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Influence of Poultry Manure Application on Insect Pests of Two Varieties of Pigeon Pea [*Cajanus cajan* L. Millsp] in a Humid Tropical Environment

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ABSTRACT

Field evaluation of the effect of variety and poultry manure application rates on the relative abundance of insect pests of pigeon pea, Cajanus cajan, was carried out at the Teaching and Research Farm of the School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri, southeastern Nigeria. The trial was laid out in a 2 x 5 factorial arrangement fitted into a Randomized Complete Block Design. Two (2) varieties of pigeon pea, locally called "Gammu gammu" and "Chorie", were treated with five levels of poultry manure (PM) at 0.00 (control), 1.80, 3.60, 5.40 and 7.20 kg/plot and replicated four times. Seeds were planted at a spacing of 30 cm x 60 cm (55,556 plants ha^{-1}). Percentage seed emergence was recorded after 50 % emergence and insect pest sampling was carried out weekly from the third week after sowing. Leaf damage and other growth parameters (number of leaves and branches) were carried out at 3, 6 and 9 weeks after planting (WAP). Yield measurement parameters (pod, seed and shell weights) were assessed. Major insect pests of pigeon pea at vegetative phase identified, in order of importance, were; Leptualaca fassicollis Thoms (leaf beetles), Empoasca facialis Jacobi (Jassids, Green leaf hoppers), Aphis craccivora Koch (Aphids), Podagrica spp. Jacoby (Flea beetles), Bemisia tabaci Gennadius (Whiteflies) and Zonocerus variegatus Linnaeus (Variegated grasshoppers). Major flower and pod-damaging insects were; Helicorverpa armigera Hübner (Pod borers), Mylabris pustulata Thunberg (Blister beetles), Nezera viridula Linnaeus (Southern green stink bugs), Riptortus dentipes Fabricius (Pod-sucking bugs), Maruca vitrata Fabricius (Bean pod borers) and Anoplocnemis curvipes Fabricius (Coreid bugs), in that order. There were no significant differences between the varieties but increased rate of poultry manure application led to increases in the number of branches, buds and leaves and also had a significant effect on leaf damage. Plants treated with highest rate of poultry manure (7.20 kg), in both varieties, tolerated insect attack and had more leaves, branches and yield (pod, seed and shell weights) than those treated with 3.60, 1.80 and 0.00 kg respectively. It may be concluded that the cultivation of pigeon pea with poultry manure, in a humid tropical environment, will increase yield and tolerance of the crop to insect pest attack..

Key words: Insect pests, pigeon pea, poultry manure, variety, yield parameters

INTRODUCTION

Pigeon pea [*Cajanuscajan* (L.) Millsp.] is a versatile, stress-tolerant, and nutritious grain legume, possessing traits of value for enhancing the sustainability of dry sub-tropical and tropical agricultural systems (Khoury *et. al*., 2015). The crop originated from India and moved to Africa about 4,000 years ago and is concentrated in developing countries, particularly in a few South and South east Asia and Eastern and Southern African countries (Snapp *et al*,. 2003). Its seeds, rich in protein (Gopalan, *et al.,* 1984, Amarteifo *et al.,* 2002,) and carbohydrate are used in the preparation of many types of dishes in India and parts of Africa (Salunkhe *et. al*., 1986)

Pigeon pea has varied products; dried seed, pods and immature seeds - used as green vegetables, leaves and stems used for fodder and the dry stems as fuel (Snapp *et al*., 2003). The mature seed, a good source of vitamins,iron, selenium and small amounts of zinc, copper and manganese, could reasonable be a substitute for dairy and meat-based diets for poor families (Simtowe *et al*., 2007).

Amongst its many medicinal uses, *C. cajan* is indicated in the relief of pain and as a sedative, for the treatment of diabetes, sores, skin irritations, hepatitis, measles, jaundice, dysentery and for expelling bladder stones and stabilizing menstrual period. It is used in the remedy of bronchitis, pneumonia, cough, respiratory infections, cold, chest problems and sore throat. The plant has vulnerary, diuretic, astringent, antidote, sedative, laxative, expectorant and vermifuge properties. Pigeon pea is also used to heal earache, abdominal pain, tumors, ulcer, wounds, sores, enteritis, inflammations, skin problems such as urticarial (skin rash), genital irritations and dermatitis (Ambasta, 2004; Ahsan and Islam, 2009; Yuan-gang *et al*., 2010; Pal *et al*., 2011; NYBG, 2013)

The crop competes poorly with weeds and can be slow to establish if soils are not at least 64°F (Mullen *et al*., 2003) but withstands low moisture condition and performs well in areas with less than 1000 mm of annual rainfall, depending on the distribution pattern (Simtowe *et al*., 2007). As a green manure, it improves soil structure, quality and can fix about 28 kg (62 lb) N/acre up to the time when pods are produced (Phatak *et al*., 1993). It also improves soil fertility through leaf fall and recycling of the nutrients (Snapp *et al*., 2002), performs well in poor soils (Reddy *et al*., 1993) and can be incorporated with crops such as maize, sorghum or groundnuts without significantly reducing the yield of the main crop (Simtowe *et al*., 2007).

Pigeon pea is damaged by over 200 species of insects worldwide (Reed and Lateef, 1990). Insects infesting the reproductive parts cause the maximum reduction in grain yield. Pod borer, *Helicoverpa* (*Heliothis*) *armigera* Hubner; seed-feeding Dipteran and Hymenopteranpod fly (*Melanagromyza chalcosoma* Spencer and *Melanagromyza obtusa* Malloch), legume pod borer or spotted caterpillar, *Maruca (testulalis) vitrata* Geyer; plume moth, *Exelastis atomosa* Walsingham; blister beetles *Mylabrisspp*; pod sucking bugs *Clavigralla spp* and bruchids, *Collasobruchus spp* are the most common (Minja *et al*.,1999; Sharma *et al*., 1999; Rao *et al*., 2002; Kumar and Nath, 2003; Dialoke, *et al*., 2010).

Pigeon pea is not a very popular crop in Owerri area of Imo state despite its nutritional value. Effort is, therefore, being made to get the appropriate rate of manure that will not aid insect infestation but increase yield, induce resistance/tolerance of the crop to insect attack through organic means, thereby reducing the risk of crop failure due to insect attack. The trial also aimed at identifying, out of the two common varieties, the one with promising growth characteristics and the relative presence of insect pests at different stages of the plant's development in the humid environment of Owerri, Nigeria.

MATERIALS AND METHODS

Field Location

The experiment was carried out at the Teaching and Research Farm of the School of Agriculture and Agricultural Technology of the Federal University of Technology, Owerri, southeastern Nigeria, located on latitude $5^0\ 28^{'}\ 46.45^{''}$ North and longitude $7^0\ 02^{'}\ 38.35^{''}$ East of the equator with an elevation of 55.3m above sea level. The location had a mean rainfall of 203.2 mm, mean temperature of between 32.2°C and 28.8°C, and mean relative humidity of 77.9 % from January to October, 2014 (the weather records were collected from Imo State Agricultural Development Programme (ADP), Owerri, Nigeria). The vegetation is tropical rain forest. The soils are mainly ultisols, generally sandy, of low nutrient reserve and acidic with high degree of erodibility. The hydrology is governed by Otamiri River.

Planting material

Two main varieties of pigeon pea seeds, locally called "*Gammu gammu*" and "*Chorie*", sourced from Nsukka, Enugu State, southeast agro-ecological zone of Nigeria and dry poultry manure, sourced from the Department of Animal Science and Technology Poultry Farm of the University, were used for this experiment. Poultry manure was incorporated in the plots following the treatment combination below.

Germination test

Thirty pigeon pea seeds were selected randomly from each variety and placed into three petri - dishes (10 seeds/petri-dish) lined with Whatman's filter paper moistened with water. These were moistened daily and allowed to stand for seven days. The number of emerged seeds per petri dish were counted and recorded. These were used to calculate the percentage:

$$\text{Percentage germination} = \frac{\text{No of germinated seeds}}{\text{No of seeds planted}} \times \frac{100}{1}$$

Field Preparation/Mapping out

The experimental site was cleared of all existing secondary vegetation with the use of cutlass and cleaned from all debris. An area of land measuring 18 m × 41 m (738 m^2) was mapped out using a 100 m tape, pegs, ranging poles and garden rope.

Experimental Design

A 2 x 5 factorial experiment was laid out in a Randomized Complete Block Design (RCBD) with four replicates. Each plot/bed measured 3 m x 3 m (9 m^2) and 1m alleys between plot and blocks which gave a total of 40 plots. At a spacing of 30 cm x 60 cm, each plot had 50 plants with a total of 2,000 plants (55,556 plants ha^{-1}).

Treatment Rates/Combinations

Treatments comprised of dry poultry manure, measured at 5 application rates thus: 0.0 t/ha (PM 0.0 kg/ 9 m^2); 2.0 t/ha (PM 1.8 kg/9 m^2); 4.0 t/ha (PM 3.6 kg/9 m^2); 6.0 t/ha (PM 5.4 kg/9 m^2) and 8.0 t/ha (PM 7.2 kg/9 m^2) and 2 varieties of pigeon pea: V_1 = Variety 1and V_2 = Variety 2. These were combined to give a total of 10 treatment combinations thus: V_1PM0.0kg; V_2PM0.0kg; V_1PM1.8kg; V_2PM1.8kg; V_1PM3.6kg; V_2PM3.6kg; V_1PM5.4kg; V_2PM5.4kg; V_1PM7.2kg; V_2PM7.2kg. The treatment combinations were randomly allocated into each block.

Field Application of Treatment/Sowing:Measured poultry manure was spread and incorporated into each plot according to the treatment randomization and combination and allowed to mineralize for seven days before sowing. Two Seeds of pigeon pea were sown per hole, later thinned down to one, at a spacing of 30 cm x 60 cm.

Weeding: Weeding was done manually with hoes at 3 weeks after planting and subsequently every 2 weeks.

Insect Sampling*:* Insect pests were collected with a sweep net, cellophane bags and sample bottles. Others were hand-picked using hand gloves and plastic forceps. Samplings were carried out from 6:30am -7:30am every Thursday from the third week after sowing. Collected insects were stored in containers with cotton wool, dipped in chloroform and later identified in the laboratory and recorded.

Data Collection

Data were collected on the following:

Percentage Emergence
This was recorded when 25 plants in each plot had emerged. It was done by hand counting and collated data converted to percentage germination as above.

Number of Leaves
The total number of leaves on each of the 15 randomly selected and tagged plants was counted at 3, 6 and 9 weeks after planting (WAP), respectively.

Leaf Damage Assessment
The assessment was done through visual recording of the number of leaves damaged by insects. It was carried out by counting the number of leaves damaged by insects on the 15randomly selected and tagged stands. Damage assessments were recorded at 3, 6 and 9 WAP, respectively.

Number of Branches per Plant
The total number of branches on each of the15 randomly selected and tagged stands were recorded at 3, 6 and 9 WAP, respectively.

Yield Measurement
Yield measurements were achieved through the following parameters:

Pod Weight
The pods from each plot were harvested and weighed, using Camry Emperor weighing balance (model J1111427541) in grams.

Seed Weight
The seed weight was measured after the pods from each plot were harvested and the seeds from dehisced pods weighed in grams.

Shell Weight
The shell weight measurement was carried out after drying under shade. The dried shell from each plot was weighed in grams.

Statistical Analysis

The data collected were subjected to Analysis of Variance (ANOVA) for Randomized Complete Block Design (RCBD) in a 2 x 5 factorial arrangement replicated four times. GENSAT Computer Software for data analysis was used and mean separation procedure was as described by Wahua, (1999) using Fisher's Least Significant Difference (LSD) at P = 0.05 level of significance.

RESULTS

Table 1 indicates no significant differences in the percentage emergence among the two varieties of pigeon pea. Though not statistically significant, variety 2 had higher germination percentage (79.90 %) than variety 1 (72.94 %). It was observed that from the third poultry manure rate (5.40 kg/plot), the germination percentage decreased as the rate of poultry manure increased. There were no significant differences as a result of the interaction between poultry manure application rate and varieties.

Table 1: Influence of poultry manure application rates on percentage emergence of two varieties of *Cajanus cajan*

Treatment [Pm (kg/plot)]	Accession		
	Variety 1	Variety 2	Mean
0	70	80.5	75.25
1.8	65.7	74.5	70.1
3.6	79.5	82.5	81
5.4	74	85	79.5
7.2	75.5	77	76.25
Mean	**72.94**	**79.9**	

$LSD_{0.05}$ Pm = NS
$LSD_{0.05}$ Var. = 7.1
$LSD_{0.05}$ Pm x Var. = NS

Where; Pm = Poultry manure , Var. = Variety
Pm + Var. = Poultry manure and Variety interaction
NS = Non-significant

Table 2: Influence of poultry manure application on the mean number of leaves in two varieties of *Cajanus cajan* at 3, 6 and 9 WAP

Treatment P.M (kg/plot)	Accession		
	Variety 1	Variety 2	Mean
3 WAP			
0	19.9	19	19.45
1.8	21.1	19	20.1
3.6	21.6	22.3	21.95
5.4	21.9	21.3	21.6
7.2	24.5	23	23.75
Mean	**21.8**	**20.94**	
$LSD_{0.05}$ Pm = NS			
$LSD_{0.05}$ Var. = NS			
$LSD_{0.05}$ Pm + Var. = NS			
6 WAP			
0	45.9	47.8	46.85
1.8	47.4	42.5	44.95
3.6	44.8	53.4	49.1
5.4	44	51.5	47.75
7.2	56.9	54.4	55.65
Mean	**47.8**	**49.92**	
$LSD_{0.05}$ Pm = NS			
$LSD_{0.05}$ Var. = NS			
9 WAP			
0	91.3	96.4	93.85
1.8	94.4	92.1	93.25
3.6	98.1	98.6	98.35
5.4	100.4	100.7	100.55
7.2	102	108.8	105.4
Mean	**97.24**	**99.32**	
$LSD_{0.05}$ Pm = 8.3			
$LSD_{0.05}$ Var. = NS			

Where; Pm = Poultry manure , Var. = Variety
Pm + Var. = Poultry manure and Variety interaction
NS = Non-significant

Table 3: Influence of poultry manure application on the mean number of branches in two varieties of *Cajanus cajan* at 3, 6 and 9 WAP

Treatment [Pm(kg/plot)]	Accession		
	Variety 1	Variety 2	Mean
3 WAP			
0	6.9	7.4	7.15
1.8	8.3	8.1	8.2
3.6	8.7	8.9	8.8
5.4	8.8	9.2	9
7.2	10.5	9.5	10
Mean	**8.64**	**8.62**	
$LSD_{0.05}$ Pm = 0.6			
$LSD_{0.05}$ Var. = NS			
$LSD_{0.05}$ Pm + Var. = 0.8			
6 WAP			
0	8.7	8.5	8.6
1.8	10.6	10.1	10.35
3.6	10.8	11.1	10.95
5.4	10.8	11	10.9
7.2	12.6	11.5	12.05
Mean	**10.7**	**10.44**	
$LSD_{0.05}$ Pm = 20.8			
$LSD_{0.05}$ Var. = NS			
$LSD_{0.05}$ Pm + Var. = NS			
9 WAP			
0	9.8	9.3	9.55
1.8	12.6	12.1	12.35
3.6	13	13.3	13.15
5.4	13	12.8	12.9
7.2	14.6	14	14.3
Mean	**12.6**	**12.3**	
$LSD_{0.05}$ Pm = 0.5			
$LSD_{0.05}$ Var. = NS			
$LSD_{0.05}$ Pm + Var. = NS			

Where; Pm = Poultry manure , Var. = Variety
Pm + Var. = Poultry manure and Variety interaction
NS = Non-significant

No significant differences existed in the mean number of leaves between the two varieties at 3 and 6 WAP (Table 2.), respectively. At 9 WAP however, poultry manure application at the highest rate (7.20 kg) had significant effect on the 2 varieties when compared with the control. The higher rate (5.40 kg) had increased number of leaves in variety 1 only.

In Table 3, poultry manure application effected no statistically significant differences on the mean number of branches in both varieties. However, increase in manure rates increased the mean number of branches (7.15-10.00), (8.60-12.05) and (9.55-14.30) at 3, 6 and 9 WAP, respectively. The interaction between manure rates and varieties had no significant effect on branching at 6 and 9 WAP, respectively. The highest manure rate (7.20 kg),

Table 4: Prevalent Major Vegetative Phase Insect Pests of Two Varieties of Pigeon pea in Owerri Ecological Zone, southeastern Nigeria

Treatment [P.M (Kg/plot)]	Lf	Pu	Bt	Ef	Zv	Ac
	VARIETY 1					
0	16.5	12.1	5	15.4	3.1	13.1
1.8	19	11.9	9.1	16.8	4.8	14.2
3.6	15.8	12.6	5.3	14.1	5.4	15.6
5.4	18.6	11.6	6.1	15.2	6.4	16.8
7.2	20.4	15.8	8.4	16.4	7.2	16.8
Mean	**18.06**	**12.8**	**6.78**	**15.58**	**5.38**	**15.3**
	VARIETY 2					
0	17	11	4.1	15.1	2.2	11
1.8	17.6	11	6.2	18.8	4.3	13.4
3.6	18.5	12.5	3.2	14.2	4.3	13.4
5.4	17.8	18	5.4	15.4	3.1	14.5
7.2	19.8	16.9	6.1	17.1	3.2	15.2
Mean	**18.14**	**13.88**	**5**	**16.12**	**3.42**	**13.5**
GRAND MEAN	**18.1**	**13.34**	**5.89**	**15.85**	**4.4**	**14.4**

Where, Lf = *Leptualaca* fassicollis Thoms (leaf beetles); Pu = *Podagrica uniforma* Jacoby (flea beetle)
Bt = *Bemisiatabaci* Gennadius (whitefly); Ef = *Empoasca facialis* Jacobi (cotton jassid, green leaf hopper)
Zv = *Zonocerus variegatus* Linnaeus (Variegated grasshopper); Ac = *Aphis craccivora* Koch (aphids)

however, had a significant effect (P ≥ 0.5) on variety 1 when compared with other interactions. There were noticeable increases in the number of branches as the poultry manure rates increased.

Table 4 shows the prevalent vegetative insect pests of pigeon pea in Owerri ecological zone, southeastern Nigeria. *Leptualacafassicollis* Thoms (Coleoptera: Chrysomelidae) (leaf beetles) had the highest grand mean (18.10), followed by *Empoasca facialis* Jacobi (Homoptera, Cicadellidae) (Jassids, Green leaf hoppers) (15.85), *Aphis craccivora* Koch (Hemiptera: Aphididae) (Aphids) (14.40), *Podagrica Species* Jacoby (Coleoptera: Chrysomelidae) (Flea beetles) (13.34), *Bemisiatabaci* Gennadius (Homoptera: Aleyrodidae) (Whiteflies) and *Zonocerus variegatus* Linnaeus (Orthoptera: Pyrgomorphidae) (Variegated grasshoppers) with the least number (4.40), in that order.

The mean number of damaged leaves at 3, 6 and 9 WAP, respectively, are as shown in Table 5. At 6 and 9 WAP, there were no significant differences on the mean number of damaged leaves. However, significant differences existed between the two varieties at 3 WAP under 7.20 kg manure application rate. The increase in the rate of poultry manure increased the mean number of damaged leaves at 3 and 6 WAP. At 9 WAP, however, there was a discernible decrease in the mean number of damaged leaves as poultry manure increased progressively. The interaction between the different levels of poultry manure and the varieties had no significant differences (P ≥ 0.5) at 3 and 9 WAP but were of significant effect at 6 WAP.

Major insect pests that attacked *C. cajan at* the flowering/podding stages in the field are shown in Table 6. Collated grand mean for the two varieties showed that *Helicorverpa armigera* Hübner (Lepidoptera: Noctuidae) (Pod borers) were predominant at the reproductive phase of the plant (45.31 insects), followed by *Mylabris pustulata* Thunberg (Coleoptera: Meloidae)(Blister beetles) (35.70), *Nezera viridula* Linnaeus (Heteroptera: Vespidae) (Southern green stink bugs) (34.66), *Riptortus dentipes* Fabricius (Heteroptera: Alydidae) (Pod-sucking bugs) (27.79), *Maruca vitrata* Fabricius (Lepidoptera: Crambidae) (Bean pod borers) and *Anoplocnemiscurvipes* Fabricius (Heteroptera: Coreidae) (Coreid bugs), in decreasing order of importance.

The effect of varietal, poultry manure application rates and insect pest infestation on the pod, seed and shell weights of *C. cajan* are as depicted on Table 7. Result showed no significant differences on yield assessment parameters (pod, seed and shell weights) in both varieties. Though not statistically different, variety 1 pod (36.26 g), seed (12.17 g) and shell (23.99 g) yields were higher than that of variety 2 (34.55, 11.83 and 22.69 g), respectively. Increase in poultry manure rate (1.80 to 7.20 kg) had significant effect on pod and seed weights but were of no significant effect on shell weight. The interaction between poultry manure and the varieties were largely of no significant effect in the yield assessment. However, the interaction between 3.60 kg poultry manure and variety 1 was exceptionally higher in pod weight (36.82 g), seed weight (10.45 g) and shell weight (26.37 g) than that of variety 2 (23.46, 6.75 and 16.68 g), respectively.

Table 5: Influence of poultry manure application on the mean number of damaged leaves in two varieties of *Cajanus cajan* at 3, 6 and 9 WAP

Treatment [P.M (kg/plot)]	Accession		
	Variety 1	Variety 2	Mean
3 WAP			
0	2.45	3	2.73
1.8	3.1	2.9	3
3.6	2.2	3.8	3
5.4	3.1	3.2	3.15
7.2	4.3	3.8	4.05
Mean	**3.03**	**3.34**	
$LSD_{0.05}$ Pm = 0.8			
$LSD_{0.05}$ Var. = 0.54			
$LSD_{0.05}$ Pm + Var. = NS			
6WAP			
0	4.8	5.1	4.95
1.8	4.9	4.9	4.9
3.6	4.2	6.4	5.3
5.4	5.1	5.5	5.3
7.2	7	6.1	6.55
Mean	**5.2**	**5.6**	
$LSD_{0.05}$ Pm = 0.8			
$LSD_{0.05}$ Var. = NS			
$LSD_{0.05}$ Pm + Var. =1.2			
9 WAP			
0	4.4	4.4	4.4
1.8	4.6	4.8	4.7
3.6	4	4.1	4.05
5.4	4.3	4.8	4.55
7.2	6	6.1	6.05
Mean	**4.66**	**4.84**	
$LSD_{0.05}$ Pm = 1.2			
$LSD_{0.05}$ Var. = NS			
$LSD_{0.05}$ Pm + Var. = NS			

Where; Pm = Poultry manure , Var. = Variety
Pm + Var. = Poultry manure and Variety interaction
NS = Non-significant

DISCUSSION

Poultry manure application rates had no effect on crop emergence indicating that germination rate and initial establishment does not necessarily depend on poultry manure application. Jalaluddin and Hamid (2011) had, in a comparison of the effect of adding inorganic, organic and microbial fertilizers in soil on the germination of seeds of 4 sunflower varieties, found that cow dung manure, triple phosphate and microbial fertilizer (VAM-fungal spores) had no effect for 6 days and the percentage of germination of seeds was equal to the control series. The two pigeon pea varieties adapted well to the humid environment of Owerri but variety 2 (79.90) had higher percentage emergence than variety1 (72.94). Variety has been reported as one of the factors which may influence emergence and establishment of pigeon pea (Khan and Ashley, 1975).

Insect pests which attacked the crop at vegetative stage of development varied with those that infested the crop during flowering. As collaborated by Dialoke (2013), at the juvenile vegetative stage, there was a high level of *L.fassicollis* infestation in the field. Following in population were, *E. facialis*, *A. craccivora*, *Podagrica Spp.*, *B.tabaci* and *Z. variegatus*, in that order. These insects were not meaningfully present during the flowering and pod - bearing stages. Though recorded as pests of pigeon pea in Asia (Ranga Rao and Shanower, 1999) and South Africa (Kunjeku and Gwata, 2011), these insectsare not, strictly speaking, regarded as economic pests of pigeon pea since they were "neither continuously present nor attacked at the middle or end of the crop cycle" (Shanower *et al*., 1999).

The rates of poultry manure application seem to have limited effect on the preponderance of insects at this stage of growth. There may have been little manure mineralization (at 4 – 5 WAP) and, therefore, manure application may not have effected vegetative growth and consequent attraction of insect pests. Gale *et al.* (2006) and Andrews and Foster (2007) have reported that only about 40 – 70 % of mineralization value of organic manure occurs within the first 4 - 8 weeks following application.

There were more insect species at the reproductive than at the vegetative stage. Shanower *et al.* (1999) has noted that insect feeders of flowers, pods and seeds are pigeon pea's most important biotic constraint to adequate production of the crop in Africa. This tended to agree with the report of Dialoke *et al*. (2010) that pod sucking bugs (*Anoplocnemis curvipes, Riptortus dentipes* and *Nezara viridula L.*) are the major insect pests of pigeon pea in Nigeria. We, however, observed that *H. armigera* were the most numerical of the insects at the onset of flowering.

Table 6: Prevalent Major Insect Pests of Pigeon pea at Flowering and Pod- bearing Phases in Owerri Ecological Zone, southeastern Nigeria

TREATMENT [P.M (Kg/plot)]	Rd	Nv	Mp	Ac	Ha	Mv
	VARIETY 1					
0	20.1	30.2	30.8	18.1	40.5	20.1
1.8	22.4	30.4	35.6	20.6	41.8	22.2
3.6	28.6	32.2	34.1	20.6	50.2	22.4
5.4	29.4	36.1	36	24.8	40.1	26.8
7.2	35.1	43.1	39	28.1	50.4	27.6
Mean	**27.12**	**34.4**	**35.1**	**22.44**	**44.6**	**23.82**
	VARIETY 2					
0	25.1	30.4	32.6	20.5	40.1	22.7
1.8	26.4	31.3	35.1	22.5	42.2	22.8
3.6	26.3	32.4	35.4	22.6	44.6	23.2
5.4	28.4	38.4	38	23.1	48	24.2
7.2	36.1	42.1	40.4	27.4	55.2	27.4
Mean	**28.46**	**34.92**	**36.3**	**23.22**	**46.02**	**24.06**
GRAND MEAN	27.79	34.66	35.7	22.83	45.31	23.94

Where, Rd = *Riptortus dentipes* Fabricius (Pod-sucking bug); Nv = *Nezera viridula* Linnaeus (Green stink bug)
Mp = *Mylabris pustulata* Thunberg(blister beetle)*;* Ac = *Anaplocnemis curvipes* Fabricius (Coreid bug)
Ha = *Helicorverpa armigera* Hübner (Pod borer); Mv = *Marucavitrata* Fabricius (Bean pod borer)

Mylabris pustulata, *N. viridula*, *R. dentipes*, *M. vitrata* and *A.curvipes*, in that order, were next in importance to *H. armigera.* Agro-climatic conditions could affect the development of pest species as very light rainfall generally support high buildup of insects while heavy rainfall discourages them (Dialoke *etal.,* 2013). It has earlier been reported that heavy rainfall (1,600.00 mm annual rainfall), flood and humidity are the major factors controlling pest populations in natural environments (Mandal *et al*., 2009).

Though there has been a subsisting and general observation that pigeon pea responds poorly to inorganic fertilizer application (Edwards, 1981; Kulkarni and Panwar, 1981), it was, however, observed that application of poultry manure had a significant effect on branching in this study. The number of branches increased with increment in the rate of organic manure application. This probably supports the findings of Okokoh and Bisong, (2011) which reported that the interaction of poultry manure (15 tonnes) application and Urea (N 30 kg/ha) produced vigorously growing plants that had the highest number of branches per plant than those planted with zero poultry manure plots fertilized with Urea-N at 20 kg/ha.

Variety type had no statistically significant ($P \geq 0.5$) effect on leaf damage. However, virtual observation showed that variety 1 had higher mean leaf damage than variety 2. Poultry manure had a significant effect on the rate of leaf damage. That the highest poultry manure rate (7.2 kg) gave the highest mean number of damaged leaves at all developmental stages in the field, may be the consequent presence of succulent and robust leaves in such plants. Though proponents of organic farming have long promoted the view that pest outbreaks is reduced with organic farming practices (Oelhaf, 1978; Merrill, 1983). Altieri and Nicholls (2003) had, however, observed that cultural methods, such as crop fertilization, affect susceptibility of plants to insect pests by altering plant tissue nutrient levels. Zehnder (2014) has posited that over-fertilizing crops can actually increase pest problems by increasing soluble nitrogen levels in plants which can decrease their resistance to pests, resulting in higher pest density and crop damage. Although Sarfraz *et al*. (2009) had posited that host plant nutritional quality could ameliorate, exacerbate, or have no effect at all on the host preference and performance of insect herbivores; Heisswolf *et al.* (2005) had earlier argued that vigorous plants frequently support higher densities of insect herbivores than their stressed counterparts. Bommesha *et al*. (2012) has also corroboratively reported that incidence of insect pests in leaves and green pods of pigeon pea could be influenced by the application of organic manures.

It should be noted, however, that at higher mean leaf damage, the crop tolerated the attack by insect pests when compared with the control (with zero application of manure). This succinctly shows that the crop, when grown under optimum soil fertility, can tolerate stress caused by insect pest's infestation. This supports the propositions of Cullinery and Pimentel (1986) and Eigenbrode and Pimentel (1988) that organic fertilizers can promote crop-plant resistance to attack by insect pests. Zehnder (2014) has recently noted that healthy, vigorous plants that grow quickly are better able to withstand pest damage.

Poultry manure application rates and accession types had significant effect on the yield of *Cajanus cajan.* The mean seed weight of both varieties did not differ significantly but variety 1 had higher mean seed yield than variety 2. This shows that though both varieties are good, Variety 1 may be imbued with higher yield genetic makeup.

Table 7: Influence of poultry manure application rates on insect pest infestation of pod, seed and shell weights in two varieties of *Cajanus cajan*

Treatment [P.M (kg/plot)]	Accession		
	Pod weight (g)		
	Variety 1	Variety 2	Mean
0	24.61	28.54	26.58
1.8	27.65	24.31	25.98
3.6	36.82	23.46	30.14
5.4	41.9	44.34	43.12
7.2	50.31	52.1	51.21
Mean	**36.26**	**34.55**	
$LSD_{0.05}$ Pm = 8.15			
$LSD_{0.05}$ Var. = NS			
$LSD_{0.05}$ Pm + Var. = NS			
	Seed weight (g)		
0	6.35	8.23	7.29
1.8	7.98	6.75	7.37
3.6	10.45	6.75	8.6
5.4	15.61	15.43	15.52
7.2	20.48	22.01	21.25
Mean	**12.17**	**11.83**	
$LSD_{0.05}$ Pm = 4.87			
$LSD_{0.05}$ Var. = NS			
$LSD_{0.05}$ Pm + Var. = 2.43			
	Shell weight (g)		
0	18.23	20.31	19.27
1.8	19.4	17.56	18.48
3.6	26.37	16.68	21.53
5.4	26.18	28.91	27.55
7.2	29.76	30	29.88
Mean	**23.99**	**22.69**	
LSD0.05 Pm = NS			
LSD0.05 Var. = NS			
LSD0.05 Pm + Var. = NS			

Where; Pm = Poultry manure , Var. = Variety
Pm + Var. = Poultry manure and Variety interaction
NS = Non-significant

Higher manure rates had a significant effect on the yield (pod, seed and shell weights) as 7.2 kg and 5.4 kg yielded more than the 1.8 kg and 3.6 kg rates. Kumar Rao (1990) had reported that pigeon pea yields increased by 22 % with 200 kg/ha fertilizer nitrogen application, suggesting that nitrogen fixation by nodules is not always enough to meet the nitrogen requirements of the crop under field conditions. Also, one or more of the elements essential for nodulation and growth may be at an inadequate level of supply, thereby preventing or minimizing a yield response to the element under test (Edwards, 1981). These essential elements for nodulation may be increased with increased organic manure application. Additionally, the robust nature of the leaves of the crop cultivated with higher poultry manure rate may necessarily increase the surface area and number of leaves exposed to solar radiation. Increased solar radiation reception may increase the performance of pigeon pea (Kumar Rao, 1990). It should be noted that the stress caused by insects on the crop with lesser rate of poultry manure, may lead to reduction in yield as pigeon pea has been reported to have a unique polycarpic flowering habit which enables the crop to shed reproductive structures in response to stress (Mligo and Craufurd, 2005).

CONCLUSION

Variety and poultry manure application rates had no significant effect on crop emergence and initial establishment. They, however, had effect on the crop performance. Application of poultry manure affected the rate of leaf damage and tolerance of the crop to insect pests' infestation. At higher mean leaf damage, the crop tolerated the attack by insect pests, as they had more leaves and branches when compared to the control. *Leptualaca fassicollis* were the most predominant insect pest that attacked the crop at the vegetative stage. At flowering and pod -bearing stages, there was a preponderance of insect species with *Helicorverpa armigera* as the predominant. Thus, it can be concluded that the cultivation of pigeon pea with poultry manure will increase the tolerance of the crop to insect pest attack and increase yield in a humid tropical environment.

REFERENCES

Ahsan, R. and Islam, M. 2009. In vitro antibacterial screening and toxicological study of some useful plants (*Cajanus cajan*). *European Journal of Science Research,* 41: 227-232.

Altieri, M. A. and Nicholls, C. I. 2003. Soil fertility management and insect pests: Harmonizing soil and plant health in agroecosystems. *Soil and Tillage Research*, 72 (2): 203–211.

Amarteifo, I. O., Munthali, D. C., Karikari, S. K., and Morake, T. K. 2002. The composition of pigeon pea

(*Cajanus cajan* (L) Millsp.) grown in Botswana. *Plant Foods for Human Nutrition,* 57: 173-177

Ambasta, S. P. 2004. The useful plants of India. 4th Ed. New Delhi: *National Institute of Science Communication*; pp: 94-95.

Andrews, N. and Foster, J. 2007. User guide: Organic fertilizer calculator. *Extension Manual; EM 8936-E.* Oregon State University. Retrieved on 20th January, 2016 from http://smallfarms.oregonstate.edu/sites/default/files/Gale_et_al_2006_JEQ.pdf

Bommesha, B., Naik, M. I., Mutthuraju, G. P., Arati, P., Syed, I. and Prashantha, C. 2012. Effect of organic manures on biochemical components of pigeon pea, *Cajanus cajan* (L.) Millsp. and their impact on the incidence of insect pests. *Current Biotica* 6(2): 171-180

Cullinery, T. W. and Pimentel, D. 1986. Ecological effects of organic agricultural practices on insect populations. *Agriculture, Ecosystems and Environment*, 15 (4): 253–266

Dialoke, S. A., Agu, C. M., Ojiako, F. O., Onweremadu, E. U., Onyishi, G. O., Ozor, N., Echezona, B. C., Ofor, M. O., Ibeawuchi, I. I., Chigbundu, I. N., Ngwuta, A. A. and Ugwoke, F. O. 2010. Survey of Insect Pests on Pigeon pea in Nigeria. *Journal of SAAT Agricultural Research* 8: 1- 8.

Dialoke, S. A. 2013. The Population of Leaf Beetles (*Leptualaca fassicollis* Thoms Coleoptera: Chrysomelidae) and Flower Thrips (*Megalurothrips usitatus* Bagnall Thysanoptera: Thripide) on Pigeon pea under the influence of plant density and planting dates in a Rain Forest Zone, Nigeria. *Journal of Biology, Agriculture and Healthcare*, 3 (8): 81 – 86

Dialoke, S. A., Egho, E. O., Bosah, B. O. and Enujeke, E. C. 2013. Population dynamics of podsucking bug (*Anoplocnemis curvipes* Hemiptera: Coreidae) on improved pigeon pea pods under different plant spacing and time of sowing in Owerri, Rainforest Tropical Environment, Nigeria. *Advances in Life Science and Technology,* 10: 12 – 16.

Edwards, D. G. 1981. Development of Research on Pigeon pea Nutrition. In: *Proceedings of the International Workshop on Pigeon peas*, Volume 1, 15-19 December 1980. ICRISAT (International Crops Research Institute for the Semi - Arid Tropics) Patancheru, A.P., India. Pp: 205 – 211.

Eigenbrode, S. D. and Pimentel, D. 1988. Effects of manure and chemical fertilizers on insect pest populations on Collards. *Agriculture, Ecosystems and Environment,* 20 (2): 109–125

Gale, E.S., Sullivan, D. M., Cogger, C. G., Bary, A. I., Hemphill, D. D. and Myhre, E. A. 2006. Estimating plant-available nitrogen release from manures, composts, and specialty products. *Journal of Environmental Quality,* 35:2321-2332.

Gopalan, C., Rama sastris B.V. and Balasubramanian, C.S. 1984. Nutritional value of Indian Foods, Hyderabad, India: *India Institute of Nutrition*, pp.204.

Heisswolf, A., Obermaier, E. and Poethke, H. J. 2005. Selection of large host plants for oviposition by a monophagous leaf beetle: Nutritional quality or enemy-free space? *European Journal of Entomology,* 30: 299–306.

Jalaluddin, M. and Hamid, M. 2011. Effect of adding inorganic, organic and microbial fertilizers on seed germination and seedling growth of Sunflower. *Pakistan Journal of Botany,* 43(6): 2807 - 2809

Khan, T. N. and Ashley, J. M. 1975. Factors affecting plant stand in pigeon pea. *Experimental Agriculture,* 11: 315-322.

Khoury, C. K., Castañeda-Alvarez, N. P., Achicanoy, H. A., Sosa, C. C., Bernau, V., Kassa, M.T., Norton, S. L., van der Maesen L. J. G., Upadhyaya, H. D., Ramírez-Villegas, J., Jarvis, A. and Struik, P. C. 2015. Crop wild relatives of pigeon pea [*Cajanus cajan* (L.) Millsp.]: Distributions, ex situ conservation status, and potential genetic resources for abiotic stress tolerance. *Biological Conservation,* 184: 259-270.

Kulkarni, K.R., and Panwar, K.S. 1981. Response of pigeon pea to fertilizers in India: A critical review. *Proceedings of the International Workshop on Pigeon peas*, Volume 1, 15- 19 December 1980. ICRISAT (International Crops Research Institute for the Semi – Arid Tropics) Patancheru, A.P., India. Pp 212 – 220.

Kumar, A. and Nath, P. 2003. Pest complex and their population dynamics on an early variety of pigeon pea UPAS-120 at Varanasi. *Indian Journal of Entomology,* 65(4): 453-460

Kumar Rao, J.V. D. K. 1990. Pigeon pea: nitrogen fixation. Pages 233-256 in The Pigeon pea (Nene,Y. L., Hall, S. D. and Sheila, V. K., Eds.). Wallingford, UK: *CAB International*. 490 pp

Kunjeku, E. C. and Gwata, E. T. 2011. A preliminary survey of insect species occurring at the reproductive stage in pigeon pea grown in Limpopo (South Africa). *Journal of Food, Agriculture and Environment*; 9 (3&4): 988 - 991.

Mandal, S. K., Parbhakar, A. K. and Roy, S. P. 2009. Insect pest complexes on a pulse crop pigeon pea , *Cajanuscajan* Linn. of Indo- Gangetic plain of Bhagalpur (Bihar, India). *The Ecoscan*. 3 (1&2):143-148.

Merrill, M. C. 1983. Bio-agriculture: A review of its history and philosophy. *Biological Agriculture and Horticulture,* 1: 181–210

Minja, E. M., Shanower, S. N., Silim, S. N. and Singh, L. 1999. Evaluation of pigeon pea pod borer and pod fly tolerant lines at Kabete and Kiboko in Kenya. *African Crop Science Journal,* 7: 71-79

Mligo, J.K. and Craufurd, P.Q. 2005. Adaptation and yield of pigeon pea in different environments in Tanzania. *Field Crops Research*, 94: 43–53.

Mullen, C.L., Holland, J. F. and Heuke. L. 2003. Cowpea, lablab, and pigeon pea. *Ag fact* P4.2.21. NSW Agriculture, Orange, New South Wales.

NYBG (New York Botanical Garden). 2013. Wild Medicine: Healing plants around the world, featuring the Italian Renaissance Garden. *New York Botanical Garden*. Retrieved on 17th February 2016 from http://www.nybg.org/files/wild-medicine/Wild-Medicine-plant-list.pdf

Oelhaf, R. C. 1978. Organic farming: Economic and ecological comparisons with conventional methods. *John Wiley*, New York.

Okokoh, S. J. and Bisong, B. W. 2011. Effect of poultry manure and urea-n on flowering occurrence and leaf productivity of *Amaranthus cruentus*. *Journal of Applied Science and Environmental Management*; 15 (1):13 -15

Pal, D., Mishra, P., Sachan, N. and Ghosh, A. K. 2011. Biological activities and medicinal properties of *Cajanuscajan* (L) Millsp. *Journal of Advanced Pharmaceutical Technology Research,* 2: 207-14

Phatak, S.C., Nadimpalli, R. G., Tiwari, S.C. and Bhardwaj, H.L. 1993. Pigeon peas: potential new crop for the southeastern United States. In: J. Janick and J.E. Simon, editors, New Crops. *Wiley, New York*. p. 597–599.

Ranga Rao, G.V. and Shanower, T. G. 1999. Identification and Management of Pigeon pea and Chickpea Insect Pests in Asia. *Information Bulletin No. 57*. Patancheru, India: International Crops Research Institute for the Semi- Arid Tropics (ICRISAT): 1 – 99.

Rao, R.G.V., Saxena, K.B., Yang Shiying, P. and Wagisan, G. 2002. Insect pests' problems of pigeon pea in Gangeni and Hainsan province of China. *International Chickpea and Pigeon pea Newsletter*, 48p

Reddy, M.V., Raju, T.N., Sharma, S.B., Nene, Y.L. and McDonald, D. 1993. *Handbook of pigeon pea diseases. Information Bulletin No. 42*. International Crops Research Institute for the Semi-Arid Tropics. 66p

Reed, W. and Lateef, S.S. 1990. Pigeon pea: Pest management. Pages 349-374 in The Pigeon pea (Nene, Y.L., Hall, S.D., and Sheila, V.K., eds.). Wallingford, UK: *CAB International.*

Salunkhe, D.K., Chavan, J.K. and Kadam, S.S. 1986. Pigeon pea as an important food source. *Critical Reviews in Food Science and Nutrition,* 23(2): 103–145.

Sarfraz, R. M., Dosdall, L. M. and Keddie, A. B. 2009. Bottom-up effects of host plant nutritional quality on Plutella xylostella (Lepidoptera: Plutellidae) and top-down effects of herbivore attack on plant compensatory ability. *European Journal of Entomology,* 106: 583–594.

Shanower, T.G., Romeis, J. and Minja, E. M. 1999. Insect pests of pigeon pea and their management. *Annual Review of Entomology,* 44: 77-96.

Sharma, H.C., Saxena, K.B. and Bhagwat, V.R. 1999. The legume pod borer, *Maruca vitrata*: bionomics and management. *Information Bulletin no. 55* (In En. Summaries in En, Fr.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. 42 p

Simtowe, F., Shiferaw, B., Kassie, M., Abate, T., Silim, S., Siambi, M., Madzonga, O. Muricho, G. and Kananji, G. 2007. Assessment of the Current Situation and Future Outlooks for the Pigeon pea Sub-sector in Malawi. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). 48p.

Snapp, S.S., Rohrbach, D.D., Simtowe, F. and Freeman, H.A. 2002. Sustainable soil Management options for Malawi: can smallholder farmers grow more legumes? *Agriculture, Ecosystems and Environment,* 91: 159–174

Snapp, S. S., Jones, R. B., Minja, E. M., Rusike, J. and Silim, S. N. 2003. Pigeon pea for Africa: A Versatile Vegetable--And More. *Hort Science,* 38 (6):1073-1079.

Wahua, T. A.T. 1999. Applied statistics for scientific studies. Afrika-link Press, Ibadan, Nigeria Pp: 87 – 250.

Yuan-gang, Z., Xiao-lei, Yu-jie, F., NanWu, YuKong, and Michael W. 2010. Chemical composition of the SFE-CO2 extracts from *Cajanus cajan* (L.) Huth and their antimicrobial activity in vitro and in vivo. *Phytomedicine,* 17: 1095-101.

Zehnder, G. 2014. Managing the soil to reduce insect pests. *Extension: America's Research-based Learning Network.* Retrieved on 26th June, 2015 from http://www.extension.org/pages/18574/managing-the-soil-to-reduce-insect-pests#VY3NzxFRHui

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