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Pyrites and Phosphate Application on Some Soil Characteristics, Grain Yield and Mineral Composition of Gram Cultivar C 235 under Calcareous Saline Alkali Soil

K PRASAD, R B SINHA and B P SINGH
Department of Soil Science and Agricultural Chemistry
College of Agriculture, Rajendra Agricultural University, Pusa, Samastipur

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Soil chemical analysis data revealed that pyrites (constituting 23% S, 21% Fe and 0.025% Zn) application resulted in sharp decrease in *p*H, EC but marked increase in the available forms of P, K, Fe and Zn. Application of 2.5 tonnes pyrites + 60 kg P_2O_5/ha increased the grain yield while that of 3.5 tonnes pyrites + 60 kg P_2O_5/ha resulted in luxuriant vegetative growth, poor flowering, flower shedding and pod setting, and ultimately poor grain yield. The chemical analysis of grain showed a significant increase in P, K, Zn and Fe contents. The phosphate application indicated antagonism on Zn content of grain. Increase in K content of grain was observed up to 1.5 tonnes pyrites + 60 kg P_2O_5/ha while Ca and Mg content declined. Increase in Ca content of grain reduced the Mg content.

Key Words: Pyrites, Calcareous saline alkali soil, Amendment, Mineral composition, Interaction

Introduction

Legume cultivation has been a problem in vast area of calcareous saline alkali soils. Several ameleorative methods have been suggested for the improvement of these soils, but low grade pyrites (FeS_2) have generally been more effective. Pyrites proved to be a suitable amendment for such soils (Sinha 74-75; Singh 73-74).

In these soils phosphate availability is generally poor because of its fixation due to high amount of free $CaCO_3$ content and high *p*H. Phosphorus plays a key role and controls the efficient utilization of most of the other nutrients in plants.

Generally, it is seen that pulses, especially gram, a non-salt tolerant crop, does not thrive well in these soils. The present investigation was planned to explore the possibility of a device to increase gram yields.

Materials and Methods

Field experiments were carried out in rabi seasons of 1978–79 and 1979–80 on gram cultivar C 235 at Agricultural Research Institute Dholi, Muzaffarpur (Bihar). The physico-chemical properties of the soil of experimental plot area presented in table 1. Standard procedures were followed for soil analysis and available zinc and iron were estimated as described by Lindsay and Norvell (1978). The treatments consisted of four levels, viz. 0, 1.5, 2.5 and 3.5 tonnes/ha of low grade pyrites (containing 23, 21 and 0.025% total S, Fe and Zn respectively) and three levels, viz. 0, 30 and 60 kg P_2O_5/ha of single superphosphate in all possible combinations. These treatments were replicated three times in a randomised block design. The pyrites were applied one month before sowing. P_2O_5 was applied as per treatment at sowing. Each individual plot received a basal application of N and K_2O @ 20 and 40 kg/ha respectively and thoroughly mixed into the soil. Only one irrigation was given before flowering to the crop. The crop was harvested at full maturity and grain yield was recorded. The grain samples were drawn

Table 1 *Physico-chemical characteristics of the initial soils*

	Year	
	1978–79	1979–80
*p*H	8.8	9.1
EC (mmhos/cm)	0.35	0.38
OC (%)	0.47	0.59
Free $CaCO_3$ (%)	27.5	30.2
Available P_2O_5 (kg/ha)	16.8	10.7
Available K_2O (kg/ha)	168.8	155.2
Exchangeable Mg (meg/100g)	3.1	2.9
Exchangeable Na (meg/100g)	2.9	3.1
Exchangeable Ca (meg/100g)	8.6	9.0
Available Fe (ppm)	4.7	4.5
Available Zn (ppm)	0.43	0.42

from individual plots washed in acidified water and distilled water. The samples were dried in an oven maintained at 67°C and pulverised in a waring blender with stainless steel blades. Samples were digested in triacid mixture in the ratio of 10:4:1 = $HNO_3 : HClO_4 : H_2SO_4$. Phosphorus, K, Ca and Mg were determined as described by Jackson (1967) and Zn & Fe by atomic absorption spectrophotometer Model (AA 120). Nitrogen content in grain was determined by modified Kjeldahl method. Soil samples were collected from individual plots at sowing and after crop harvest. The composite soil samples were analysed for physico-chemical characteristics as given in tables 2 and 3.

Results and Discussion

Physico-chemical Characteristics of the Soil

The data indicate that different doses of pyrites had effectively influenced some of the soil characteristics (table 1). A marked decrease in *p*H and EC was noted due to pyrites application. A reduction of 0.6 *p*H units in both the years of investigations was noted. Dixit (1976) had reported reduction in *p*H due to pyrites additions within one month by 0.5 to 2.0 units. The available P_2O_5 content increased by pyrites application.

Visual Observations

In the control plots where no pyrites and phosphate were applied the germination was poor and seedlings were weak and stunted. With advancement in age, yellowing of the younger leaves and marginal edge firing as well as purple coloration were observed in older leaves indicating nutrient deficiencies. Pyrites and phosphorus-treated plots on the contrary had a better germination and

Table 2 *Effect on some of the soil characteristics after one month of pyrites application*

Treatment	pH		EC (mmhos/cm)		OC (%		P_2O_5 (kg/ha)		K_2O (kg/ha)		Zn (ppm)		Fe (ppm)	
	1978–79	1979–80	1978–79	1979–80	1978–79	1979–80	1978–79	1979–80	1978–79	1979–80	1978–79	1979–80	1978–79	1979–80
PY_0	8.7	8.9	0.37	0.47	0.48	0.50	16.5	14.8	178.0	169.5	0.55	0.52	4.5	5.3
PY_1	8.4	8.5	0.32	0.41	0.49	0.51	20.4	19.0	189.7	183.2	0.72	0.69	7.9	8.0
PY_2	8.3	8.4	0.28	0.36	0.49	0.51	25.0	24.0	192.8	190.1	0.78	0.74	8.3	8.4
PY_3	8.2	8.3	0.26	0.31	0.50	0.52	26.2	25.9	193.9	192.9	0.93	0.87	9.8	9 9

Table 3 *Influence of pyrites and phosphate application on some physico-chemical characteristics of the calcareous saline alkali soil after harvest of gram*

Treatments	pH		EC (mmhos/cm)		OC (%)		Avail. P_2O_5 (kg P_2O_5/ha)		Avail. K_2O (kg K_2O/ha)		DTPA-ext. Zn (ppm)		DTPA-ext. Fe (ppm)	
	1978–79	1979–80	1978–79	1979–80	1978–79	1979–80	1978–79	1979–80	1978–79	1979–80	1978–79	1979–80	1978–79	1979–80
PY_0+P_1	8.7	8.9	0.36	0.46	0.48	0.50	16.6	15.0	171.2	160.8	0.53	0.50	4.2	5.0
PY_0+P_2	8.6	8.8	0.35	0.43	0.50	0.52	18.2	17.2	172.8	162.7	0.54	0.52	4.1	5.0
PY_0+P_3	8.6	8.7	0.35	0.44	0.50	0.52	20.6	19.2	172.0	163.0	0.54	0.52	4.1	4.9
PY_1+P_1	8.4	8.5	0.30	0.38	0.52	0.52	23.8	21.5	183.2	176.8	0.63	0.66	6.8	7.6
PY_1+P_2	8.4	8.5	0.31	0.37	0.52	0.53	25.4	24.8	186.7	177.5	0.65	0.68	6.7	7.2
PY_1+P_3	8.3	8.4	0.31	0.37	0.53	0.53	29.8	28.0	188.0	178.9	0.67	0.68	6.4	7.0
PY_2+P_1	8.3	8.4	0.26	0.34	0.53	0.54	27.7	26.9	188.7	184.6	0.67	0.69	8.1	8.1
PY_2+P_2	8.3	8.4	0.26	0.34	0.54	0.54	29.4	28.4	188.9	185.0	0.68	0.69	8.0	8.2
PY_2+P_3	8.2	8.3	0.26	0.33	0.54	0.54	32.0	31.4	191.2	186.3	0.68	0.70	7.8	8.0
PY_3+P_1	8.2	8.3	0.25	0.27	0.55	0.54	28.8	27.9	188.7	187.4	0.67	0.68	8.8	8.5
PY_3+P_2	8.2	8.3	0.25	0.26	0.55	0.54	31.7	30.8	188.0	187.0	0.69	0.71	9.2	8.4
PY_3+P_3	8.2	8.3	0.24	0.26	0.55	0.54	33.2	32.7	191.2	189.3	0.69	0.72	9.0	8.2

PY = Pyrites; PY_0 = No Pyrites; PY_1 = 1.5 tonnes pyrites/ha; PY_2 = 2.5 tonnes pyrites/ha; PY_3 = 3.5 tonnes pyrites/ha;
P = Phosphate; P_1 = No phosphate; P_2 = 30 kg P_2O_5/ha; P_3 = 60 kg P_2O_5/ha

good vegetative growth. Application of 2.5 tonnes pyrites + 60 kg P_2O_5/ha resulted in maximum flowering and pod setting whereas 3.5 tonnes pyrites + 60 kg P_2O_5/ha level exhibited luxuriant vegetative growth, but poor flowering, shedding and pod setting.

Grain Yield

The grain yield data are given in table 4. Both pyrites and phosphate applications individually as well as in combination effectively influenced the grain yield in both the years. Application up to 2.5 tonnes pyrites resulted in a significant increase in grain yield but further increase in the application of pyrites decreased the yield. The beneficial effect of pyrites might be due to a sharp decrease in *p*H, EC and an increase in available plant nutrients (table 5). Sinha (unpublished) found an increase of 36.5% in grain yield of gram by pyrites application in calcareous—sodic soils. At higher levels of pyrites application the reduction in yield might be associated with luxuriant vegetative growth, poor flowering, shedding and pod setting as observed visually. Our findings are similar to those reported by Verma and Kumari (1978) and Sinha (1977).

The interaction effect between pyrites and phosphate levels was highly significant. Application of 2.5 tonnes pyrites with 60 kg P_2O_5/ha yielded 2200 and 1830 kg grain/ha in 1978–79 and 1979–80 respectively, which proved statistically superior to all the other combinations.

Mineral Composition of Grain

The mineral composition of grain with respect to N, P, Fe and Zn contents is presented in table 5 while K, Ca and Mg values are depicted in figure 1. P content of the grain was effectively influenced by the application of pyrites and phosphate levels in both the years of the study. A significant increase in its content was obtained with 2.5 tonnes/ha pyrites application while at 3.5 tonnes/ha level P content in grain decreased significantly. In case of phos-

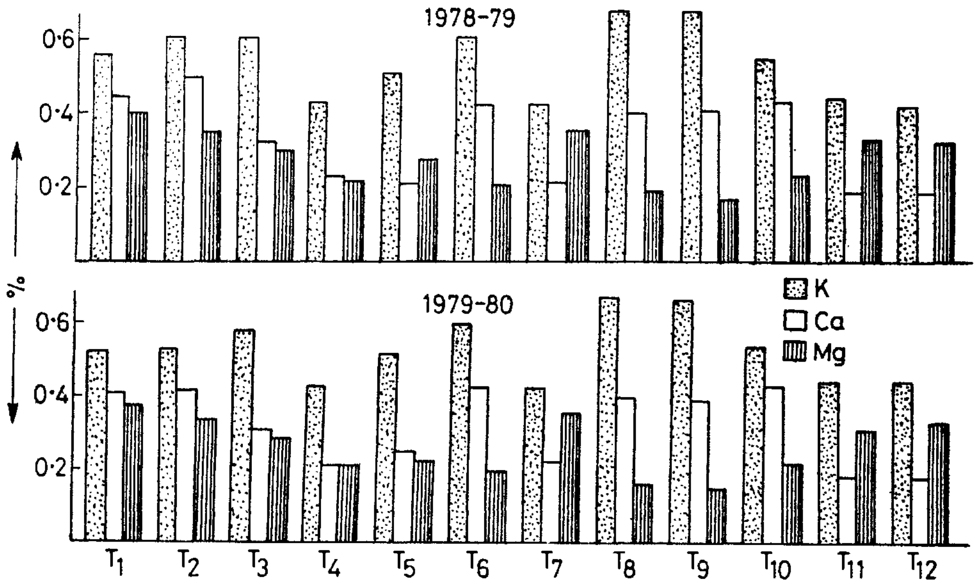

Figure 1 K, Ca and Mg content of grain in different treatments

Table 5 *Influence of pyrites and phosphate application on mineral composition of grain*

PY level	N content (%)								P content (%)							
	1978–79				1979–80				1978–79				1979–80			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
PY_0	2.8	3.0	3.3	3.0	2.6	2.8	3.1	2.8	.29	.33	.38	.33	.27	.31	.37	.32
PY_1	3.0	3.4	3.4	3.3	2.9	3.2	3.4	3.2	.32	.37	.40	.36	.31	.37	.39	.36
PY_2	3.3	3.5	3.8	3.5	3.2	3.4	3.6	3.4	.34	.40	.42	.39	.33	.41	.42	.39
PY_3	3.4	3.6	3.5	3.5	3.3	3.6	3.6	3.5	.33	.39	.41	.38	.32	.39	.40	.37
Mean	3.1	3.4	3.5		3.0	3.3	3.4		.32	.37	.40		.31	.37	.40	
	C D at 5%								C D at 5%							
PY	0.15				0.14				0.03				0.01			
P	0.13				0.12				0.02				0.01			
PY×P	NS				NS				NS				0.02			

Table 5 *(Contd.)*

PY level	Zn content (ppm)								Fe content (ppm)							
	1978–79				1979–80				1978–79				1979–80			
	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean	P_1	P_2	P_3	Mean
PY_0	19.6	18.8	18.0	18.8	19.0	18.4	17.2	18.2	82.7	83.6	85.0	83.7	77.5	78.6	80.0	78.7
PY_1	28.5	24.5	23.8	25.6	28.0	23.8	23.0	24.9	94.5	95.0	95.6	95.0	89.0	90.0	90.6	89.9
PY_2	31.7	27.9	25.8	28.5	31.2	27.3	25.2	27.9	96.8	97.4	97.2	97.1	92.0	93.2	92.6	92.6
PY_3	30.9	27.2	23.8	27.3	30.2	26.8	24.0	27.0	98.0	97.6	98.2	97.9	93.0	92.6	93.2	92.3
Mean	27.7	24.6	22.8		27.1	24.1	22.3		93.0	93.4	94.0		87.9	88.6	89.1	
	C D at 5%								C D at 5%							
PY	0.75				0.67				1.8				2.2			
P	0.87				0.77				NS				NS			
PY×P	1.50				1.34				NS				NS			

PY = pyrites; PY_0 = No pyrites; PY_1 = 1.5 tonnes pyrites/ha; PY_2 = 2.5 tonnes pyrites/ha; PY_3 = 3.5 tonnes pyrites/ha;
P = Phosphate; P_1 = No phosphate; P_2 = 30 kg P_2O_5/ha; P_3 = 60 kg P_2O_5/ha

Table 4 *Influence of pyrites and phosphate application on grain yield (kg/ha)*

Pyrites level (tonnes/ha)	1978–79 P_2O_5 level (kg/ha)				1979–80 P_2O_5 level (kg/ha)			
	0.0	30.0	60.0	Mean	0.0	30.0	60.0	Mean
0.0	825	1015	1090	977	720	850	910	827
1.5	1635	2105	2155	1965	1395	1760	1800	1652
2.5	1680	2160	2200	2013	1430	1795	1830	1685
3.5	1650	2100	2150	1967	1415	1780	1800	1665
Mean	1448	1845	1899		1240	1546	1585	
C.D. at 5% for pyrites			18.48			19.65		
C.D. at 5% for P_2O_5			16.13			17.16		
C.D. at 5% for pyrites × P_2O_5			30.7			31.25		

phate application, P content of the grain distinctly increased up to its maximum level of application. The interaction effects between pyrites and phosphate on P contents in grain revealed that although P content exhibited an increasing though statistically non-significant trend in 1978–79, it increased significantly in 1979–80. The increase in P content might be associated with dilution effect due to increased grain yield in the first year. Similar findings were also reported by Hulagur et al. (1975), and Shukla and Singh (1979).

N content of grain progressively increased with pyrites applications up to 2.5 tonnes/ha level and above this a significant decreasing trend was noted while phosphate applications influenced the N content significantly up to its maximum level of application (60 kg P_2O_5/ha). Desai and Khanvilkar (1977) also reported improvement in protein content of Bengal gram with P application. Interaction P × pyrites was not significant on N content.

Both the pyrites and phosphate application as well as their interaction effects on Zn content were found significant in this study. A gradual rise in Zn contents was obtained up to 2.5 tonnes/ha pyrites application but above this level Zn content decreased appreciably.

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