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The impact of phosphate fertilizer as a pest management tactic in four cowpea varieties

Asiwe, J. A. N.

Agricultural Research Council, Grain Crops Institute, Private bag X1251, Potchefstroom, 2520, South Africa.
E-mail: AsiweJ@arc.agric.za. Fax: +27 18 294 7146.

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Insect pests constitute serious threat to cowpea production in sub-Saharan Africa. In some severe situations, total yield loss results. Chemical control, although most effective, is very costly, hazardous and unsustainable. Investigation of other control options such as cultural practices that are environment friendly is critically important. This paper reports the effects of four levels of phosphorus fertilizer application (0, 15, 30 and 45 kg P$_2$O$_5$ ha$^{-1}$) on insect population, damage and grain yield of four cowpea varieties (IT91K-180, IT95M-118, TVu 1890 and Vita 7) planted at research farm of International Institute of Tropical Agriculture (IITA), Nigeria. Data were collected on insect counts, pod evaluation index and damage by *Aphis craccivora*, *Megalurothrips sjostedti*, *Maruca vitrata* and pod-sucking bugs. Results indicated that damage by *A. craccivora*, *M. sjostedti* and *M. vitrata* were significantly (P < 0.05) lower at 30 and 45 kg P$_2$O$_5$ ha$^{-1}$ and consequently higher grain yields were obtained.

Key words: Cowpea, grain yield, insect pests, pod evaluation index, phosphate fertilizer.

INTRODUCTION

Cowpea, *Vigna unguiculata* (L.) Walp, is one of the important staple food crops in sub-Saharan Africa. It is rich in protein, carbohydrate and vitamins (Bressani, 1985; Kholi, 1990). Cowpea is also important because it fixes atmospheric nitrogen (Asiwe et al., 2009) and excess of its nitrogen requirements are made available for subsequent crop uptake thereby reducing the cost of nitrogen fertilization. Cowpea is attacked by several insect pests from seedling to storage leading to zero grain yield in many instances in Sub Saharan Africa (Singh and Jackai, 1985; Jackai and Daoust, 1986; Asiwe et al., 2005). At Mokwa and Ibadan IITA research stations, zero yield or 100% crop failure due insect pests (especially Thrips, *Maruca* pod borer and pod-sucking bugs) are possible without any insecticide protection or yield enhancement (Ajeigbe and Singh, 2006). For this reason, insect pests pose the greatest challenge to cowpea production in sub-Saharan Africa. The most important insect pests of cowpea in Africa are aphids (*Aphis craccivora* Koch) (Homoptera: Aphididae), flower thrips (*Megalurothrips sjostedti* Trybom) (Thysanoptera: Thripidae), legume pod borer (*Maruca vitrata* Fabricius) (Lepidoptera: Pyralidae) and a complex of pod-sucking bugs (PSBs) (Singh et al., 1990; Dreyer et al., 1994). Several management strategies are being employed in the suppression of these insect pests, including biological control (Kumar et al., 1980; Tamo et al., 1997), chemical control (Jackai et al., 1985; Amatobi, 1994; Jackai et al., 2001, Asiwe, 2009), host plant resistance (Singh, 1987; Fatokun et al., 1997) and cultural methods (Mallett, 1982; Karungi et al., 2000; Asiwe, 2004; Asiwe et al., 2005).

The use of fertilizers as a yield booster has been reported (Kang and Juo, 1979; Kang and Nangju, 1983; Kutu et al., 2009). Also, some macro-nutrients, nitrogen, phosphorus and potassium have received some attention in the study of plant resistance to insect pests. Fertilizers not only improve crop yield, but also influence crop suitability for insect development, depending on the type of fertilizer and pest species (Van Emden, 1966; Wooldbridge and Harrison, 1968; Kogan, 1994). For example, phosphorus is known to increase cowpea grain yield as well as influencing the contents of certain nutrients levels in the leaves (Kang and Nangju, 1983). We also know that it interacts with other soil nutrients such as nitrogen, sulphur and zinc to improve yield of other crops (Kang and Juo, 1979). Even though recent reports showed that, the application of phosphorus reduced the population densities and damage of pod-
sucking bugs (Pitan et al., 2000) and *Empoasca dolichi* Paoli (Shri Ram et al., 1987, 1990) not much is known of the its effects on other insect pests of cowpea. The soils in humid and semi-arid of West Africa are highly leached, eroded and are deficient in phosphorus (Mokwunye, 1979). Phosphorus deficiency in these areas is further worsened by farmers’ practices of intensive cropping with little or no fallowing and removal of cowpea haulms or biomass due to the cut and carry method of harvesting by the farmers to feed their animals in kraals or for sale as fodder (Bottenberg, 1995). The eventual grazing of leftover crop residues by animals (IITA, 1998; Barzegar et al., 2002) further depletes the soil of organic material return to the soil. To evaluate the influence of phosphorus on insect pests of cowpea in such soils is therefore necessary. We know that other nutrients if deficient could limit cowpea growth and development (Carsky, 2003), therefore one important assumption in this work was that phosphorous is often most deficient and that cowpea can fix 80 - 90% of its nitrogen demand (Eaglesham et al., 1977). This paper reports the effects of applying different levels of phosphate fertilizer on insect counts, flower and pod damage as well as grain yield of four cowpea varieties.

**MATERIALS AND METHODS**

The experiment was conducted at the International Institute of Tropical Agriculture (IITA) Ibadan, in two cropping seasons: the first (April to July) and second (September to November), in 1999. Four cowpea varieties (Vita 7, IT95M-118, TVu 1890, IT91K-180) were chosen because of their differential susceptibility to cowpea insects. Vita 7 is susceptible to all cowpea insect pests and was therefore used as the susceptible check. IT95M-118 is a breeding line developed by IITA with low level of resistance to *M. sjostedti* and *M. vitrata* TVu 1890 has low to moderate level of resistance to pod-sucking bugs (IITA, 1987). Their average grain yield under full insecticide protection is about 0.8 - 1.0 t/ha. Plot sizes were 5 by 5 m (25 m²) and consisted of 250 plants at the rate of two plants per stand. Four levels (0 kg P₂O₅ ha⁻¹, 15 kg P₂O₅ ha⁻¹, 30 kg P₂O₅ ha⁻¹ and 45 kg P₂O₅ ha⁻¹) of single super phosphate fertilizer were applied, in a split-plot experimental design. Fertilizer levels were the main plots and the varieties the sub-plots. Each treatment was replicated three times. No insecticide was applied.

Three seeds were sown per stand in rows spacing of 1.0 m apart and 0.20 m apart within the row. Plant stands were thinned to two seedlings soon after germination. Fertilizer treatments were applied two weeks after planting (2WAP) as a side-dressing along the cowpea rows. In each plot, a one-metre row length was randomly staked out in each of the three middle rows and used as areas for sampling PSBs and pod counts. This was to ensure that during flower sampling, flowers were not picked from these areas so that data on pod counts would not be confounded.

**Assessment of insect population and yield parameters**

Damage caused by *A. craccivora* was assessed on cowpea plants taken from the three middle rows of every plot using a 9-point scale described by Jackai and Singh (1988). Damage of flowers by *M. sjostedti* was assessed in two ways: (a) by scoring visual damage symptoms observed on racemes, growing tips, stipules and flowers using a 9-point scale described by Jackai and Singh (1988) and (b) by direct counts of *M. sjostedti* (adults and larvae) in a sample of 10 flowers hand-picked randomly from the middle rows (outside the staked areas). The flower samples were put in vials containing 50 - 70% alcohol and subsequently examined in the laboratory. In the laboratory, the samples were dissected open for examination under an illuminated macro-projector to count the number of *M. sjostedti*.

Pod damage by *M. vitrata* was assessed by a technique known as Pod Evaluation index, (*Ipe*) described by Jackai (1995). *Ipe* measures two parameters: pod damage (PD) and pod load (PL). Pod damage measures the presence of *M. vitrata* frass and/or entry/exit holes of larvae while Pod load measures the degree of successful pod production. Each parameter was scored on a 9-points scale as described by Jackai and Singh (1988). Pod load was rated 1 (low) to 9 (high) and pod damage was rated 9 as high and 1 as low. An Index (pod evaluation index) was then derived from the following relationship:

\[ Ipe = PL \times (9-PD) \]

Data analysis

All the data collected were subjected to statistical analysis using SAS (SAS, 1990). Test for normality of data was done using SAS procedure. The data was found to be normal and did not require any form of transformation. Analysis of variance (ANOVA) was executed using SAS procedure. Pre-planned comparisons of checks (0 level of P and Vita 7 variety) with other factor levels were performed using Dunnett’s method (SAS option). Interaction plots of least significant means (LSmeans) were used to examine the nature or pattern of interaction in cases where significant interactions were obtained between variety and P-levels.

**RESULTS**

**Response of *Aphid craccivora* damage to P-levels and cowpea varieties**

Significant difference (P < 0.05) was obtained in the severity of infestation by *A. craccivora* during the first season and the lowest damage was recorded on 30 kg P₂O₅ ha⁻¹ treatment. During the second season, although mean aphid infestation was higher, significant differences (P < 0.05) were obtained only among the varieties (Table 1). Fertility level made no discernable difference in the population of this insect.

**Response of *Megalurothrips sjostedti* infestation to P-levels and cowpea varieties**

Significant differences (P < 0.05) were observed among
Table 1. Means of insect damage and pod production of four cowpea varieties at four P-levels.

<table>
<thead>
<tr>
<th>Variety/P-level</th>
<th>Mean number</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A. craccivora damage score (1-9)</td>
<td>M. sjostedti damage score (1-9)</td>
<td>Number of M. sjostedti per flower</td>
<td>M. vitrata Pod evaluation index (Ipe)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IT91K-180</td>
<td>2.50</td>
<td>3.17*</td>
<td>2.22*</td>
<td>2.57*</td>
<td>28.95*</td>
<td>134.06</td>
<td>42.46*</td>
<td>40.00*</td>
<td></td>
</tr>
<tr>
<td>IT95M-118</td>
<td>2.50</td>
<td>3.75*</td>
<td>3.10*</td>
<td>3.39*</td>
<td>25.40*</td>
<td>149.19</td>
<td>34.67*</td>
<td>30.58*</td>
<td></td>
</tr>
<tr>
<td>TVu 1890</td>
<td>0.33</td>
<td>2.67*</td>
<td>3.64*</td>
<td>3.38*</td>
<td>29.74*</td>
<td>105.18*</td>
<td>32.25*</td>
<td>34.00*</td>
<td></td>
</tr>
<tr>
<td>Vita 7</td>
<td>0.17</td>
<td>4.83</td>
<td>5.77</td>
<td>6.93</td>
<td>58.27</td>
<td>210.16</td>
<td>2.75</td>
<td>13.00</td>
<td></td>
</tr>
<tr>
<td>SE ±</td>
<td>0.14</td>
<td>0.30</td>
<td>0.19</td>
<td>0.11</td>
<td>5.8</td>
<td>21.00</td>
<td>2.210</td>
<td>3.60</td>
<td></td>
</tr>
<tr>
<td>0 kg (P\textsubscript{2}O\textsubscript{5})/ha</td>
<td>0.25</td>
<td>2.67</td>
<td>3.80</td>
<td>4.72</td>
<td>30.12</td>
<td>145.86</td>
<td>19.29</td>
<td>19.58</td>
<td></td>
</tr>
<tr>
<td>15 kg (P\textsubscript{2}O\textsubscript{5})/ha</td>
<td>1.95</td>
<td>3.0</td>
<td>3.72</td>
<td>4.2</td>
<td>32.73</td>
<td>157.65</td>
<td>24.54</td>
<td>24.66</td>
<td></td>
</tr>
<tr>
<td>30 kg (P\textsubscript{2}O\textsubscript{5})/ha</td>
<td>0.01*</td>
<td>4.34</td>
<td>3.49</td>
<td>3.05*</td>
<td>28.47</td>
<td>137.04</td>
<td>34.42*</td>
<td>39.00*</td>
<td></td>
</tr>
<tr>
<td>45 kg (P\textsubscript{2}O\textsubscript{5})/ha</td>
<td>0.33</td>
<td>4.42</td>
<td>3.68</td>
<td>3.79*</td>
<td>48.92*</td>
<td>153.69</td>
<td>33.87*</td>
<td>34.33*</td>
<td></td>
</tr>
<tr>
<td>SE ±</td>
<td>0.05</td>
<td>0.86</td>
<td>0.17</td>
<td>0.13</td>
<td>1.90</td>
<td>21.93</td>
<td>1.80</td>
<td>2.31</td>
<td></td>
</tr>
</tbody>
</table>

*Means of treatments are significantly (P < 0.05) different from that of control (Vita 7 or 0 kg (P\textsubscript{2}O\textsubscript{5})/ha) using Dunnett’s t-test, SE = Standard Error of means.

Figure 1. P-level x variety interaction effects on the severity of *Megalurothrips sjostedti* infestation. The interaction was not significant in the first season

The varieties (2.22-5.77) only in the first season (Table 1) but in the second season when infestation of *M. sjostedti* was higher, significant differences existed in both varieties (2.57-6.93) and P-levels (3.05-4.72). The interaction between them was also significant (P < 0.05) (Figure 1). Severity of damage (3.05) and number of *M. sjostedti* per flower (28.47) were lowest in the 30 kg P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1} treatment for all varieties. During both seasons, Vita 7 harboured the highest thrips density per flower and suffered the greatest damage (Table 1, Figure 1).

Responses of varieties to P-levels, *M. vitrata* and pod-sucking bug infestation

There were significant differences in the main and interactive effects of the cowpea varieties and P-levels for pod evaluation index (*Ipe*) during both seasons (Table 1). Variety x P-level interaction plot showed that *Ipe* values were higher at 30 kg and 45 kg P\textsubscript{2}O\textsubscript{5} ha\textsuperscript{-1} in all the varieties (Table 1, Figure 2).

Pod sucking bug species recorded in this study were *C.*
Table 2. Mean grain yield, number of pods per plant, seed damage index and number of pod-sucking bugs of four cowpea varieties at four P-levels.

<table>
<thead>
<tr>
<th>Variety/P-level</th>
<th>Mean number of pods per plant</th>
<th>Seed damage index (Lsd)</th>
<th>Average number of pod-sucking bugs per 1 m row-length</th>
<th>Grain yield (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1999 first season</td>
<td>1999 second season</td>
<td>1999 first season</td>
<td>1999 second season</td>
</tr>
<tr>
<td>IT91K-180</td>
<td>1.75*</td>
<td>2.55*</td>
<td>47.25*</td>
<td>49.14</td>
</tr>
<tr>
<td>IT95M-118</td>
<td>1.54*</td>
<td>1.28*</td>
<td>54.12</td>
<td>50.92</td>
</tr>
<tr>
<td>TVu 1890</td>
<td>1.38*</td>
<td>1.32*</td>
<td>50.99</td>
<td>53.70</td>
</tr>
<tr>
<td>Vita 7</td>
<td>0.90</td>
<td>0.97</td>
<td>61.44</td>
<td>61.57</td>
</tr>
<tr>
<td>SE ±</td>
<td>0.01</td>
<td>0.01</td>
<td>2.97</td>
<td>4.23</td>
</tr>
</tbody>
</table>

No fertilizer (0 kg (P₂O₅)/ha) 1.24 0.16 53.43 59.71 8.20 7.90 271.31 172.41
15kg (P₂O₅)/ha 1.23 1.11 56.42 56.17 8.10 7.80 199.45 171.50
30kg (P₂O₅)/ha 1.58* 1.48* 44.49 51.76 8.10 7.80 281.16 290.56*
45kg (P₂O₅)/ha 1.54 1.41 50.09 47.50 8.00 8.20 288.69 312.09*
SE ± 0.01 0.01 3.69 4.72 0.02 0.01 8.62 11.24

*Means of treatments are significantly (P < 0.05) different from that of control (Vita 7 or 0 kg (P₂O₅)/ha) using Dunnett's t-test, SE = Standard Error of means.

Figure 2. P-level x variety interaction effects on pod evaluation index, Ipe, during the first season. The interaction was not significant in the second season.

Yield response of cowpea varieties to P-levels

Table 2 also shows that significant (P < 0.05) mean differences were obtained in the main effects. The nature of the variety x P-level interaction suggests that high flower production (Figure 3) was obtained among the varieties at the 30 kg P₂O₅ ha⁻¹ and 45 kg P₂O₅ ha⁻¹. Grain yield varied significantly among the varieties during both seasons, whereas, among the P-levels, significant
differences were observed only in the second season (Table 2). Grain yield produced at 30 kg $P_2O_5$ ha$^{-1}$ (290.56 kg ha$^{-1}$) and 45 kg $P_2O_5$ ha$^{-1}$ (312.09 kg ha$^{-1}$) were higher than those produced at lower P-levels. Vita 7 produced the lowest grain yield during both seasons.

**DISCUSSION**

The infestations of aphids and thrips were not consistently high during both seasons. Severity of *A. craccivora* was higher during the second season than the first due to the carry-over effect from the first season into the second. Such carry-over effect was observed in flower thrips (Salifu, 1982).

However, Annan et al. (1977) found that about 20 kg $P_2O_5$ ha$^{-1}$ was needed to reduce *A. craccivora* damage on a resistant cowpea variety. In this study the range is between 15 and 30 kg $P_2O_5$ ha$^{-1}$. The slight variation in the results obtained in this study and that of Annan et al., 1977 could be due to differences in variety used.

Higher dosage of phosphorus, especially, 30 kg $P_2O_5$ ha$^{-1}$ reduced the severity of damage by *M. sjostedti*. This means that the increased nutrition enabled the plants to repair damage by thrips. However, the higher number of thrips in flowers obtained from plants fertilized at 45 kg $P_2O_5$ ha$^{-1}$ was a function of increased flower numbers, a factor that was not used in determining pest load. This heavy thrips load in this P-treatment in part accounted for its lower pod load per plant than 30 kg $P_2O_5$ ha$^{-1}$.

The *Ipe* at 30 kg $P_2O_5$ ha$^{-1}$ was higher because it exhibited a higher pod load with less damage by *M. vitrata* across the cowpea varieties. In addition, the reduced damage by *A. craccivora* and *M. sjostedti* at this P-application rate also contributed to its productivity in comparison with other P-levels. The slight drop of *Ipe* value in the 45 kg $P_2O_5$ ha$^{-1}$ treatment as against 30 kg $P_2O_5$ ha$^{-1}$ was influenced by the reduced pod load caused by increased flower and pod damage from thrips and *M. vitrata*, respectively. In addition, the drop of *Ipe* value obtained at the rate of 45 kg $P_2O_5$ ha$^{-1}$ was possibly due to higher demand for other nutrients which were either unavailable or in limited proportion as to limit yield. Dense canopy associated with cowpea plots fertilized at 45 kg $P_2O_5$ ha$^{-1}$ in part, had also contributed to the increased pod damage by *M. vitrata* by providing suitable micro-environment such as low temperature, high humidity and low light transmission. These factors created by dense canopy have been reported to enhance damage by *M. vitrata* (Oghiakhe et al., 1991). The significant low seed damage value for IT91K-180 is a new breakthrough which may be related to its earliness (65 days) or evasion and this needs further laboratory studies for confirmation.

**Figure 3.** P-levels x variety interaction effects on number of flowers produced per ten plants during the first season.

TVu 1890 was previously the only variety widely reported to have a low-moderate level of resistance to PSBs (Olatunde et al., 1991; Koona, 1999). Although, the performance of all P-levels was better than the control (0 kg $P_2O_5$ ha$^{-1}$) in their yield components which suggests the role of phosphorus in cowpea grain production (Ntare and Bationo, 1992, Ankomah et al., 1995, Vadez et al., 1999, Waluyo et al., 2004), however, grain yields were lower than expected possibly due to the effect some nutrient antagonism since other macro-nutrients and micro-nutrients were not at optimum level. Several researchers have reported that the supply of P plays important roles in establishment, growth and function of nodules (Israel, 1987; Beck and Munns, 1984; Leung and Bottomley, 1987) and growth of host plants (Munns et al., 1981). The application of 30 kg $P_2O_5$ ha$^{-1}$ promoted good nutrition and crop development which
reduced pest damage; a level at which the supply of other soil nutrients necessary for crop performance were not critical. This finding is in conformity with past work on phosphorus nutrition in cowpea. Tenebe et al. (2000) reported that although grain yield increased with increasing P-levels, there was no accruing yield advantage if cowpea is fertilized with 40 kg P$_2$O$_5$ ha$^{-1}$ and beyond. Similarly, the findings of Agboola and Obigbesan (1977) showed that 30 kg P$_2$O$_5$ ha$^{-1}$ was the optimum rate of P application for maximum grain yield of cowpea.

Insect damage by aphids, thrips, Maruca pod borer and PSBs were lower on the new cowpea breeding lines (IT91K-180, IT95M-118 and TVu 1890) than on the susceptible Vita 7, thus indicating that they possess some levels of resistance to these pests. The high insect damage obtained on Vita 7 affected the number of flowers, pods per plant and grain yield produced. This supports the findings of Salifu (2001) who reported that Vita 7 is susceptible to all cowpea insect pests. Since most soils of sub Saharan Africa are prone to phosphorus deficiency, the results from this study would be useful in advising farmers the optimal application rate of phosphorus fertilizer for optimum yield and management of cowpea insect pests. In South Africa where crop rotation is commonly practiced and maize crop is heavily dosed with N and P fertilizers, extension agents will find the results from this study useful to advise their farmers to plant cowpea immediately after maize cropping so that cowpea will use the residual phosphorus left after maize uptake. Such residual P left after maize uptake is usually enough and above the critical level to improve the yield of cowpea and enhance resistance to insects. However, in other parts of sub Saharan Africa where farmers intercrop cereals with cowpea without the cereal component receiving any P-fertilizer, a generous application of P at 30 kg P$_2$O$_5$ ha$^{-1}$ will not only improve the growth and development of the two companion crops in the intercrop but also enhance the resistance of cowpea to rebuild damages and/or compensate losses caused insects.

In conclusion, fertilizer provided good nutrition for the reduction of pest load and damage and consequently, enhanced grain yield of IT91K-180, IT95M-118 and TVu 1890. Application of 30 and 45 kg P$_2$O$_5$ ha$^{-1}$ provided the best nutrition for effective reduction of cowpea pest load and damage with increased grain production. However, given the fact that yield difference between the application rate of 30 and 45 kg P$_2$O$_5$ ha$^{-1}$ was not significant and higher cost involved of applying P at 45 kg P$_2$O$_5$ ha$^{-1}$, the optimal level of phosphorus application for cowpea production under no insecticide protection is 30 kg P$_2$O$_5$ ha$^{-1}$. In other words, phosphorous application above 30 kg P$_2$O$_5$ ha$^{-1}$ will not result a corresponding increase in marginal return. The findings of this study also recommend that although P-application at 30 kg P$_2$O$_5$ ha$^{-1}$ reduced pest load and increased grain yield, higher grain yield could be enhanced through integrated pest management, especially if this rate is applied in conjunction with other cultural practices such as crop rotation, inter-cropping, planting date manipulation, plant spacing and biological control.

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