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EFFECT OF TIME OF APPLICATION OF SYNTHETIC PESTICIDES ON INSECT PEST DAMAGE TO, AND YIELD OF PIGEON PEA (*Cajanus cajan* (L.) Millsp.) IN MAKURDI, SOUTHERN GUINEA SAVANNA, NIGERIA

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ABSTRACT

Field experiments were conducted in the Teaching and Research Farm of University of Agriculture, Makurdi, Nigeria, in 2011 and 2012 cropping seasons to evaluate the effect of synthetic pesticides on insect damage to, and yield of pigeon pea (*Cajanus cajan* (L.) Millsp.). Experimental design was randomized complete block with four replications of three weekly applications of cypermethrin + dimethoate (0.13kg+0.56kg a.i./ha) at mid-vegetative (MV), mid-flowering (MF), mid-podding (MP), mid-vegetative and mid-flowering (MV +MF), mid-vegetative and mid-podding (MV + MP), mid-flowering and mid-podding (MF +MP) and mid-vegetative through to mid-podding (MV +MF +MP) stages of pigeon pea growth. An untreated plot served as the control (CT). Sprays applied at mid-flowering stage resulted in low damage by *Maruca vitrata* larvae and pod-sucking bugs, dominated by *Clavigralla tomentosicollis*, to pods (33.0-35.1% in 2011 and 34.1-38.0% in 2012), and seeds (31.8 - 34.6 % in 2011 and 33.4 - 36.0 % in 2012). Consequently, pod yield (153.0 - 175.0 pods/plant in 2011 and 111.0-147.5 in 2012), pod weight (0.8-1.1tha^{-1} in 2011and 0.7-0.8tha^{-1} in 2012), and seed yield (0.7 - 0.9t ha^{-1} in 2011 and 0.5 - 0.7t ha^{-1} in 2012) were significantly higher compared with plots sprayed at mid-vegetative and mid-podding stages. Three weekly insecticide sprays commencing at mid-flowering stage of pigeon pea production is recommended given the profit margins of ₦97,811.00 in 2011 and ₦37,811.00 obtained in 2012.

Keywords: Pigeon pea, Insecticide application, Insect damage, Crop growth stages, Yield.

INTRODUCTION

Pigeon pea (*Cajanus cajan* (L.) Millsp. is a tropical legume crop. India is the current largest world producer with an estimated production of 1.4 tonnes per hectare (AICRP Report, 2012). The crop is grown in many African countries: Kenya, Tanzania, Uganda, and South Africa (Minja *et al*., 1999, Muthomi *et al*., 2007; Kunjeku and Gwata, 2011;Marimuthu*et al*., 2012). In Nigeria, the major pigeon pea producing areas include Edo, Imo, Benue, Kogi, Enugu, and Nasarawa States (Egbe and Vange, 2008; Dialoke *et al*., 2010; Madang *et al*., 2012).

Pigeon pea is rich in protein and contains amino acids such as methionine and lycine (Saxena*et al*., 1998). It is grown in intercrop with cereals, in rotation with other crops, or grown to restore soil fertility (Egbe and Vange, 2008). Farmers in Nigeria have not developed control measures to maximize yield of pigeon pea in spite of the number of insect pests associated with it, their distribution and destructiveness (Lal and Singh, 1998; Shanower, 1999; Saboo and Senapathi, 2000; Dialoke *et al*., 2012; Sreekanth *et al*., 2015). Several synthetic insecticides have been found effective in controlling insect pests of legume crops in Nigeria (Oparaeke *et al*., 2005; Olotuah and Ofuya, 2010; Egbo, 2011). However, information on the efficacy of insecticides against insect pests of pigeon pea in the Nigerian Guinea savanna is scanty making judicious usage of insecticide on the crop difficult. In this paper, we report the effect of time and frequency of cypermethrin + dimethoate application on insect pest damage to pigeon pea and the economic benefits obtained.

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Farm, University of Agriculture, Makurdi, (Lat. 7° 41'N, Long.8° 37'E) in the southern Guinea savanna of Nigeria, during the 2011 and 2012 cropping seasons. The land which had been ploughed, harrowed, and ridged was demarcated into 32 plots each measuring 5 m × 5 m to accommodate four replications of eight treatments in randomized complete block design. The treatments were three weekly applications of cypermethrin (Cymbush10% EC^R) + dimethoate (Perfekthion 40% EC^R) (0.13kg+0.56kg a.i./ha) at mid-vegetative (MV), mid-flowering (MF), mid-podding (MP), mid-vegetative and mid-flowering (MV+MF), mid-vegetative and mid-podding (MV+MP), mid-flowering and mid-podding (MF+MP), and mid-vegetative through to mid-podding (MV+MF+MP) stages of pigeon pea growth. An untreated plot served as the control (CT). Two seeds of Igbongbo white variety of pigeon pea, obtained at Otobi, were sown per hole on 18th June 2011 and 15th June 2012 at inter-and intra-row spacing of 100cm and 30cm, respectively. Seedlings were thinned to one per stand at one week after sowing, giving a total of 34,000 plants per hectare. The plots were hoe-weeded at 3, 7 and 12 weeks after planting (WAP). All plots received 15 kg N, 6.45 kg P and 12.45 kg K per hectare by side placement of 100 kg of NPK 15:15:15, immediately after the first weeding.

At crop maturity, one plant was randomly selected per plot in each treatment and the pods were harvested, counted and recorded. Thereafter, pods in the three inner rows of each plot were harvested and weighed. A 250 g sample of pods was taken and sorted to assess damage, indicated by perforation and/or tunneling, shriveling or incomplete filling. A 250g sample of the seeds from threshed pods was taken to assess damage, indicated by malformed/pitted, sub-sized and discoloured seed.

Cost of insecticide application was computed as the sum of the cost of insecticides (₦3,330.00), application equipment ₦375.00 per day for hiring sprayer), and labour (₦600.00 per man day). Economic benefit of the insecticide application was obtained by comparing the cost with the revenue, i.e., the product of yield (t/ha) and market price of produce ₦ha).

All data were subjected to analysis of variance and significantly different means (P<0.05) were separated using Duncans Multiple Range Test. Data in percentages were transformed to arcsine and those with low and zero values were transformed to $\sqrt{x + 0.5}$ before analysis.

RESULTS AND DISCUSSION

The results in Tables 1 and 2 showed that the percentages of pod and seed damage in plots sprayed at mid-flowering stages were lower and not significantly different from each other in the two cropping seasons. Percentages of pod damage in the control plots were significantly higher but they were not as high as that reported by Dialoke *et al*. (2010) [70.77 %] in their survey of farmers' fields in Benue State. *Maruca vitrata* and pod-sucking bugs, dominated by *Clavigralla tomentosicollis*, were largely responsible for pod damage (as high as 56.4 %) and seed damage (as high as 56.5 %) in this study compared with 54.2% pod damage attributed to *M. vitrata* alone in the study by Sreekanth *et al*. (2015). High seed damage sequel to high pod damage (Tables 3 and 4) is not surprising. Mugo (1989) had reported that damaged pods may not produce seeds or may produce seeds in low quantity and quality and sometimes the seeds produced may not be viable.

Table 1. Pod and seed damage in pigeon pea plots sprayed with synthetic insecticides at various stages of growth in 2011.

Treatments[1]	**%** Pod damage [2,3]	% Seed damage[2,3]
CT	56.2±2.0a	56.5±2.5a
MV	56.4±2.4a	56.1±1.9ab
MF	33.5±5.5c	34.6±4.2d
MP	49.8±2.4b	49.5±3.3c
MV+MF	35.1±4.1c	31.8±1.3d
MV+MP	53.0±4.0ab	51.7±1.9bc
MF+MP	33.0±4.4c	33.1±2.9d
MV+MF+MP	32.1±3.8c	33.3±2.9d

[1]CT = Control; MV= Mid- vegetative stage; MF= Mid-flowering stage; MP= Mid-podding stage; MV+MF= Mid-vegetative + Mid-flowering stage; MV+MP= Mid-vegetative + Mid-podding stage; MF+MP= Mid-flowering + Mid-podding stage; MV +MF +MP= Mid-vegetative + Mid- flowering + Mid-podding stage.
[2] Column means (plus or minus standard error) followed by the same letters are not significantly different at P=0.05 (DMRT).
[3]Based on the 250 g sample examined.

Table 2: Pod and seed damage in pigeon pea plots sprayed with synthetic insecticides at various stages of growth in 2012.

Treatments[1]	% pod damage [2,3]	% Seed damage [2,3]
CT	50.8±1.4a	54.7±1.8a
MV	50.7±4.2a	49.9±1.9b
MF	35.8±3.2c	36.0±2.3c
MP	45.5±0.5b	49.3±4,0b
MV+MF	34.1±3.2c	33.4±1.7c
MV+MP	46.5±1.0ab	47.1±1.0b
MF+MP	38.0±3.9c	34.0±1.4c
MV+MF+MP	34.6±3.1c	33.8±1.0c

[1] CT = Control; MV= Mid- vegetative stage; MF= Mid- flowering stage; MP= Mid-podding stage; MV+MF= Mid-vegetative + Mid-flowering stage; MV+MP= Mid-vegetative + Mid-podding stage; MF+MP= Mid-flowering + Mid-podding stage; MV +MF +MP= Mid vegetative + Mid- flowering + Mid-podding stage. [2] Column means (plus or minus standard error) followed by the same letters are not significantly different at P=0.05 (DMRT).
[3]Based on the 250g sample examined

Table 3: Yield and yield components of pigeon pea sprayed with synthetic insecticides at various stages of growth in 2011.

Treatments[1]	No. pods/plant[2]	Pod yield (t/ha)	Seed yield. (t/ha)
CT	43.3±4.1d	0.3±0.0e	0.1±0.0d
MV	55.5±5.1d	0.4±0.1de	0.3±0.0cd
MF	175.0±2.3a	0.9±0.1ab	0.8±0.0ab
MP	138.8±1.7abc	0.5±0.1de	0.4±0.1c
MV+MF	159.0±9.7ab	0.8±0.1bc	0.7±0.1b
MV+MP	106.8±2.6c	0.6±0.1cd	0.5±0.1c
MF+MP	130.3±1.6bc	1.0±0.2ab	0.8±0.1ab
MV+MF+MP	153.0±2.6ab	1.1±0.2a	0.9±0.1a

[1] CT= Control; MV= Mid- vegetative stage; MF= Mid- flowering; MP= Mid-podding stage; MV+MF= Mid- vegetative + mid- flowering stage; MV+MP= Mid- vegetative + Mid-podding stage; MF+MP= Mid-flowering + Mid-podding stage; MV+MF+MP= Mid- vegetative + Mid-flowering + Mid-podding stage.
[2] Column means (plus or minus standard error) followed by the same letters are not significantly different at P=0.05 (DMRT).

Table 4: Yield and yield components of pigeon pea sprayed with synthetic insecticides at various stages of growth in 2012.

Treatments[1]	No. pods/plant[2]	Pod yield (t/ha).	Seed yield (t/ha).
CT	21.3±1.3c	0.4±0.0b	0.2±0.0c
MV	23.0±2.0c	0.4±0.1b	0.2±0.1c
MF	111.0±24.9b	0.8±0.1a	0.5±0.1b
MP	53.8±3.7c	0.4±0.1b	0.3±0.1c
MV+MF	141.5±7.1ab	0.7±0.1a	0.6±0.1ab
MV+MP	48.3±10.4ab	0.4±0.1b	0.6±0.0ab
MF+MP	120.3±17.4ab	0.8a000.8a0.8a	0.6±0.0ab
MV+MF+MP	147.5±9.7a	0.8±0.0a	0.7+0.0a

[1] CT= Control; MV= Mid- vegetative stage; MF= Mid-flowering stage; MP= Mid-podding stage; MV+MF= Mid- vegetative and Mid-flowering stage; MV+MP= Mid- vegetative + Mid-podding stage; MF+MP= Mid-flowering + Mid podding stage; MV+ MF+ MP= Mid- vegetative + Mid- flowering + Mid-podding stage.
[2] Column means (plus or minus standard error) followed by the same letters are not significantly different at P=0.05 (DMRT).

The plots sprayed at mid-flowering were highly productive in terms of pod and seed yield. In this study, the combined impact of *M. vitrata* and *C. tomentosicollis* resulted in high values of seed yield loss (66.7-88.9%). In Uganda, seed yield loss attributed to *Heliohis armigera* was 5.0% (Kochler and Rachie, 1971); at Kabete and Katumani in Kenya, pod borers caused 25.8 % and 62.7 % seed yield loss, respectively (Okeyo-Owuor and Kamala, 1980).

Economic analysis of the spray regimes (0-9) show that three weekly sprays of pigeon pea commencing at mid-flowering was the most profitable in both 2011 and 2012 (Tables 5 and 6). This is comparable with the findings of Amatobi (1995) and Oparaeke *et al*. (2005) in their studies on economic production of cowpea seeds. The lower profit margin in 2012 is attributed to slightly lower yield and a drop in market price of the produce. The high marginal return obtained in plots treated at MF will be an incentive to the peasant farmer because he can increase grain production substantially with minimal usage of insecticide.

CONCLUSION

Based on insect pest damage and seed yield data, three weekly sprays of cypermethrin + dimethoate commencing at the mid-flowering stage is the most profitable for economic production of pigeon pea seeds.

Table 5. Economic analysis of insecticide application in 2011.

Treatment[1]	No. of sprays	Cost (₦)	Seed yield (t/ha).	Revenue (₦)	Profit Margin(₦)
CT	-	-	0.1	15,000.00	15,000.00
MV	3	12,915.00	0.3	45,000.00	32,085.00
MF	3	12,915.00	0.8	120,000.00	107,085.00
MP	3	12,915.00	0.4	60,000.00	47,085.00
MV+MF	6	25,830.00	0.7	105,000.00	79,170.00
MV+MP	6	25,830.00	0.5	75,000.00	49,170.00
MF+MP	6	25,830.00	0.8	120,000.00	94,170.00
MV+MF+MP	9	38,745.00	0.9	135,000.00	96,255.00

[1]CT= Control; MV= Mid-vegetative stage; MF= Mid-flowering stage; MP= Mid-podding stage; MV+MF= Mid-vegetative + Mid-flowering stage; MV+MP= Mid-vegetative + Mid- podding stage; MF+MP= Mid-flowering + Mid-podding stage; MV+MF+MP= Mid-vegetative + Mid-flowering + Mid-podding stage.

Table 6: Economic analysis of insecticide application in 2012.

Treatments[1]	No. of sprays	Cost (₦)	Seed yield (t/ha.)	Revenue (₦)	Profit Margin(₦)
CT	_	_	0.2	24,000.00	24,000.00
MV	3	12,915.00	0.2	24,000.00	11,085.00
MF	3	12,915.00	0.5	60,000.00	47,085.00
MP	3	12,915.00	0.3	36,000.00	23,085.00
MV+MF	6	25,830.00	0.6	72,000.00	46,170.00
MV+MP	6	25,830.00	0.6	72,000.00	46,170.00
MF+MP	6	25,830.00	0.6	72,000.00	46,170.00
MV+MF+MP	9	38,745.00	0.7	84,000.00	45,255.00

[1]CT= Control; MV= Mid-vegetative stage; MF= Mid-flowering stage; MP= Mid-podding stage; MV+MF= Mid-vegetative + Mid-flowering stage; MV+MP= Mid-vegetative + Mid-podding stage; MF+MP= Mid-flowering + Mid-podding stage; MV+MF+MP= Mid-vegetative + Mid-flowering Mid-podding stage

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