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Cowpea *Vigna unguiculata* (L.) walp and chilli pepper *Capsicum frutescens* (L.) intercropping as affected by planting pattern and insect pest management in the rain forest area of Nigeria

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Abstract
Field experiments were conducted at Yaba College of Technology Instructional and Research Farm during 2019/2020 wet and dry seasons to investigate the performance of cowpea and chilli pepper intercropping for the management of insect pests of cowpea. The experiment was arranged in alternate intercropping (chilli pepper and cowpea), strip cropping (chilli pepper and cowpea), border cropping (chilli pepper around cowpea) and sole cropping in a randomized complete block design (RCBD) replicated three times with twelve plots of sixty ridges. Data were collected on growth parameters of cowpea at 2, 4 and 6 weeks after planting, pest population, assessment of thrips (*Megalurothrips sjostedti*) and legume pod borer (*Maruca vitrata*), assessment of both nymphs and adult of legume pod borer and pod sucking bugs (*Clavigralla tormentosicollis*), pod damage, grain yield and yield loss. Alternate intercropping was significantly ($p \leq 0.05$) superior to another cropping system concerning grain yield (0.12±0.01), reduction in pest infestation (3.56±0.11) and yield loss (322.12±5.43) when compared to sole cropping. Intercropping cowpea and chilli pepper can therefore be used to reduce the attack of insect pests on cowpea.

Keywords: Chilli pepper, cowpea, cowpea insect pests, intercropping

Introduction

Cowpea is one of the key sources of protein in the human diet consumed in different forms, especially in developing countries who may not always have the means for animal protein in adequate quantities, as a ‘’food security crop’’ for populations that consume it, as a traditional staple food and as a significant cash crop [1] as fodder for farm animals (to make hay and silage) as well as for restoration of soil fertility (green manure and cover crops).

Regular agronomic farm practices employed in crop production have a profound influence on the incidence and populations of crop pests. Farmers in the tropic and semi-arid tropics have practiced for generations, the growing of two or more crops in conjunction with one another on the same piece of land so that there is a temporal and spatial overlap in most of their growth [2] Intercropping has been widely recognized as an important farming system that is used to alter the microenvironment of the pest which can be manipulated by increasing or changing the sequence or pattern of crops in the ecosystem [3] and researchers have recognized the need to investigate such systems [2]. Companion cropping also increases crop diversity, changes the insects habitat (habitat modification) and interfere with the insects identification of and responses to its host plant [3].

In Nigeria, over 83 percent of the cowpea crops is grown in intercrops, mostly in di-and tri-crop systems with maize, sorghum, millet and cassava but occasionally groundnut, cotton, sugarcane and relayed cropped in standing rice [4, 5], majorly by small scale farmers in Northern Nigeria for profit maximization and better monetary returns from the crops, efficient use of limited arable land and labour, better use of environmental resources, improved yield, stability and minimization of agricultural risks and uncertainties. With the increase in population, the demand for land has also increased, resulting in intense cultivation with little or no fallow period, hence the practice of monocropping by large scale- farmers. When cowpea is grown as monocrop, it is subjected to heavy depredation and yields are low in the absence of adequate chemical control measures [6].

The key pest complex of cowpea consists of the flea beetles (*Podarica spp.* Jac.), foliage beetle (*Ootheca mutabilis*), cowpea aphids (*Aphis craccivora* koch), leafhoppers (*Empoasca spp*.), flower bud thrips (*Megalurothrips sjostedti* Trybom), flower bud thrips (*Megalurothrip sjostedti* Trybom) flower eating beetles (*Mylabris spp*. and *Coryna spp*.), blister beetles (*Hycleu slugens*), green stink bugs (*Nezara viridula*), legume pod borer (*Maruca vitrata* Fab.), pod-sucking bugs (*Clavigralla tomentosicollis Stal),* Shield bug *(Riptortus spp. and Anoplocuemis curvipes),* Pod borer *(Cydia ptychora)* and cowpea weevil (*Callosobruchus maculatus* Fab.). The cowpea weevil is a cosmopolitan polyphagous field to store pest ranked as the principal post-harvest pest of cowpea in the tropics [7, 8, 9].

However, research reports showed that, intercropping of cowpea confirmed that the populations of several pests are reduced and yields increases [10]. Fatokun [10] confirmed that the practice of cereal-cowpea intercropping and crop rotation coupled with effective soil fertility management could increase yields of cereals succeeding cowpea by fixing 150 kg per ha of N, which can supply 80-90% of plants total requirement. Reports by Adipala *et al.,* [11] also revealed that intercropping offers remedial control, but the crop must consider pest profile, cowpea/sorghum intercropping being effective against aphids and thrips and cowpea/green grain against legume pod borers and pod sucking bugs as well as close spacing (30cm by 20cm) effectively reduces aphid infestation, (early season pests) but seems to promote thrips, legume pod borers and pod bug infestations. Hence, diverse cowpea pest complexes dictates that a single control strategy is unlikely to produce satisfactory control.

Capsicum frutescens is a fruit vegetable widely cultivated as condiments, medicine, and cosmetic production throughout the tropics. The extreme pungency or phyto-toxicity characterises its insecticidal activity at a high rate [12]. It is against this background that this study sought to evaluate cowpea *Vigna unguiculata* (L.) walp and chilli pepper *Capsicum frutescens* (L.) intercropping as affected by planting pattern and insect pest management in the rainforest area of Nigeria.

Materials and Methods

Experimental site: The field trial was carried out at Yaba College of Technology, Odoragushin, Epe Campus (Longitude $3^0 58^0 56^0$N and Latitude $6^0 38^0 36^0$N) above sea level (Google earth, 2019) during the wet and dry seasons of 2019 and 2020. The site lies on km 16, along Epe, Ijebu-Ode road, Epe, Lagos in the lowland rainforest vegetation zone within South-Western Nigeria with an annual rainfall of 1506.6mm (www.lagos.chinatemps.com).

The climate follows a tropical pattern, with the rainy season starting about March and ending in November, and the dry season beginning in December and ending in February. The site has experienced long term cultivation of maize and cassava production for more than 40 years. Soil analysis of the site was carried out before and after the experiment to determine the physicochemical properties and nutrient content level in the soil.

Collection of cowpea and chilli pepper seeds

The cowpea (Ife Brown Variety) and chilli pepper used were purchased from Lagos State Input Supply Company (LAISCO), Epe depot. Ife brown cowpea seeds were cleaned, sundried and kept in the deep freezer at a temperature of 10ºC for seven days in order to prevent insect infestation and standardize their moisture content. They were taken out and allowed to acclimatize for about 24 hours under ambient laboratory conditions until when needed for the assay. The chilli pepper seed was prepared for sowing in nursery trays and production into an extract for field work. The seed was dressed in Apron plus before planting. Seeds of *Capsicum frutescens* (L.) were air dried (for 3 weeks), bulked and packaged (in a polythene bag) until a constant weight was maintained in preparation for sowing in nursery trays. Portions were prepared into extracts. Seeds for field trial were dressed with Apron plus at the rate of one sachet per kilogramme of seeds. Pre-emergence herbicide (Extraforce) was applied before the sowing of seeds. Benlate (benomyl) at 0.33kg a.i/ha was sprayed on seedlings every week for four weeks to control fungal diseases.

Experimental protocol: The experimental land was cleared, stumped and the debris was packed away. It was then ploughed, harrowed and ridges were prepared for planting of chilli pepper and cowpea. The experiment was laid out in a randomized complete block design (RCBD) with 4 treatments replicated 3 times arranged as follows:

I. Alternate intercropping of chilli pepper and cowpea
II. Strip cropping (Chilli pepper and cowpea)
III. Border cropping (Chilli pepper around cowpea plot)
IV. Sole cropping of cowpea

The net plot for data collection was 18.75m^2 (with each plot having 5 ridges and 0.75m apart on a diameter of 5m x 3.75m). Thus, there are 12 experimental plots with 60 ridges. The gross plot size was 474.38m^2 (with a furrow spacing of 1.5m left between blocks and plots). Seedlings of *Capsicum frutescens* raised in the nursery were transplanted to the field 6 weeks after planting at a spacing of 60cm x 45cm (with cowpea mixture) while that of sole cropping was planted at 25cm apart at 2 seeds per hole. Missing stands were supplied within a week of planting.

Data collection: Data on cowpea was collected based on the following parameters:

i. **Growth parameters of cowpea at 2, 4 and 6 weeks after planting:** 20 plants per plot were selected and tagged. The number of leaves were counted at 2, 4 and 6 weeks after planting while plant height was measured using tape rule, taking from the soil level to the top of the last leaf from 20 stands per replicate selected randomly from the middle row of each replicate treatment from where crop component interactions were assumed to be highest.
ii. **Pest population:** Pest population was sampled very early in the morning (6:30am – 9:00am) when the insect pests were less active. The number of insects on the plant were counted visually recorded uing direct method that enables quantitative estimation of pest incidence for the cowpea crop [32] using the Handerson Tilton Formular (Okunlola *et al.*, 2008).

Efficacy % =1 - (Ta/Ca × sCb/Tb) × 100

Where Ta= Infestation in the treated plot after application
Ca= Infestation in the check plot after application
Tb= Infestation in the treated plot before application
$_sC_b$= Infestation in the check plot before application

iii. **Assessment of thrips (*Megalurothrips sjostedti*) and Legume pod borer (*Maruca vitrata*):** This was done by removing 20 flowers from plants in each plot. The flowers were placed in vials containing 30% alcohol and taken to the laboratory where the flowers were dissected the next day. The number of thrips and legume pod borers found were recorded following methods described by Oparaeke *et al.*, [12], Amatobi, [15], Ahmed *et al.*, [16].

iv. **Examination of both nymphs and adult of legume pod borer (*Maruca vitrata*) and pod sucking bugs (*Clavigralla tormentosicollis*):** This was based on visual observation of 3 plants randomly selected within 1.0m x 1.0m on quadrants randomly selected within the main ridges on each plot. Each nymph and adults of pod borer and pod sucking bugs were identified, counted and recorded.

v. **Pod damage:** Shrivelling, twisting, stunting and constriction were accessed by counting the number of damaged pods per plant and divided by the total number of pods produced per plant in a random sample of 20 plants per plot. This was expressed in % by multiplying by 100.

vi. **Grain Yield:** Grain yield was recorded from each plot after harvesting, threshing and winnowing. Grain yield data was converted to kg/ha before ANOVA using the following formulas [17].

$$\text{Yield (kg/ha)} = \frac{a \times 10{,}000}{b \times 10{,}000}$$

Where: a = plot yield
b = net plot size

vii. **Yield loss:** Yield loss was calculated using the [18] formula:

AL = (a – b) x NAT

Where: AL = Actual loss
a = mean yield of unattacked plant
b = mean yield of attacked plant
NAT = Number of attacked plant

Data analysis

The results were subjected to Analysis of Variance in Randomized Complete Block Design (RCBD). Tukey Comparison Lines at 0.05 probability level was used to determine differences among means using SPSS software.

Results

Physico-chemical properties of the soil pre and post-planting: Shown in table 1 is the physico- chemical properties of the soil at pre and post- planting. It was evident that the particle size distribution varied but with sand (78.81%) dominating among the fractions. The textural class was sandy-loam with silt and clay below 25%. There were high base saturation (98.28%) which also increased at post-planting (98.39%) while the Cation Exchange Capacity (CEC) recorded high value at pre (14.91cmol/Kg^{-1}) and post-planting (14.85cmo/kg^{-1}). The soil reaction (pH) at pre- planting was 6.6 and became slightly acidic (6.2) at post-planting. Most of annual crops are productive within this soil pH range. The exchangeable Ca and Mg were adequately available and dominated exchangeable complex of soil. There was reduction in the N (0.60%) and K (0.04%) contents at post-planting because chilli-pepper may have used up the N produced in the soil. The available P was moderate at pre (18.48 mg kg^{-1}) and post-planting (19.46 mg kg^{-1}). Thus, chilli pepper had significant (higher) effect on acidity, base saturation, CEC and available P.

Table 1: Physico-chemical properties of the soil at pre-planting and post planting

Parameters		Pre-planting Values	Post-planting Values
	pH	6.6	6.2
Particle Size (%)	Sand (%)	71.72	78.81
	Silt (%)	18.20	14.8
	Clay (%)	10.10	6.7
Exchangeable bases (meq/100g)	Ca	14.10	13.88
	Mg	0.49	0.46
	Na	0.06	0.04
	K	0.06	0.04
Exchangeable Acidity (meq/100g)		0.20	0.18
C.E.C		14.91	14.85
Base Saturation	(%)	98.28	98.39
Macro-nutrient	N (%)	1.28	0.60
	Mg (%)	0.88	0.66
	Available P (ppm)	18.48	19.46
Micro nutrients	Fe (mg/kg)	23.51	24.53
	Cu (mg/kg)	1.20	1.22
	Zn (mg/kg)	2.23	2.43
	Mn (mg/kg)	5.38	5.26

Field report, 2019

Effect of intercropping of cowpea and chilli pepper on growth parameters at 2, 4 and 6 WAP: Result for effect of intercropping of cowpea and chilli pepper on growth parameters (plant heights and the number of leaves) is shown in Table 2. There was no significant variation in the values recorded for the number of leaves and plant heights at 2, 4 and 6 weeks after planting (WAP). The maximum number of leaves at 2 weeks was observed in sole cropping (replicate 3) (3.38±0.07) while the least number of leaves was recorded in alternate cropping (replicate 3) (3.02±0.07). In the same vein, plant height (cm) at 2 weeks in border cropping (replicate 3) (24.38±1.53) gave the highest plant height while the plots in strip cropping replicate 1 (18.37±1.53) gave the lowest plant height.

Moreover, no significant variation (P≤0.05) was sustained at 4 and 6 WAP for the number of leaves at 4 weeks and plant heights. The highest value for the leaves at 4 weeks was observed in alternate cropping interaction (replicate 1) (5.24±0.24), followed by strip cropping (4.98±0.24) and lowest in sole cropping (replicate 1) (4.48±0.24). Ditto for plant height (cm) (replicate 1) (48.04±3.52) higher in sole cropping but lowest in strip cropping (replicate 3) (36.28±3.52). At 6 WAP, the highest number of leaves was recorded against sole cropping (replicate 1) (10.03±0.40) while the lowest value was obtained in alternate cropping (replicate 1) (8.65±0.40).This same trend was observed in cowpea plant height (cm) having the highest value recorded in sole cropping (replicate 1) (108.28±6.14) and the lowest in alternate cropping (replicate 1) (84.58±6.14).

Table 2: Effect of intercropping of cowpea and chilli pepper on growth parameters at 2, 4 and 6 WAP:

Treatments	Growth Traits					
	No. of Leaves (2 wks)	Plant Height (2 wks)	No. of Leaves (4 wks)	Plant Height (4 wks)	No. of Leaves (6 wks)	Plant Height (6 wks)
ALT CRP R_1	3.05±0.07^{a}	19.32±1.53^{a}	5.24±0.24^{a}	37.75±3.52^{a}	8.65±0.40^{a}	84.58±6.14^{a}
ALT CRP R_2	3.06±0.07^{a}	19.01±1.53^{a}	4.54±0.24^{a}	38.39±3.52^{a}	9.70±0.40^{a}	96.77±6.14^{a}
ALT CRP R_3	3.02±0.07^{a}	18.34±1.53^{a}	4.88±0.24^{a}	40.19±3.52^{a}	9.71±0.40^{a}	96.78±6.14^{a}
STR CRP R_1	3.26±0.07^{a}	18.37±1.53^{a}	4.98±0.24^{a}	40.89±3.52^{a}	9.31±0.40^{a}	90.28±6.14^{a}
STR CRP R_2	3.07±0.07^{a}	18.87±1.53^{a}	4.57±0.24^{a}	39.90±3.52^{a}	9.85±0.40^{a}	94.28±6.14^{a}
STR CRP R_3	3.09±0.07^{a}	18.29±1.53^{a}	4.79±0.24^{a}	36.28±3.52^{a}	9.85±0.40^{a}	94.28±6.14^{a}
BOR CRP R_1	3.35±0.07^{a}	20.32±1.53^{a}	4.76±0.24^{a}	41.39±3.52^{a}	9.54±0.40^{a}	92.43±6.14^{a}
BOR CRP R_2	3.13±0.07^{a}	21.18±1.53^{a}	4.77±0.24^{a}	41.06±3.52^{a}	9.79±0.40^{a}	93.97±6.14^{a}
BOR CRP R_3	3.26±0.07^{a}	24.38±1.53^{a}	4.75±0.24^{a}	44.54±3.52^{a}	9.79±0.40^{a}	93.97±6.14^{a}
SOL CRP R_1	3.29±0.07^{a}	20.27±1.53^{a}	4.48±0.24^{a}	41.69±3.52^{a}	10.03±0.40^{a}	108.28±6.14^{a}
SOL CRP R_2	3.15±0.07^{a}	22.01±1.53^{a}	4.61±0.24^{a}	41.98±3.52^{a}	9.64±0.40^{a}	101.28±6.14^{a}
SOL CRP R_3	3.38±0.07^{a}	21.95±1.53^{a}	4.84±0.24^{a}	48.04±3.52^{a}	9.64±0.40^{a}	101.28±6.14^{a}

Values represent least square means (LS-means) ± standard error. LS-means were separated using Turkey-Kramer Comparison and LS-means within a column followed by different letters are significantly different at P≤0.05.

ALT CRP= alternate cropping, STR CRP= strip cropping, BOR CRP = border cropping, SOL CRP = sole cropping, R_1 = Replicate 1, R_2 = Replicate 2, R_3 = Replicate 3

Effect of intercropping of cowpea and chilli pepper on assessment of thrips and legume pod borers, nymph and adult of legume pod borer and pod sucking bugs: Result in table 3 revealed effect of intercropping of cowpea and chilli pepper on assessment of thrips, nymphs and adults of legume pod borer and pod sucking bugs which were significant (*P*≤0.05). All treatements had significantly lower number of flower thrips and legume pod borers as compared to control. Border cropping (replicate 2) had the highest number of thrips (5.12+0.11) and Legume pod borers (3.03±0.24) while alternate cropping (replicate 3) had the lowest number of thrips (3.79+0.11) and legume pod borers (1.76±0.24) relative to sole cropping checks having the highest number of thrips (5.91±0.11, 5.41±0.11). Similar trends was observed for legume pod borers (3.36±0.24, 3.74±0.24).

Intercropped plots also performed statistically better (*P*≤0.05) by reducing the number of nymph and adult pod sucking bugs in the treated plots as compared to control, with sole cropping (replicate 1) having the highest number of nymphs (2.06±0.09) and adult pod sucking bugs (1.97±0.07) than border cropping (replicate 2) (1.87±0.09) and alternate cropping (replicate 3) respectively.

Table 3: Effect of intercropping of cowpea and chilli pepper on assessment of thrips and legume pod borers, nymph and adult of legume pod borer and pod sucking bugs

Treatments	No. of Thrip	No. of LPB	NYMPH LPB	ADULT LPB	NYMPH PSB	ADULT PSB
ALT CRP R_1	3.91±0.11^{f}	2.36±0.24^{bcd}	1.37±0.06^{cd}	1.26±0.05^{cde}	1.31±0.09^{c}	1.27±0.07^{de}
ALT CRP R_2	3.83±0.11^{f}	1.90±0.24^{cd}	1.32±0.06^{cd}	1.18±0.05^{de}	1.32±0.09^{c}	1.26±0.07^{de}
ALT CRP R_3	3.79±0.11^{f}	1.76±0.24^{d}	1.17±0.06^{d}	1.07±0.05^{e}	1.50±0.09^{bc}	1.19±0.07^{e}
STR CRP R_1	5.26±0.11^{bcd}	3.24±0.24^{ab}	1.96±0.06^{a}	1.72±0.05^{a}	2.00±0.09^{a}	1.82±0.07^{ab}
STR CRP R_2	4.90±0.11^{cde}	2.70±0.24^{abcd}	1.74±0.06^{ab}	1.47±0.05^{abc}	1.81±0.09^{ab}	1.67±0.07^{abc}
STR CRP R_3	4.65±0.11^{e}	2.37±0.24^{bcd}	1.68±0.06^{ab}	1.34±0.05^{bcd}	1.67±0.09^{abc}	1.46±0.07^{cde}
BOR CRP R_1	5.57±0.11^{ab}	3.54±0.24^{ab}	1.82±0.06^{ab}	1.40±0.05^{bcd}	1.96±0.09^{a}	1.67±0.07^{abc}
BOR CRP R_2	5.12±0.11^{bcde}	3.03±0.24^{abc}	1.74±0.06^{ab}	1.45±0.05^{bcd}	1.87±0.09^{ab}	1.67±0.07^{abc}
BOR CRP R_3	4.76±0.11^{de}	2.80±0.24^{abcd}	1.62±0.06^{bc}	1.44±0.05^{bcd}	1.72±0.09^{abc}	1.60±0.07^{bcd}
SOL CRP R_1	5.91±0.11^{a}	3.74±0.24^{a}	1.93±0.06^{ab}	1.61±0.05^{ab}	2.06±0.09^{a}	1.55±0.07^{bcd}
SOL CRP R_2	5.62±0.11^{ab}	3.36±0.24^{ab}	1.84±0.06^{ab}	1.54±0.05^{ab}	1.96±0.09^{a}	1.87±0.07^{ab}
SOL CRP R_3	5.41±0.11^{abc}	3.04±0.24^{abc}	1.78±0.06^{ab}	1.46±0.05^{abc}	1.88±0.09^{ab}	1.97±0.07^{a}

Values represent least square means (LS-means) ± standard error. LS-means were separated using Turkey-Kramer Comparison and LS-means within a column followed by different letters are significantly different at P≤0.05.

ALT CRP= alternate cropping, STR CRP= strip cropping, BOR CRP = border cropping, SOL CRP = sole cropping, R_1 = Replicate 1, R_2 = Replicate 2, R_3 = Replicate 3, No. Thrip = number of thrips, No. LPB = number of legume pod borer, NYMPH LPB – nymph of legume pod borer, ADULT LPB = adult of legume pod borer, NYMPH PSB = nymph of pod sucking bug, ADULT PSB = adult of pod sucking bug

Effect of intercropping of cowpea and chilli pepper on pest population: Result obtained in table 4 showed significant effects (*P*≤0.05) of intercropping of cowpea and chilli pepper on pest population. The incidence of pest populations was highest in sole cropping (replicate 1) (7.30±0.19) and (replicate 2) (6.23±0.19) while the alternate (replicate 3) had the least number of pest population (2.57±0.19).

Table 4: Effect of intercropping of cowpea and chilli pepper on pest population

Treatments	Pest Population
ALT CRP R_1	5.34±0.19[c]
ALT CRP R_2	2.76±0.19[d]
ALT CRP R_3	2.57±0.19[d]
STR CRP R_1	6.40±0.19[ab]
STR CRP R_2	3.14±0.19[d]
STR CRP R_3	3.11±0.19[d]
BOR CRP R_1	6.38±0.19[ab]
BOR CRP R_2	3.41±0.19[d]
BOR CRP R_3	3.24±0.19[d]
SOL CRP R_1	7.30±0.19[a]
SOL CRP R_2	6.23±0.19[bc]
SOL CRP R_3	5.48±0.19[bc]

Values represent least square means (LS-means) ± standard error. LS-means were separated using Turkey-Kramer Comparison and LS-means within a column followed by different letters are significantly different at $P \leq 0.05$.

ALT CRP= alternate cropping, STR CRP= strip cropping, BOR CRP = border cropping, SOL CRP = sole cropping, R_1 = Replicate 1, R_2 = Replicate 2, R_3 = Replicate 3, PPOP = pest population

Effect of intercropping cowpea and chilli pepper on pod damage, grain yield and yield loss: The effect of intercropping cowpea and chilli pepper on pod damage, grain yield (kg) and yield loss (kg) is summarized in table 5. There was higher reduction in pod damage with respect to intercropped plots. Thus (replicate 3) (1.19± 0.02) and (replicate 2) (1.28±0.02) in alternate cropping had the lowest value compared to sole cropping (control) with (replicate 3) (1.46±0.02) and (replicate 2) (1.43±0.02) had higher value with pod damage. Similarly, there was appreciable difference in the grain yield of treated plots, where alternative cropping had higher value (0.12±0.00) and sole cropping control had the least value. Thus, pure stand cowpea plots suffered more from the activity of insect pests resulting in pod damage, grain yield reduction and loss.

Table 5: Effect of intercropping cowpea and chilli pepper on pod damage, grain yield and yield loss

Treatments	POD DAM	GRAIN YIELD	YIELD LOSS
ALT CRP R_1	1.36±0.02[bc]	0.12±0.00[a]	336.63±9.41[c]
ALT CRP R_2	1.28±0.02[c]	0.12±0.00[a]	330.13±9.41[c]
ALT CRP R_3	1.19±0.02[d]	0.12±0.00[a]	299.58±9.41[c]
STR CRP R_1	1.43±0.02[ab]	0.10±0.00[ab]	327.92±9.41[c]
STR CRP R_2	1.41±0.02[ab]	0.10±0.00[ab]	341.75±9.41[c]
STR CRP R_3	1.40±0.02[ab]	0.11±0.00[ab]	343.20±9.41[c]
BOR CRP R_1	1.38±0.02[ab]	0.10±0.00[ab]	347.48±9.41[bc]
BOR CRP R_2	1.43±0.02[ab]	0.10±0.00[ab]	335.57±9.41[c]
BOR CRP R_3	1.44±0.02[ab]	0.10±0.00[ab]	336.87±9.41[c]
SOL CRP R_1	1.43±0.02[ab]	0.10±0.00[ab]	442.32±9.41[a]
SOL CRP R_2	1.43±0.02[ab]	0.07±0.00[b]	417.70±9.41[a]
SOL CRP R_3	1.46±0.02[a]	0.10±0.00[ab]	395.27±9.41[ab]

Values represent least square means (LS-means) ± standard error. LS-means were separated using Turkey-Kramer Comparison and LS-means within a column followed by different letters are significantly different at $P \leq 0.05$.

ALT CRP= alternate cropping, STR CRP= strip cropping, BOR CRP = border cropping, SOL CRP = sole cropping, R_1 = Replicate 1, R_2 = Replicate 2, R_3 = Replicate 3, POD DAM = pod damage, POD DEN = pod density.

Discussion

As the result of the soil analysis revealed, the available P was moderate at pre and post planting which exceeded the critical limit ($15 mgkg^{-1}$) established for crops in South-Western Nigeria [9] and critical level of $15 mgkg^{-1}$ extractable P recommended by [20, 21]. This showed that the soil had the available P required for the production of both crops. Thus, chilli pepper had significant (higher) effect on acidity, base saturation, CEC and available P.

In this study, observations were made only on insect pests of cowpea in sole stand and in intercropped with chilli pepper. The results from this research showed that cowpea thrips, legume pod borers, pod sucking bugs are key pests complex of cowpea irrespective of the cropping system as observed in monitored pest infestation. The nymph of pod sucking bugs were significantly lower in intercropped plots. Also, intercropped plots had significantly reduced number of thrips and legume pod borers and this supports the findings of Emeasor and Ezueh, [22] who reported that intercropping pepper intra row with cowpea reduced flower thrips and cowpea aphids on cowpea and improved cowpea yield compared with sole cropped cowpea. Grain yield obtained from sole cropping was substantially reduced when compared with the intercropped plots. This should be expected since the damage caused by thrips on cowpea flowers will affect pod formation and quality and consequently yield reduction.

This study ranks alternate intercropping superior to other cropping patterns in terms of pest reduction and grain yield as Chilli pepper may have acted as a barrier or trap crop thereby reducing their infestation on cowpea plants and do not impair its yield. These findings confirmed earlier work done by other researchers such as Singh and Gulliver [2], Fatokun [10] and Kahn [23], Karel [24], Uddin and Odebiyi [25], Munford and Butiddawa [26] which generally quoted low build-up of insect pests as one of the main advantages in favour of crop mixtures resulting from increase in complexity of plants in crop mixtures, which provide a less favourable habitat for some of the insect pests than when crops are grown in pure stands. Moreso, crop mixtures also prevent the spread of some pests to toher areas in some cases and they avoid their preferred crops when shaded by taller crops in mixtures [24].

This was also corroborated by Munford and Baliddawa [26] which found that, there is often a significant decrease in the rate of pest population development due to the unfavourable environment of intercrops and a net reduction in damage and infestation, as insect pests settled on crops only when host factors such as visual stimulus, taste and smell are satisfied and this is more likely in monocultures where the chances of meeting a wrong is lower [27, 28].

There are several reports by Nanpala *et al.*, [29] that thrip populations are reduced when cowpeas are intercropped with maize or sorghum and this is in line with this study which indicated reduced number of pest population, number of thrips, legume pod borer and pod sucking bugs when cowpea is being intercropped with chilli pepper. Here, alternate cropping tends to show the highest pest reduction, grain yield and reduced yield loss. Furthermore, in the words of Uddin and Odebiyi [25], intercropping studies under optimum technology indicated substantial increase of more than 50% from different combinations of alternate row cropping over the two separate oure cultures. This assertion is confirmed by this report. Apart from this, the intercropping system helps to reduce weeds to its bearest minimum which would compete with the crop plants for mineral elements in the soil. However, there are also conflicting reports by Ezueh, [30] indicating increased pod borer and pod sucking bug populations in mixed cropping of cowpeas with sorghum Nanpala *et al.*, [29].

As the pod damage, grain yield and yield loss was substantially reduced in intercropped cowpea/chilli pepper mixtures, viability of the cowpea seeds will be enhanced. This is in line with the Uddin and Odebiyi [25] observation while also quoting Tahvanian and Root [31] that, the confusing olifactory and visual stimuli received from the host and non-host may disrupt normal feeding habits or mating behaviour associated with intercropping.

Conclusion and Recommendations

Intercroppingg has been widely recognized as an important farming system in the arid and semi-arid tropics. Cowpea represents the main food legumes in tropical Africa as a major source of dietary protein in tropical and sub-tropical regions of the world. Its importance is underscored by its use as a component in many cropping system combinations in Africa.

Intercropping is one of the cultural methods of control that is effective in resource management, pest control and increased productivity.

Alternate cropping of chilli pepper and cowpea proved to be superior to other cropping system in respect to grain yield, reduction in pest infestation and reduction in yield loss. Thus, it will be more stable, sustainable and profitable since it will allow farmers to harvest different crop produce for use and sale. Therefore, small scale farmers who cannot afford the cost of synthetic insecticides or technicalities involved in the preparation of chilli pepper extract may adopt the use of alternate cropping system of chilli pepper and cowpea.

Even though the scope of this work do not capture revenue and Land Equivalent Ratio (LER) of cowpea and chilli pepper combination, it is obvious from this work that highest net revenue for the total system will be generated and give overall LER values greater than one. This merits further investigation.

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