

CUMULATIVE AND RESIDUAL EFFECTS OF PHOSPHORUS AND ZINC NUTRIENTS UNDER GERANIUM– RICE (*ORYZA SATIVA*) CROPPING SEQUENCE

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Abstract: A field experiment was conducted at Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow to evaluate the cumulative and residual effects of phosphorus and zinc sources of nutrients under geranium– rice cropping sequence. The treatment involved three cropping system viz geranium paired sole, garlic sole and geranium paired + garlic, three level of phosphorus (0, 40 & 80 Kg P₂O₅/ha) and two levels of zinc (0 and 30 kg ZnSO₄/ha). Results revealed that application of Phosphorus at 40 Kg P₂O₅ ha⁻¹ proved significantly better than control (No Phosphorus) in respect of production of geranium oil and garlic bulbs, further application of 30 kg ZnSO₄ ha⁻¹ significant increased the herb and oil yields of the crop over the no zinc application (control). Residual effects of P and Zn on the grain yield of succeeding rice crop that geranium crop followed by rice, 40 Kg P₂O₅ ha⁻¹ was desirable, particularly in rabi crop season. However application of 30 Kg P₂O₅ ha⁻¹ and 25 kg ZnSO₄ ha⁻¹ to rice grown after geranium was more beneficial.

Keywords: Geranium-rice sequence, Phosphorus & Zinc sources & levels, Cumulative and residual effects

INTRODUCTION

Phosphorus and zinc fertilizers have a carry over effects on the succeeding crops. The utilization efficiency of applied phosphatic fertilizers seldom exceeds 15% by the first crop, but a substantial amount of them is left as residue for the next crop (Roy *et al.*, 1978 and Mahala *et al.*, 2006). Geranium - rice is one of the important cropping systems in northern Indian plains, where the poor tribal farming community is not using phosphorus. Hence it become necessary to findout some low-priced indigenous alternative. Further more, in the north Indian plains, rice is grown as a major food crop during Kharif season. In the rice growing belt of the north Indian plains, geranium and upland rice can be grown in sequential cropping system. The recommendation for phosphorus and zinc are made crop based. Such recommendation does not take into account the carry over effect of quantity of nutrient applied to the preceding crop. Hence, rice though in sequence after the geranium cropping is fertilized with full dose of P and Zn. It is, therefore, imperative to study the residual effect of P and Zn on the grain yield of succeeding rice crop and also to workout, the requirement of nutrient for this crop when grown in sequential cropping system. So far, no research work has been carried out to study the nutritional requirement of the geranium – rice based cropping systems, hence, the aim of the present study was to stabilize the production of geranium and garlic in intercropping system and also the succeeding upland rice crop of the geranium based cropping systems.

MATERIAL AND METHOD

The experiment was conducted during 1998-1999 at Central Institute of Medicinal and Aromatic Plants Lucknow. The soil was sandy loam in texture and alkaline (pH 8.3) in reaction. The nutrients in the 0-15 cm soil layer were; Low (168.9 kg ha⁻¹) in N (Subbiah and Asija, 1956), Medium (21.6 kg ha⁻¹) in P₂O₅ (Olsen *et al.*, 1954) and K₂O 82.7 kg ha⁻¹ (Jackson, 1967). The available Zn was 0.4 ppm, estimated by DTPA CaCl₂ TEA method. Three cropping systems (geranium paired sole, garlic sole and geranium paired + garlic), three levels of P (0, 40 and 80 kg P₂O₅ ha⁻¹) and two levels of zinc (0 and 30 kg Zn SO₄ ha⁻¹) were evaluate in experiment No. 2 during rabi season. The same layout was used to observe the residual and cumulative effects of the treatment on succeeding rice crop. An uniform dose of 120 kg. N and 60 kg. K₂O ha⁻¹ was applied to the paddy crop. Phosphorus and Zinc fertilizers were applied basally as per the treatment at the time of planting. The potassium fertilizer was also applied basally at the time of planting. Nitrogen was top dressed in three equal proportions at 20, 40 and 60 days after planting. The cumulative effect was examined over the direct application of P (0, 30 and 60 kg P₂O₅ ha⁻¹) and Zn (0 and 25 kg ZnSO₄ ha⁻¹) were evaluated in a factorial randomized block design with three applications. The seeds of the variety pant – 12 were obtained from G.B. Pant University of Agriculture and technology Pantnagar. 25 days old seedlings were transplanted at a spacing of 20 × 10 cm using 2-3 seedlings per hill on 2 July 1999 and harvested at 100 days after transplanting. Observation on yield attribute and yield were recorded.

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RESULT AND DISCUSSION

Effect on geranium and garlic

Herb and oil yield of Main Crop

The first harvest, the decrease in the oil yield of geranium intercrop combination was about 7.6% in comparison to paired sole crop of geranium. (Table-1)

The herb and oil yields of geranium recorded from first, second and total of both harvests were significantly increased due to 40 kg P₂O₅ ha⁻¹ over control. Further increase in phosphorus level did not influence the herb yield of the crop significantly. Application of 30 kg ZnSO₄ ha⁻¹ significantly increased in the herb and oil yield over control. A significant response to application of Zn was also observed by Armungam and Kumar (1979) in geranium (Singh *et al.*, 2012 & Singh *et al.*, 2014).

Intercrop Productivity

Diameter and weight per bulb were significantly improved with sole crop than the intercropped garlic; where as number of cloves per bulb were not influenced significantly. The bulb yield of garlic sole was increased by almost two times than the bulb yield of intercrop garlic (Table-2). This reduction in yield of intercrop may be due to low plant population in the mixture. The diameter per bulb and weight per bulb was enhanced up to 80Kg P₂O₅ ha⁻¹ indicating that garlic is quite responsive crop to phosphorus fertilizer. Similar findings of higher rates of P application for enhancing garlic bulb yield have been reported by several workers, Wankhade *et al* (1996), Singh *et al.*, 2012 & Singh *et al.* 2014. Panchal *et al.*, (1992) observed the largest bulb diameter (3.67 cm) with highest bulb yield of 7.9t ha⁻¹ in garlic by receiving a does of 100 kg N+50 kg P₂O₅+50 kg K₂O ha⁻¹. Higher rates of P application helped in improving the diameter of bulb and percentage of 'A' grade garlic. Singh *et al.*; (2000) also reported a does of 75 P₂O₅ ha⁻¹ for the better survival of seedling and increase weight per bulb in garlic as compared to control and higher/or lower levels of P. Cloves per bulb and weight per bulb in garlic were improved with 30 kg ZnSO₄ ha⁻¹ over control. Higher doses of Zinc (5 kg ZnCl₂ ha⁻¹) increased the number of leaves, weight of bulb and yield of garlic under subtropical condition of the north Indian plains (Phor *et al.*; 1995). Jawaharlal *et al* (1986) increased bulb yield in garlic with Zn application also reported.

Cumulative and residual effect of P and Zn in rice

Effect of P on yield attributes and yield in rice

Rice crop grown in the field plots after the harvest of geranium sole as well as intercropped geranium did not differ significantly in yield attributing characters. However, the application of P at 30(40) kg P₂O₅ ha⁻¹ and Zinc at 25(30) kg ZnSO₄ ha⁻¹ showed an improvement both in development of panicles and grain. In the cumulative effect, the P levels were

added both to geranium and rice crops. The significant differences in the yield attributes of rice at lower doses of P were mainly because of the residual effect of P applied (40 Kg P₂O₅ ha⁻¹) to previous crop of geranium. But higher doses of P applied to rice directly did not contribute significantly with respect to yield attributes. It is interesting to note that the grain weight per panicle of rice was observed significant at 60(80) kg P₂O₅ ha⁻¹ which was applied to rice crop directly in the plots of previous crop fertilized with 80 kg P₂O₅ ha⁻¹ (Table-3). As a result, the grain yield was found to be significant in the residual fertility soil status. This implies that the added fertilizer to the preceding geranium crop continued to have marginal residual effects in the succeeding rice crop. Present findings are supported by the observation made by other workers in food crops (Dev and Mistry, 1979, Wichmann, 1979, Mahala *et al.*, 2006 and Singh and Singh 2006). Dang *et al* (1989) observed the residual effect of P in wheat - rice system and they found that P at 26.4 kg P₂O₅ ha⁻¹ in wheat increase the yield of wheat (674 kg ha⁻¹) as well as the yield of succeeding rice (712 kg ha⁻¹). P at the rate of 26.4 Kg ha⁻¹ used in rice also increased the yield of when the preceding wheat receiving no application, but up to 13.2 kg P ha⁻¹ only when the preceding wheat received only 13.2 kg P ha⁻¹. Rathi and Yadav (1992) also reported that residual effect of P applied to pigeon pea crop was positive on grain yield of wheat. It is clear from the findings that the yield of rice grains under residual fertility status of P at 80 kg P₂O₅ ha⁻¹ supplied to geranium was almost equal to the yield of rice grain recorded with 30 kg P₂O₅ ha⁻¹ applied in the plot of 40 kg P₂O₅ ha⁻¹ received by previous crop of geranium. Therefore, it follows from the results that geranium crop followed by rice, 40 kg P₂O₅ ha⁻¹ is desirable particularly in Rabi crop season. But to grow rice after geranium 30 kg P₂O₅ ha⁻¹ is suggested (Table-4). On the other hand we can say that neither the higher doses of P (80 kg P₂O₅ ha⁻¹) are required neither to geranium nor to rice (60 kg P₂O₅ ha⁻¹)

Effect of Zn on yield attributes and yield in rice

Application of 25Kg ZnSO₄ ha⁻¹ influenced significantly the yield attributing characters and grain yield on cumulative and residual soil fertility status. The requirement of Zinc for rabi crop of geranium is 30 Kg ZnSO₄ ha⁻¹ and the rice crop grown in sequence after geranium is 25Kg ZnSO₄ ha⁻¹. It has been observed that soi application of ZnSO₄ at 20 Kg ha⁻¹ to rice improve the grain yield in wheat (Prasad and Umar, 1993). Higher levels of P with Zinc may decrease the availability of Zn to the plants. Several workers have reported the P induced zinc deficiency in agricultural crop (Takkar 1989).

CONCLUSION

It may be inferred from these experiment that the results of residual effects of P and Zn on the grain yield of succeeding rice crop that geranium crop

followed by rice, 40 kg P₂O₅ ha⁻¹ is desirable, particularly in rabi crop season. But to grow rice after geranium 30 kg P₂O₅ ha⁻¹ and 25 kg ZnSO₄ ha⁻¹ is suggested.

Table 1. Fresh biomass and oil yields of geranium as influenced by different cropping systems and rates of phosphorus and zinc

Treatment	Biomass yield (q ha ⁻¹) at			Oil yield (kg ha ⁻¹) at		
	I st harvest	II nd harvest	Total	I st harvest	II nd harvest	Total
Cropping System						
Geranium paired sole (40/80 cm)	236.92	152.50	389.92	48.72	32.98	81.73
Garlic sole (20×10cm)	-	-	-	-	-	-
Geranium paired (40/80 cm) + Garlic	217.77	140.40	358.15	44.98	30.37	75.35
SEm	5.98	4.30	9.72	1.19	0.82	2.02
CD at 5%	17.54	NS	28.50	3.49	2.40	5.92
Phosphorus levels (Kg P₂O₅ ha⁻¹)						
0	194.57	123.05	317.62	40.33	27.05	67.38
40	237.81	153.18	391.00	49.05	33.7	82.75
80	249.66	163.08	412.75	51.17	34.28	85.5
SEm	7.32	5.28	11.90	1.46	1.00	2.47
CD at 5%	21.48	15.48	34.92	4.28	2.94	7.25
Zinc levels (kg ZnSO₄ ha⁻¹)						
0	214.23	137.42	351.65	44.30	29.72	74.00
30	240.46	155.45	395.90	49.40	33.63	83.08
SEm	5.98	4.31	9.72	1.19	0.82	2.02
CD at 5%	17.54	12.64	28.51	3.49	2.40	5.92

NS= Non significant

Table 2. Yield attributes & Bulb yield of garlic at harvest as influenced by different cropping systems and rates of phosphorus and zinc

Treatment	Diameter/bulb (cm)	No. of Cloves/bulb	Weight/bulb (gram)	Bulb yield (q ha ⁻¹)
Cropping System				
Geranium paired sole (40/80 cm)	4.55	15.82	32.11	122.24
Garlic sole (20×10cm)	-	-	-	-
Geranium paired (40/80 cm)+ Garlic	3.79	15.50	26.00	56.27
SEm	0.11	0.46	0.80	2.56
CD at 5%	0.33	NS	2.34	7.27
Phosphorus levels (kg P₂O₅ ha⁻¹)				
0	3.90	12.97	22.17	80.02
40	4.19	16.18	29.5	90.78
80	4.42	17.83	35.50	96.96
SEm	0.14	0.57	0.98	3.14
CD at 5%	0.40	1.66	2.86	8.91
Zinc levels (kg ZnSO₄ ha⁻¹)				
0	4.06	14.61	26.61	85.45
30	4.28	16.71	31.50	93.05
SEm	0.11	0.46	0.80	2.56
CD at 5%	NS	1.35	2.34	7.27

NS= Non significant

Table 3. Yield attributes of rice as influenced by cumulative and residual effect of P and Zn under different cropping systems

Treatment	Cumulative						Residual					
	No. of panicles /m ²	Length of panicle (cm)	No. of rachilla/ panicle	No. of grains/ panicle	grain weight/ panicle (g)	1000 grain weight (g)	No. of panicles /m ²	Length of panicle (cm)	No. of rachilla/ panicle	No. of grains/ panicle	grain weight/ panicle (g)	1000 grain weight (g)
Cropping System												
Geranium paired sole (40/80 cm)	240.78	26.76	13.47	176.19	4.92	32.06	226.28	25.94	12.93	160.86	4.79	31.67
Garlic Sole (20×10 cm)	249.00	26.74	13.38	175.91	4.94	31.83	223.78	26.13	13.03	168.56	4.63	31.06
Geranium paired (40/80 cm)+ Garlic	240.89	26.65	13.13	163.45	4.54	31.95	227.45	25.49	12.88	158.15	4.37	31.05
SEm	5.98	0.77	0.43	5.66	0.12	0.67	5.15	0.70	0.31	4.32	0.13	0.94
CD at 5%	NS	NS	NS	NS	0.34	NS	NS	NS	NS	NS	0.37	NS
Phosphorus levels (kg P₂O₅ ha⁻¹)												
0 (0)	226.33	25.89	12.65	155.23	4.32	30.33	216.67	24.83	12.57	149.10	4.17	29.78
30 (40)	246.67	26.75	13.44	175.45	4.82	32.45	224.17	26.10	13.03	162.96	4.61	31.44
60 (80)	257.67	27.51	13.88	184.87	5.27	33.06	236.67	26.62	13.24	175.52	5.01	32.56
SEm	5.98	0.77	0.43	5.66	0.12	0.67	5.15	0.70	0.31	4.32	0.13	0.94
CD at 5%	17.24	NS	NS	16.30	0.34	1.94	14.80	NS	NS	12.44	0.37	2.69
Zinc levels (kg ZnSO₄ ha⁻¹)												
0 (0)	231.44	26.13	12.90	160.82	4.39	30.89	216.93	25.13	12.62	154.04	4.31	30.37
25 (30)	255.67	27.30	13.75	182.89	5.22	33.00	234.74	26.58	13.28	171.01	4.89	32.15
SEm	4.89	0.63	0.35	4.62	0.10	0.55	4.20	0.57	0.25	3.53	0.10	0.76
CD at 5%	14.07	NS	NS	13.31	0.28	1.58	12.10	NS	NS	10.15	0.30	NS

Table 4. Yield of rice (q ha⁻¹) as influenced by cumulative and residual effect of P and Zn under different cropping systems

Treatment	Cumulative		Residual	
	Grain Yield	Straw yield	Grain Yield	Straw yield
Cropping System				
Geranium paired sole (40/80 cm)	49.09	60.87	44.32	56.85
Garlic Sole (20×10 cm)	53.88	66.54	45.10	58.17
Geranium paired (40/80 cm) + Garlic	47.14	59.52	41.88	53.72
SEm	1.39	1.73	1.00	1.45
CD at 5%	4.00	5.00	2.89	4.19
Phosphorus levels (kg P₂O₅ ha⁻¹)				
0 (0)	42.17	58.33	38.85	54.67
30 (40)	51.57	64.08	43.28	55.56
60 (80)	56.36	64.51	49.16	58.52
SEm	1.39	1.73	1.00	1.45
CD at 5%	4.00	5.00	2.89	NS
Zinc levels (kg ZnSO₄ ha⁻¹)				
0 (0)	44.46	60.19	40.41	55.87
25 (30)	55.61	64.43	47.12	56.63
SEm	1.13	1.41	0.82	1.18
CD at 5%	3.27	4.08	2.37	NS

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