	333.33	280.21	14.40	212.12
$S_1N_3P_1K_1$	6.33	123.65	366.67	320.70	13.13	184.87
$S_1N_3P_1K_2$	4.67	45.73	358.33	332.07	14.20	208.00
$S_1N_3P_2K_1$	5.00	71.58	375.00	335.56	18.80	307.82
$S_1N_3P_2K_2$	3.67	36.33	256.67	200.78	16.80	264.17
$S_2N_1P_1K_1$	8.33	101.78	341.67	183.43	14.27	212.78
$S_2N_1P_1K_2$	8.33	100.65	400.00	224.95	7.19	275.86
$S_2N_1P_2K_1$	7.67	87.40	341.67	184.50	20.53	346.96
$S_2N_1P_2K_2$	4.00	-0.65	350.00	191.49	18.87	308.48
$S_2N_2P_1K_1$	5.67	30.15	525.00	333.00	20.00	333.56
$S_2N_2P_1K_2$	6.33	53.55	533.33	342.89	17.67	283.94
$S_2N_2P_2K_1$	7.67	88.80	566.67	374.47	19.47	326.07
$S_2N_2P_2K_2$	7.67	92.04	425.00	251.71	21.00	356.73
$S_2N_3P_1K_1$	5.00	19.00	366.67	203.22	18.88	308.90
$S_2N_3P_1K_2$	6.00	46.88	535.00	343.17	18.80	311.20
$S_2N_3P_2K_1$	8.00	89.34	516.67	327.51	23.71	414.31
$S_2N_3P_2K_2$	8.00	74.38	491.67	310.72	25.40	353.69
$S_3N_1P_1K_1$	5.67	61.52	475.00	341.79	14.47	208.31
$S_3N_1P_1K_2$	4.00	1.36	485.33	221.58	16.07	248.71
$S_3N_1P_2K_1$	7.33	87.73	558.33	394.16	19.70	320.08
$S_3N_1P_2K_2$	8.67	129.85	461.67	306.12	20.09	328.61
$S_3N_2P_1K_1$	5.33	42.27	490.00	343.53	17.70	277.58
$S_3N_2P_1K_2$	7.00	96.97	433.33	384.16	17.61	275.33
$S_3N_2P_2K_1$	7.33	98.64	653.33	491.32	15.60	232.66
$S_3N_2P_2K_2$	9.00	164.40	516.67	362.70	14.37	205.86
$S_3N_3P_1K_1$	3.33	-8.64	428.33	195.44	13.20	181.48

Contd.

Table 2 contd.

Treatment	No. of tuber plant^{-1}	% increased (+) or decreased (-) over control	Weight of tubers plant^{-1} (g)	increased/ decreased over control %	Yield t ha^{-1}	increased / decreased over control %
$S_3N_3P_1K_2$	5.33	42.27	400.00	252.54	14.16	201.90
$S_3N_3P_2K_1$	7.00	88.18	525.00	366.79	18.80	300.90
$S_3N_3P_2K_2$	8.33	145.46	511.67	361.12	16.77	257.04
$S_4N_1P_1K_1$	5.00	-2.24	498.33	119.67	14.40	185.75
$S_4N_1P_1K_2$	6.67	20.26	543.33	138.38	17.21	239.34
$S_4N_2P_2K_1$	8.33	62.47	350.00	53.15	20.73	110.82
$S_4N_1P_2K_2$	5.67	7.47	400.00	77.30	18.93	273.78
$S_4N_2P_1K_1$	6.00	15.22	616.67	171.07	20.08	296.40
$S_4N_2P_1K_2$	6.00	15.22	611.67	169.16	17.67	247.47
$S_4N_2P_2K_1$	6.33	23.16	491.67	116.67	19.56	286.03
$S_4N_2P_2K_2$	6.33	18.49	641.67	182.97	21.00	317.56
$S_4N_3P_1K_1$	7.33	35.85	603.33	166.12	18.67	270.26
$S_4N_3P_1K_2$	5.00	-3.64	558.33	147.17	18.40	265.93
$S_4N_3P_2K_1$	4.33	$^{-1}$9.42	383.33	69.48	23.81	369.68
$S_4N_3P_2K_2$	10.67	109.92	661.60	182.38	25.07	398.50
SEm(±)	**1.31**	**335.19**	**59.19**	**53.22**	**0.39**	**9.96**
LSD(0.05)	**3.72**	**99.83**	**167.92**	**150.98**	**1.11**	**28.25**

Note: $N_1 =_{150}$, $N_2 =_{200}$, $N_3 =_{250}$ kg ha^{-1} N; $P_1 =_{100}$, $P_2 =_{125}$ kgha^{1} P_2O_5; $K_1 =_{100}$, $K_2 =_{125}$ kgha^{-1} K_2O
The NPK gradients in soils low (S_1) = 278.3:9.9:80.3, medium S_2 =290.1:22.9:97.0, moderate (S_3) = 301.8: 26.6: 213.5, and high (S_4) = 296.0:37.1:282.8

When all the foliar diseases were considered in aggregate the minimum disease was observed in different soil gradients as low (S_1) $N_{150}P_{100}K_{125}$ (8.39) statistically at par with $N_{250}P_{100}K_{100}$ (8.49). In medium (S_2) $N_{250}P_{100}K_{125}$ (6.94) followed by $N_{250}P_{125}K_{125}$ (7.03). In moderate (S_3) $N_{200}P_{100}K_{125}$ (5.70) followed by $N_{200}P_{100}K_{100}$ (6.71) and in high (S_4) gradient minimum disease severity was observed in $N_{150}P_{100}K_{125}$ (2.97) followed by $N_{250}P_{125}K_{125}$ (3.08). Similar trend was also observed in per cent reduction of disease severity in comparison to untreated control ($N_0P_0K_0$). In moderate (S_3) and high (S_4) gradient maximum reduction of disease severity was observed (7.50%) in every treatments irrespective of different N P and K levels.

Disease severity of wheat blight was reduced with increased level of K and N fertilizers (Devi *et al*., 2012). In case of late blight of potato the result confirmed the results of Mahapatra *et al*., 2011 who found that fertilizer treatment with higher concentrations of N and K increased susceptibility to leaf infection by *Phythophthorainfestans*.

Tuber yield

The effect of different levels of N P and K applied in different combinations to manage foliar diseases of potato grown under different fertility gradient soil condition also effect on the yield of potato tuber and yield parameters.

Number of tubers per plant

NPK interaction in different soil gradients showed that in low fertility gradient (S_1) maximum number of tubers per plant were obtained in $N_{150}P_{125}K_{100}$ (8.00) and minimum were in $N_{250}P_{125}K_{125}$ (3.67) where as in medium fertility gradient soil (S_2) maximum number of tubers per plant was obtained in $N_{150}P_{100}K_{100}$ (8.33), $N_{150}P_{100}K_{125}$ (8.33), $N_{250}P_{125}K_{100}$ (8.00) and $N_{250}P_{125}K_{125}$ (8.00) which are statistically at par with each other and minimum number was obtained in low (S_1) $N_{150}P_{100}K_{125}$ (4.00) (Table 2).

In moderate (S_3) gradient maximum tuber number was obtained in $N_{200}P_{125}K_{125}$ (9.00) *at par* with $N_{150}P_{125}K_{125}$ (8.67) and $N_{250}P_{125}K_{125}$(8.33). Minimum numbers were obtained in $N_{250}P_{100}K_{100}$ (3.3) which are statistically at par with $N_{150}P_{100}K_{125}$ (4.00) and $N_{250}P_{100}K_{125}$ (5.33) (Table 2). In high (S_4) gradient it was observed that $N_{250}P_{125}K_{125}$ produced maximum number of tubers per plant (10.67)

Weight of tubers

N P K interaction in different fertility gradients also showed the maximum tuber weight per plant was in $N_{150}P_{125}K_{100}$ in low (S_1) (441.67 g), $N_{200}P_{125}K_{100}$ in medium (S_2) (566.67g), $N_{200}P_{125}K_{125}$ in moderate (S_3) (653.33 g), $N_{250}P_{125}K_{125}$ in high (S4) (661.17g) gradient soil. Similar results were also observed in $N_{200}P_{125}K_{125}$, $N_{200}P_{125}K_{100}$, $N_{200}P_{100}K_{125}$ and $N_{250}P_{100}K_{100}$ in high (S4) gradient (Table 2).

Yield of tubers

Highest tuber yield was obtained in $N_{150}P_{125}K_{125}$ (20.13 t ha^{-1}) which was statistically *at par* with $N_{150}P_{125}K_{100}$ (19.60 t ha^{-1}), in low (S_1) gradient, $N_{250}P_{125}K_{125}$ (25.40 t ha^{-1}) followed by $N_{250}P_{125}K_{100}$ (23.71 t ha^{-1}), in medium (S_2) gradient; $N_{150}P_{125}K_{125}$ (20.09 t ha^{-1}) at par with $N_{150}P_{125}K_{100}$ (19.70 t ha^{-1}), in moderate (S_3) gradient; $N_{250}P_{125}K_{125}$ (25.07 t ha^{-1}), followed by $N_{250}P_{125}K_{100}$ (23.8 t ha^{-1}) in high (S_4) gradient soil. Whereas, minimum tuber yield was observed in $N_{250}P_{100}K_{100}$ (13.18 t ha^{-1}) in low and $N_{150}P_{100}K_{125}$ (7.19 t ha^{-1}) in medium; $N_{250}P_{100}K_{100}$ (13.20 t ha^{-1}) in moderate and $N_{150}P_{100}K_{100}$ (14.40 t ha^{-1}) in high gradient soil. So in low fertility gradient soil (S_1) minimum N (150 kg ha^{-1}) maximum P (125 kg ha^{-1}) whereas K has no response in increasing the tuber yield of potato. In medium fertility gradient (S_2) maximum N (250 kg ha^{-1}), maximum P (125 kg ha^{-1}) and maximum K (125 kg ha^{-1} increased, in moderate soil fertility gradient (S_3) minimum N (150 kg ha^{-1}) maximum P (125 kg ha^{-1}) and minimum K (100 kg ha^{-1}) and in high fertility gradient soil (S_4) maximum yield was obtained when the plots were treated with maximum N (250kg ha^{-1}) maximum P (125kg ha^{-1}) and maximum level of K (125 kg ha^{-1}) (Table 2). Mahapatra *et al*., 2011 also reported the similar results where optimum doses of N increases potato yield. However contradicts with low (S_1) and moderate (S_3) gradient soil where minimum N (150kg ha^{-1}) increased tuber yield and maximum N (250 kg ha^{-1}) significantly reduced tuber yield. Jaurez *et al*., 2000 reported that optimum N (160 kg ha^{-1}) increased the yield of tuber but doubling (220 kg ha^{-1}) did not increase the yield in absence of late blight. A modest increase in N application (135 kg ha^{-1}) increase in tuber yield and increase resistance when plants are exposed to *P. infestans* (Jin *et al*., 2014). The results revealed that the growth parameters and the yield attributing traits were significantly influenced by different planting dates and sources of nutrients in case of tomato (Singh *et al.*, 2015).

The above results therefore suggested that fertility levels of soil should be considered before application of N P and K for maximum yield and minimum disease to reduce the cost of plant protection and environment pollution. Among the four fertility status observed, minimum dose of N (150kg ha^{-1}) and K (100 kg ha^{-1}) applied in this experiment and maximum P (125kg ha^{-1}) in low (S_1), maximum N (250kg ha^{-1}), P and K (125kg ha^{-1} each) in medium (S_2), minimum N andK (150 kg ha^{-1}&100kg ha^{-1} respectively) and maximum P (125kg ha^{-1}) in moderate (S_3) and maximum N P K (250 kg ha^{-1}, 125kg ha^{-1} and 125kg ha^{-1} respectively) in high fertility (S_4) soil increased the tuber yield and reduced early blight, late blight and leaf blotch and multiple disease complex in eco-friendly disease management.

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