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Effects of phosphate fertilizer levels on cowpea pod-sucking bug populations and damage

(*Keywords:* control, phosphate, pod-sucking bugs, infestation, damage)

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Abstract. The effect of different application levels of phosphate fertilizer on cowpea pod-sucking bugs [*Clavigralla* sp., *Riptortus* sp., *Anoplocnemis*., *Mirperus* sp. and *Negara* sp. (Heteroptera)] was studied using 0 (control), 20, 40 and 60 kg/ha of single super-phosphate. The results showed that the bug densities decreased significantly with increase in rate of application. At 40 and 60 kg/ha, grain yields were significantly higher than at the lower rates of application. Crude protein, fibre, oxalate, phytin, potassium and magnesium contents as well as seed hardness also increased with increase in the rate of fertilizer application.

1. Introduction

In most parts of Africa, the traditional method of maintaining soil fertility and productivity has hitherto been the bush fallow system, whereby available land is allowed to revert to fallow after 3–4 years of continuous cultivation. However, with agriculture becoming more and more intensive, coupled with the introduction of high yielding and more nutrient-demanding crop varieties, it became obvious that farmyard manure could not be obtained in sufficient quantities to meet the farmers' demand. Even where available, transportation problems and labour costs unavoidably limit its use on a routine basis. In this circumstance, attention was given to mineral fertilizers as the only obvious alternative. The first recorded indication of the potential value of inorganic fertilizers in Nigeria was in 1937, when it was shown that the response of cereal crops to small applications of farmyard manure was matched by the use of single super phosphate-containing quantities of phosphate equivalent to that in organic manure (Federal Department of Agriculture, 1989). This, together with similar studies in parts of southern Nigeria, marked the beginning of fertilizer usage in the country. The maintenance of high yields under intensive cultivation in present-day Nigeria is possible only through the use of inorganic fertilizers. Next to soil acidity, shortage of phosphorus is the major constraint upon food production in the humid tropics (Federal Department of Agriculture, 1989). In the semi-arid tropics, phosphorus deficiency is only second to nitrogen as the most frequently encountered agronomic problem.

Phosphorus, while not needed in large quantities, is critical to cowpea yield (particularly for improved photoperiod insensitive cultivars) because of its multiple effects on nutrition; it not only increases seed yields but also nodulation (Luse *et al.*, 1975). Other workers have reported that phosphate application influences the contents of other nutrients in leaves (Kang and Nangju, 1983) and seed (Omueti and Oyenuga, 1970). Absorption of phosphorus occurs primarily at the end of the growing period and is mainly transported to the seed (Singh and Rachie, 1985). At the present level of management in tropical Africa, phosphate is the single most recommended fertilizer (P_2O_5; 20–60 kg/ha) (Rachie and Roberts, 1974).

The longevity, fecundity and damage by insects and mites are greatly affected by the major plant nutrient components of fertilizer (Anonymous, 1969).

Several conflicting observations have been reported on the influence of fertilizers on the population of pests in fields. For example, a high level of nitrogenous fertilizer makes corn plants more succulent, rapid growing and attractive for oviposition by the European corn borer moth (*Ostrinia nubilasis* Hubner) (Lepidoptera: Nuctuiidea). Phosphorus applied alone or mixed with nitrogen at planting time has been found to be closely associated with the cutting activities of the wheat stem sawfly both in winter and spring wheat (Anonymous, 1969). The same author also reported that potassium, applied together with nitrogen and phosphorus, decreased the amount of sawfly cutting in wheat. Panchabhavi *et al.* (1974) noted that nitrogen in combination with phosphorus increased the rate of infestation damage caused by sorghum shootfly, *Atherigona soccata*. However, potassium in combination with phosphorus reduced the infestation of potato aphids and leaf hoppers (El-Saadany *et al.*, 1977). Nitrogen, coupled with phosphorus, gave a higher degree of incidence of gall midge and yellow stem borer. But NPK lowered the incidence of rice bug, leaf folder, gall midge and yellow stem borer (Pramanick *et al.*,1995).

Shri Ram *et al.* (1990) also showed that increase in phosphorus concentration alone reduced leaf hopper population consistently in wheat, they explained that the yield obtained in the plot containing a high concentration of phosphorus was due to some complex mechanisms, occurring in plant systems. These mechanisms help in building up anatomical features of the foliage so that plants develop resistance to the damaging activity of the defoliators. The present study explored the effects of use of single superphosphate fertilizer on the population of

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cowpea pod-sucking bugs (PSBs) and the damage they cause. The bugs studied were *Clavigralla* spp., *Riptortus* spp., *Anoplocnemis* spp., *Mirperus* spp. (Heteroptera: Coreidea) and *Nezara* spp. (Heteroptera: Pentatomitidae).

2. Materials and methods

The study was carried out at the Teaching and Research Farm of the Faculty of Agriculture and Forestry, University of Ibadan, Ibadan, Nigeria. 'Ife Brown', an improved local determinate semi-erect cowpea variety of medium maturity, which is highly susceptible to pod-sucking bug (PSB) damage, was used. Each field experiment was carried out in the early and late seasons of 1991 and 1992 using a completely randomized block design with four replicates. The plot size was 5 m × 5 m and the treatments were different application levels of single super phosphate fertilizer of 0 (control), 20, 40 and 60 kg/ha (P_2O_5). The fertilizer was applied by band application at planting. The planting spacing was 30 cm × 60 cm for all the treatments. The cowpea seeds were planted at the rate of two seeds per hole. At 14 days after planting (d.a.p.) the plants were thinned to one per stand. Deltametrin at 25 g a.i./ha was applied at 15, 25 and 35 d.a.p. against the leaf and flower pests of cowpea.

Before planting in both seasons, the soil was sampled from the planting site and chemical analysis was carried out for pH, organic carbon, total nitrogen, available phosphate, exchangeable calcium, magnesium and sodium as described by IITA (1982). The assessment of the number and species of the PSBs started at the budding stage (50 d.a.p.). This was done by visual counting on ten randomly selected plants in the middle row of each plot. Sampling was done at weekly intervals till pod maturity (72 d.a.p.) between 7.30 and 9.30 a.m. when the insects were relatively less active. The data collected were subjected to ANOVA. Least Significant Difference (LSD) was used to assess significance of difference of the means of treatments. Data from insect counts were transformed ($\sqrt{} + 0.5$) before analysis.

At maturity, all the pods were harvested and dried to a moisture content of 12%. Damaged and undamaged seeds and pods were sorted out for each of the treatments. A pod was considered damaged if it had one or more constrictions along its length, showing seed failure due to the bug attack, or if it was shrivelled. Seeds damaged consisted of aborted seeds, wrinkled or shrivelled seeds or seeds showing necrosis and/or feeding lesions. Pods damaged by PSBs, when opened, contained damaged seeds with darkly stained 'feeding lesions' compared with physiologically aborted, wrinkled or shrivelled seeds.

Evaluation of damage by the PSBs was based a 100 pod-samples per replicate per treatment. For the seed damage, 1000 seeds were selected randomly and the damaged and undamaged seeds were sorted out for each of the treatments. The data on yield collected were subjected to ANOVA and LSD was then used to assess the significance of differences between means of treatments.

2.1. Determination of seed hardness

Hardness of seeds was determined by using a hardness tester to which a punching pin 5 mm in diameter was attached. One hundred seeds from each of the 0, 20, 40 and 60 kg/ha plots were dried in the oven for 48 h at 105°C in the laboratory. Ten healthy seeds of about the same size were then selected from each treatment and each was punched around the middle. The pressure at which the seed snapped was read on the scale attached to the tester. The mean seed hardness was measured in kilogramms per square millimetre. The mean pressure (kg/mm^2) as determined by the hardness meter was calculated and subjected to analysis of variance and LSD.

2.2. Chemical analysis of seeds

One hundred seeds from each of the treatments were ground in a Christy-Norris hammer mill using a 1/32 inch mesh size sieve. The ground material was dried in the oven at 105°C for 6 h and then stored in screw-capped bottles until needed for analysis. Two grams of the dried samples were digested by the wet digestion method. The digested materials were made up into four solutions in different 100 ml graduated flasks. The nutrient contents of crude protein, crude fibre, oxalate, phytin, fat, moisture, ash, calcium, phosphorus sodium, potassium and magnesium were determined by methods described by IITA (1982, 1984).

3. Results

The fertility status of the soil at the experimental site is shown in table 1. There was a general decrease in the PSB population with increase in phosphate level irrespective of the season (table 2). There were no significant differences ($P > 0.05$) in the population of *Clavigralla* sp., *Riptortus* sp. and *Anoplocnemis* sp. between 0 and 20 kg/ha levels of phosphate fertilization. Species populations at these levels were significantly higher ($P < 0.05$) than populations on plots treated at 40 and 60 kg/ha which were not significantly different from each other. Compared with other bugs, the populations of *Mirperus* and *Nezara* spp. were generally low in both seasons and did not respond to fertilization (table 2). Again, irrespective of seasons, there was no significant difference in the damage to pods and seeds between the control and plots treated at 20 kg/ha. These were however, different from those of 40 and 60 kg/ha, which were not significantly different from each other (table 3). There were no significant differences between the number of pods/plant and number of seeds/pod between the control and the other treatments, irrespective of seasons. The phosphate fertilizer only affected seed weight; thus yield/plant and yield/ha increased significantly ($P < 0.05$) with increase in level of phosphate fertilizer (table 4). The yield/plant in the 40 and 60 kg/ha plots were about twice as high as those of the control and 20

Table 1. Some chemical characteristics of the experimental site before planting in the early and late 1991 cropping seasons

	Early season, 1991	Late season, 1991
PH	6.2	5.9
Organic carbon (g/kg)	1.8	2.1
Total nitrogen (g/kg)	1.1	1.6
Available phosphate (mg/kg)	7.7	8.9
Exchangeable calcium (cmol/kg)	2.8	2.2
Exchangeable magnesium (cmol/kg)	0.4	0.5
Exchangeable sodium (cmol/kg)	0.2	0.1

kg plots. The results of the proximate analysis of the seeds indicated that crude fibre, oxalate, phytin and moisture contents did not increase with increase in phosphate levels. However, crude protein, fat, ash, calcium, phosphorous, potassium and magnesium contents increased at higher phosphate levels especially between 40 and 60 kg/ha treatments (table 5).

There was no significant difference in terms of hardness between the seeds in the control and those of 20 kg/ha plots (table 6). But the seeds from 40 and 60 kg/ha plots were significantly harder ($P < 0.05$) than those of the control and 20 kg/ha.

4. Discussion

The significant differences in the yields of cowpea at higher fertilizer rates are in agreement with the reports of Luse *et al.* (1975), Singh and Lamba (1971), Swami and Pal (1974), Kumar and Pillai (1979) and Singh *et al.* (1981) on cowpea. These workers all concluded that most tropical soils were deficient in phosphorus in relation to other nutrients. This was also observed in this study. It was reported that the yields, growth rate, leaf area index, nodules per plant and dry matter production were improved by phosphate fertilization. This improvement was considered responsible for the significant increase in grain and stalk yield as well as the increase in harvest index at high phosphate levels (Singh *et al.*, 1981). In addition to this, the populations of PSBs and seed weight were found to be affected by the high phosphate level in this study. Seeds from 40 and 60 kg/ha phosphate-treated plots were significantly heavier and suffered less damage than those of the control and 20 kg/ha.

The significant reduction in the level of infestation agrees with the reports of Shri Ram *et al.* (1990). It has been reported that phosphorus, in combination with nitrogen and potassium,

Table 2. The mean number of different species of PSB at different levels of phosphate fertilizer application on cowpea in the late 1991 and early 1992 cropping seasons

	Phosphate level in kg/ha									
	0	20	40	60	$LSD_{(0.05)}$	0	20	40	60	$LSD_{(0.05)}$
PBS	Late season, 1991					Early season, 1992				
Clavigralla sp.	41.4	37.4	29.6	27.3	4.2	29.4	28.6	20.3	19.5	2.7
Riptortus sp.	7.1	7.1	5.6	4.1	1.1	4.0	4.6	2.3	1.8	1.4
Anoplocnemis sp.	7.2	7.3	3.9	4.3	2.6	4.0	5.3	1.8	1.4	2.1
Mirperus sp.	1.1	1.1	0.7	1.0	0.4	0.7	0.4	0.4	0.1	0.4
Nezara sp.	1.5	1.8	1.1	0.9	0.9	1.1	1.3	1.3	0.7	0.6

LSD = Least significant difference.
Values were transformed ($\sqrt{x + 0.5}$) before analysis.

Table 3. The percentage pod and seed damage by the PSD at different application levels of phosphate fertilizer

Application levels (P_2O_5 Kg/ha)	Late season, 1991		Early season, 1992	
	Pod damage[a]	Seed damage[b]	Pod damage	Seed damage
0	92.0	68.3	62.0	57.0
20	90.0	66.9	63.0	50.0
40	73.0	41.3	50.0	37.0
60	75.0	40.1	51.0	35.0
$LSD_{(0.05)}$	2.4	5.6	4.8	6.0

[a]Based on 200 pods per treatment.
[b]Based on 1000 seeds per treatment.
LSD = Least significant difference.
Values were transformed arcsin (x) before analysis.

Table 4. The effect of different application levels of phosphate fertilizer on cowpea yield in the late 1991 and early 1992 cropping seasons

	Phosphate level in kg/ha									
	0	20	40	60	$LSD_{(0.05)}$	0	20	40	60	$LSD_{(0.05)}$
Yield	Late season, 1991					Early season, 1992				
Mean no. of pods/plant	10.6	10.7	10.6	10.7	0.3	10.0	10.0	9.8	10.3	0.4
Mean no. of seeds/pod	10.7	10.7	10.5	10.6	0.3	10.0	9.9	10.1	10.0	0.2
Mean 100 seed weight (g)	17.7	17.8	19.9	19.9	1.8	16.5	16.6	18.1	18.0	1.1
Mean yield/plant (g)	5.2	6.2	10.9	10.7	2.2	5.5	5.9	10.5	10.8	2.8
Mean yield/ha (kg)	287.9	345.3	604.9	593.4	128.3	302.3	323.3	583.0	596.0	63.4

LSD = Least significant difference.

Table 5. The proximate analysis of cowpea seed samples at different application levels of phosphate fertilizer in the late 1991 and early 1992 cropping seasons

	Phosphate application rates (kg/ha)							
	0	20	40	60	0	20	40	60
Nutrient	Late season, 1991				Early season, 1992			
Crude protien	21.0	22.0	24.5	26.5	24.1	24.3	25.8	27.1
Crude fibre (%)	10.5	11.0	11.0	11.8	12.5	12.5	12.8	12.9
Oxalate (%)	0.2	0.2	0.3	0.3	0.1	0.1	0.1	0.1
Phytin	0.5	0.5	0.6	0.6	0.6	0.7	0.7	0.7
Fat	3.5	5.0	5.2	5.8	4.5	5.4	5.8	7.0
Moisture content (%)	8.1	8.0	7.8	8.0	7.8	7.8	7.6	7.8
Ash content (%)	2.6	2.8	3.6	3.6	2.0	2.5	3.4	3.6
Calcium (mg/kg)	82.0	84.0	85.0	86.2	76.6	79.1	83.9	85.5
Phosphorus (mg/kg)	490.0	520.0	640.0	690.0	320.0	410.0	580.0	650.0
Sodium (mg/kg)	9.0	9.0	9.6	10.0	8.1	8.0	8.7	7.4
Potassium (mg/kg)	1010.0	1080.0	1101.0	1090.0	860.0	890.0	950.0	980.0
Magnesium (mg/kg)	280.0	290.0	290.0	300.0	210.8	230.0	230.6	250.0

Table 6. The hardness of cowpea seeds at different application levels of phosphate fertilizer as determined by the use of the hardness tester in the late 1991 and early 1992 cropping seasons

Fertilizer rate (P_2O_5 kg/ha)	Late season, 1991 (kg/mm^2)	Early season 1992 (kg/mm^2)
0	0.652	0.654
20	0.659	0.060
40	0.689	0.694
60	0.690	0.697
$LSD_{(0.05)}$	0.01	0.009

LSD = Least significant difference.

decreased the amount of sawfly cutting in wheat (Anonymous, 1969). Shri Ram *et al.* (1990) also reported that the increasing concentration of phosphorus alone consistently reduced leaf-hopper populations. They postulated that the high yield obtained was due to mechanisms that help build up anatomical features of the foliage which confer resistance to the damaging activity of the defoliators.

Investigation of these mechanisms was further attempted through the proximate analysis of the seeds from various phosphate levels in the experiment. The results from this study showed that increase in phosphate level increased the crude protein, fat and calcium contents of the seeds. In addition, reports have shown that there is an increase in the concentration of Co, Fe, Zn, Cu and Mb as phosphate concentration increased while that of sodium was not influenced significantly (Omueti and Oyenuga, 1970). These results suggest that since phytin content was not significantly raised with increase in phosphate level, more of the calcium, phosphorus and magnesium would now be available at higher levels of phosphate application. Calcium and magnesium are known to form salts of oxalate and phytates (FAO, 1981; Oke, 1965). We suggest that the increase in phosphate rate raised the concentration of these elements without simultaneously raising the oxalate and phytin contents. This means that high levels of phosphorus in the soil would tend to increase the proportion of available calcium and magnesium in seeds. In addition to this, Omueti and Oyenuga (1970) pointed out that the increase they observed in iron as a result of the increase in the phosphate level probably indicated a difference in the iron compound formed and stored in the seeds. Other compounds could also be formed with Zn, Cu, Co and Mb whose concentration were also raised. The rise in protein levels with increasing soil phosphate level may be due to the role of phosphorus in energy metabolism providing more energy for protein synthesis and it is possible that more phospho-protein is also formed.

Tests for the hardness of seeds revealed that the seeds from 40 and 60 kg/ha were significantly harder than those of 0 and 20 kg/ha. Thiery (1984) reported different chemical properties in some fabaceous seeds (*Phaseolus vulgaris* L., *P. cocineus* L. and *Lablab purpureus* L. in relation to the strength of their seed coats. He found out that the seed coat of *P. lanatus* contained some complex substances and was harder than other species investigated and consequently, *Acanthoscelides obstectus* (Say) nymphs were unable to penetrate through it. In the present study it is also possible that hardening of the seeds may be due to changes in the internal chemical composition. PSBs do not attack dry seeds; they initiate attack when the pods and seeds are still maturing and succulent, therefore, toughness of the seed coat at the early part of seed development may be responsible for reducing the PSB population at higher phosphate levels.

In conclusion, the higher yields observed at 40 and 60 kg/ha could have been due either to reduction in damage by PSBs or to improved growth and seed set as a result of the direct effects of phosphorus fertilizer or, indeed, to a combination of both factors.

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