Kasetsart J. (Nat. Sci.) 27: 480-483 (2536)

Agronomic Effectiveness of Calcined Phosphate (Phospal-34) on Maize (*Zea mays* L.)

Piya Duangpatra, Paiboon Prabuddham and Chairerk Suwannarat[1]

ABSTRACT

A field experiment was conducted to evaluate the relative effectiveness of calcined phosphate, Phospal-34 (PP-34), on growth and yield of corn. Fertilizer treatments assessed comprised application of P fertilizers from various combination of Diammonium phosphate (DAP) and PP-34. Corn was grown on a loamy soil and the weights of dry stover, grain yield and P concentrations in plant were measured.

Corn grown on loamy soil showed substantial responses to N, P and K fertilizers. Mixed fertilizers containing PP-34 and DAP as P materials at various proportions were as effective as PP-34-free mixed fertilizers. Moreover, mixed fertilizers containing P from both PP-34 and DAP tended to be superior to mixed fertilizers containing P solely from PP-34. Based on the results of this experiment, it was apparent that mixed fertilizer containing 44% and 56% of total available P derived from PP-34 and DAP, respectively was the best formulation for maize.

Keywords : agronomic effectiveness, calcined phosphate, Phospal-34, *Zea mays* L.

INTRODUCTION

Fertilizers used for corn in Thailand were largely in mixed forms. They were primarily of grades 16-20-0 and 20-20-0 for fine textured soils and 15-15-15 for coarse-textured soils (Division of Soil Science, 1979). Except Ammosul, most of these fertilizers are produced from ammonium phosphate sulfate (APS), ammonium phosphate-based materials and nitric phosphates. In Thailand so far, no calcined phosphate fertilizer has been used for corn neither directly nor as the P material in mixed fertilizers. Most of the soils under corn are acidic and the relatively high effectiveness of some calcined phosphate fertilizers such as Calciphos and Phospal-34 (PP-34) for various field crops in acid soils (Doak *et al.*, 1965; Buchan *et al.*, 1970; Singh, 1983; Quillon, undated; Anonymous, undated; Meesook *et al.*, 1983/1984; Kitichaichayanont, 1992). A question arises as to what are the potential of these materials when directly applied to soil and when used as phosphorus ingredients for the formulation of mixed fertilizers.

This investigation was attempted to assess the relative effectiveness of calcined phosphate fertilizer, PP-34, on the growth, yield and phosphorus uptake of corn grown on loamy acid soil. The studies covered the impact on corn of this calcined phosphate when used either directly or in combination with diammonium phosphate (DAP) at various proportion.

METERIALS AND METHODS

During the rainy season 1986, a field experiment on corn was set up in a farmer's field in Nakon Rachasima province, Northeast Thailand. Soil at the site has been classified as Warin soil series, some important characteristics of which are presented in Table 1. The experimental design was a randomized complete block with 10 treatments and 5 replications. The treatments comprised of an unfertilized treatment (control or check), a phosphorus checked treatment and 8 other treatments with various sources of P fertilizers as shown below.

The plot for each treatment measured 4m. x 8m. within which three corn plants per hill were grown at 50cm. x 80cm. spacing. All fertilizers were applied by broadcasting and incorporating into the soil one day prior to planting. At maturity, measurements were made on dry stover weight, grain yield at 14 percent moisture content and phosphorus concentrations in ear-leaf, in stover and in grain.

1 Dept. of Soils, Faurlty of Agaicerlture. Kasetsart University, Bangkok 10900, Thailand.

Trt. No	Fertilizer rate ($N-P_2O_5-K_2O$, kg/ha)	Source of fertilizer[1] N	P	K	Available Pderived from PP-34 (%)[2]
1	0-0-0	-	-	-	-
2	75-0-37.5	AS	-	MOP	-
3	75-75-37.5	AS	DAP	MOP	-
4	"	AS	DAP+PP-34	MOP	10
5	"	AS	DAP+PP-34	MOP	44
6	"	AS	PP-34	MOP	100
7	75-75-75	Mixed fert. grade15-15-15			-
8	"	AS	DAP+PP-34	MOP	18
9	75-94-47	<APS(16-20-0)>		MOP	-
10	"	AS	DAP+PP-34	MOP	25

[1] AS = Ammosul, DAP = diammonium phosphate, PP-34 = Phospal-34, MOP = muriate of potash, APS = ammonium phosphate sulfate

[2] Available P derived from PP-34 was calculated basing on Julie reagent-soluble P content.

RESULTS

Dry stover at maturity

Even though the difference in weight of dry stover was not statistically significant, P-treated corn plants generally outweighed P-checked plant (Table 3). Considering the impacts of P sources, it was evident that mixing PP-34 with DAP gave higher weights of dry stover than using either sole PP-34 or sole DAP. As shown in Table 3, mixing 10% PP-34 with 90% DAP and 44% PP-34 with 56% DAP produced 3,021 and 2,969 kg/ha of dry stover, respectively. Moreover, the combination of 25% PP-34 with 75% DAP (treatment no.10) also outweighed APS-treated plant (treatment no.9) (Table 2). Nevertheless, corn treated with P derived from the mixed fertilizer grade 15-15-15 gave higher dry stover weight than that treated with P derived from 82% DAP+ 18% PP-34. The overall results seemed to demonstrate the merit of PP-34 as a source of P in combination with P derived from DAP on increasing dry matter of maize.

Grain yield

Corn grown on Warin soil series showed marked response to added phosphorus (Table 3). Apparently, this was attributed to the fact that this soil was fairly unfertile containing only 1% organic matter and 4 ppm available P (Table 1). Concerning the impact of each P source and P source combinations, it was evident that sole PP-34 gave higher grain yield (1,901 kg/ha) than those of sole DAP and 10% PP-34 + 90% DAP (Table 2 and 3). Besides, the combination of 44% PP-34 + 56% DAP obviously produced the highest grain yield (2,485 kg/ha). Nevertheless, it was observed that corn plants treated with 18% PP-34 + DAP and 25% PP-34 + DAP gave lower grain yields than those treated with P derived from mixed fertilizer grade 15-15-15 and APS (Table 2). Regardless of P sources and NPK rates, grain yields of corn as affected by fertilizer P deriving from DAP in combination with PP-34 were increased as PP-34 contents in the mixture were increased from nil to 10, 18, 25 and 44 percent, respectively (Table 2). Note that fertilizer of which P deriving from the combination of 44% PP-34 + 56% DAP gave grain yield comparable to those of P deriving from mixed fertilizer grade 15-15-15 and from APS.

Phosphorus concentrations in plant

The results on the effects of fertilizer treatments on P concentrations in ear-leaf at silking, in stover and in grain at maturity are summarized in Tables 2 and 3. Despite of poor response to added P, P-treated plants contain slightly higher P concentrations in ear-leaf, in stover and grain than plants treated with no P. Considering the influence of PP-34, it was observed that the mixed fertilizer containing P partially or solely from PP-34 resulted in relatively low P concentrations in all plant parts analyzed. Apparently, the data obtained were similar to those of dry stover weight and grain yield, *i.e.* the use of PP-34-free fertilizers slightly outyielded fertilizers containing PP-34 (Table 3). However, since the means grain yield for the fertilizers formulated with and without PP-34 were not significantly different, it could hardly con-

Table 1 Physical and chemical characteristics of surface soil from the experimental site.

Characteristics	Soil test values
pH (Water, 1:1)	5.0
Organic matter (%)	1.0
Available P (ppm)[1]	4.0
Available K (ppm)[2]	78
Texture	loam

1 Determined by Bray 2 method.

2 Extracted by pH 7.0, 1 N, Ammonium acetate.

Table 2 Effects of fertilizer treatments on growth, yield and phosphosus concentration in corn.

Trt. No	Fertilizer rate (N-P_2O_5-K_2O,kg/ha)	Fertilizer sources N	P	K	Dried stover (kg/ha)	Grain yield (kg/ha)	P concentrations (%) Ear-leaf	Stover	Grain
1	0-0-0	-	-	-	1693 b[1]	1085 c	0.20 c	0.066 a	0.51 b
2	75-0-37.5	AS	-	MOP	2083 ab	1491 bc	0.22 bc	0.078 a	0.52 b
3	75-75-37.5	AS	DAP	MOP	2734 ab	1798 abc	0.24 ab	0.110 a	0.63 a
4	"	AS	DAP+PP-34(10%)	MOP	3021 ab	1754 abc	0.23 bc	0.078 a	0.58 ab
5	"	AS	DAP+PP-34(44%)	MOP	2969 ab	2485 a	0.25 ab	0.064 a	0.57 ab
6	"	AS	PP-34	MOP	2292 ab	1901 abc	0.23 bc	0.064 a	0.50 b
7	75-75-75	Mixed fertilizer grade 15-15-15			3125 ab	2494 a	0.24 ab	0.090 a	0.63 a
8	"	AS	DAP+PP-34(18%)	MOP	2684 ab	2180 ab	0.24 ab	0.078 a	0.56 ab
9	75-97-47	< APS(16-20-0) >		MOP	2760 ab	2518 a	0.25 ac	0.082 a	0.60 ab
10	"	AS	DAP+PP-34(25%)	MOP	3255 a	2335 ab	0.22 bc	0.084 a	0.51 b
		Average			2662	2004	0.23	0.079	0.56

1 Means within a column followed by same letter are not significantly different at $P < 0.05$ according to Duncan's multiple range test.

cluded on the basis of P concentrations data that PP-34 is inferior to other soluble P sources.

DISCUSSION

In term of grain yield, marked responses to added P and NPK fertilizers were evident as has already been described in the foregoing section. Nevertheless, for the influence of PP-34 formulated in various mixed fertilizers, it was noted that the average responses to PP-34-free fertilizers and fertilizers containing PP-34 were comparable. In other words, mixed fertilizers containing PP-34 at any proportion of P ingredient were as effective as those of the PP-34-free fertilizers. Based on P source used in mixed fertilizer formulated only with PP-34, the relatively high effectiveness of PP-34 were concurred with the results of others found on various annual crops including maize (Singh, 1983; Quillon, undated; Anonymous, undated). Regarding the impact of PP-34 contents in various proportion in combination with other soluble P sources, past research results are lacking. However it is interesting to note from this experiment that as the available P contents in various mixed fertilizers deriving from PP-34 were increased from 10 to 18, 25 and 44 percent in relative to the total available P contents, the grain yield were gradually increased from 1,754 to 2,180, 2,335 and 2,485 kg/ha respectively. From this, it seems probable that in the formulation of mixed fertilizers, the presence of both PP-34 and DAP at certain proportion helps enhance the effectiveness of the NPK fertilizers formulated. According to the works of Alston and Chin (1974) and Wright (1975), who concluded from their experimental results with acid sandy soils in high rainfall areas, some less water soluble P were more effective than superphosphate in the short term. They further stated that in these soils, water-soluble P was readily leached, while the less water-soluble P sources probably maintained a continuous supply of P near the plant roots.

Table 3 Growth, yield and phosphorus concentration in corn as affected by P fertilizers derived from Phospal-34 and /or diammonium phosphate (DAP).

Comparisons P-response		Dried stover (kg/ha)	Grain yield (kg/ha)	P concentrations (%) Ear-leaf	Stover	Grain
P_0		2,083a	1,491b	0.22a	0.078a	0.52a
P(overall)		2,932a	2,229a	0.24a	0.081a	0.57a
P-sources						
Available P derived from PP-34 and DAP (%)						
PP-34	*DAP*					
0	100	2,734a	1,798ab	0.24a	0.110a	0.63a
10	90	3,021a	1,754ab	0.23a	0.078a	0.58ab
44	56	2,969a	2,485a	0.25a	0.064a	0.57 b
100	0	2,292a	1,901ab	0.23ab	0.064a	0.50b

ACKNOWLEDGEMENT

The authors would like to thank the Sociente Senegalaise des Phosphates de Thies, Senegal for financial support and Kasetsart University for allowing the authors to undertake this research project.

LITERATURE CITED

Anonymous, undated. Phospal fields trials. Booklet, Neuilly Sur Seine, France, 18 pp.

Alston, A.M. and K.W. Chin. 1974. Rock phosphate and superphosphate as sources of phosphorus for subterranean clover on an acid sandy soil. Aust. J. Exp. Anim. Husb. 14 : 356-61.

Buchan, J.A.J., F.B. Muller, J. Rogers, R.H. Seager and T.A.Yong. 1970. Agronomic use of calcined Christmas Island iron/aluminium phosphates. II Pot trials. N.Z.J. Agric. Res. 13 : 465-480.

Division of Soil Science. 1979. Fertilizer recommendations for upland crops. Handbook, Div. of Soil sci., Dept. of Agric., Bangkok, (In Thai).

Doak, B.W., P.J. Callaher, L. Evans and F.B. Muller. 1965. Low temperature calcination of C-grade phosphate from Christmas Island. N.Z.J. Agric. Res. 8 : 15-29.

Kitichaichayanont, P. 1992. A Study on Chemical, Mineralogical Properties and Relative Agronomic Effectiveness of Calcined Rock Phosphate. Ph.D. Thesis, Dept. of Soils, Kasetsart Univ., Bangkok, Thailand, 246 p.

Meesook, L., P. Choovoravech and R. Deemark. 1983/1984. Response of corn to calcined phosphate from Roi-Et. Ann. Res. Rep., Div. of Soil Sci., Dept. of Agric., Bangkok, p. 44-52, (In Thai).

Quillon, P.J. undated. Possibilities and future offers to rice, *etc.*, phosphatic fertilization in Asia/Anew promising fertilizer: Calcined calcium-aluminium phosphate (Phospal) from Senegal, SSPT, Senegal-France, 22 pp.

Singh, G.B. 1983. Study on Senegalese calcined phosphate and SSP on rice-wheat rotation. Papers presented at the 3rd Internat. Congress on Phosphorus Compounds. Brussels-Belgium.

Wright, D.N. 1975. Calcined Christmas Island c-grade rock phosphate as a fertilizer. Aust. J. Exp. Anim. Husb. 15 : 419-423.