DETERMINATION OF CRITICAL YIELD COMPONENTS AND KEY LOSS FACTORS OF COWPEA (*Vigna unguiculata L, Walp)* IN ENUGU AREA, SOUTH EASTERN NIGERIA.

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Abstract

Field experiments to determine the critical yield components and key loss factors of cowpea were conducted in two agro-environments simultaneously in Enugu Area, South Eastern Nigeria in 2007, 2008, and 2009 cropping seasons. The experimental design for each experiment was a split plot in a randomized complete block (RCB) replicated three times. "Sherpa plus 280EC" as water emulsifiable concentrate, Furadan 10G, Neem emulsion as whole plot treatment and two cowpea varieties (Ife brown and potiskum) as slit plot treatment were used in the experiments. The data obtained were used to build up crop life tables as not affected by insecticide treatments. In the two agro-environments, the critical yield component was plant at reproductive phase and the key loss factor was flower abortion. There was a direct relationship ($y = 88.55 + 0.003x$; $p=0.05$, and $r = 0.99$) between rainfall (x) and yield losses (y) in the two agro-environments. Nsukka agro-environment with a mean annual rainfall of 1681.53mm had a mean non-cumulative yield loss of 56.65%, whereas Enugu agro-environment with a mean annual rainfall of 1804.81mm had a mean non-cumulative yield loss of 59.99%.

Introduction

Cowpea is one of the most widely used legumes in the tropical world. The grain is used extensively for human nutrition, especially in African. It is one of the most important tropical multi-purpose legumes being used as vegetables (leaves and flowers), grains, as fresh cut and carry forage, hay and silage (Olawole, 2008). It constitutes the cheapest source of dietary protein and energy for most poor people in the tropical world. In addition, the haulm is fed to cattle in a number of countries, (Jachai and Daoust, 2009). Cowpea also plays an important role in providing soil nitrogen to cereal crops grown after it. It provides a high proportion of its own nitrogen requirement besides leaving a fixed nitrogen deposit of up to 60-70 kgha-1 in the soil for the succeeding cereal crop (Moima, 1991).

In Nigeria, the greatest production of cowpea comes from the northern region. Yield of this crop is generally very low particularly in the southern parts of the country. The production of this crop in Nigeria is low and has not matched the demand of consumers (Okele and Ariyo, 2000).

The production of this important crop is limited by various yield factors. Among those factors causing yield variabilities include:

- Location, climatic factors, soil

types, nutrient status of the soil;

- Crop varieties; and
- Incidence of insect pests and diseases.

In Nigeria, more studies need to be carried out especially on quantifying the contributions of each of these yield variability factors and to determine the key loss factors in Enugu south Eastern Nigeria, hence the aim of this research work. The general objective is therefore, to determine the critical yield components and key loss factors of cowpea in two agro-environments in Enugu Area, South Eastern Nigeria.

The specific objective was to quantify yield losses caused by rainfall (climatic factor), weeding, flower abortions, pod abortion, pod borers and pod sucking bugs, rodents and bush fowls.

Materials and Methods

Experiment Locations

The experiment was carried out in two locations (Nsukka and Enugu Agro-environments) simultaneously for three consecutive years (2007, 2008, and 2009).

Nsukka Location: In Nsukka, the experiment was sited at the school farm of Enugu State University of Science and Technology (ESUT). Nsukka lies within latitude 060 51'N, longitude 070 15'E, with mean elevation of 400m and an annual rainfall of 1600 – 1700 mm, relative humidity of 44.77% – 74.94%, and mean annual temperature of 19.76 0C (University of Nigeria Metrological Station, Nsukka).

Enugu Location: In Enugu, the experiment was carried out in the Teaching and Research farm of Faculty of Agriculture and Natural Resources Management, Enugu State University of Science and Technology (ESUT) Enugu. The area lies between latitude 06052'N, longitude 07015'E, with mean elevation of 450 above sea level and an annual rainfall of 1800 mm to 2100 mm. The soil is of shale parent material and is classified as typic paleudult and is of sandy clay textural class (Anikwe *et al,* 2005).

Experimental Treatments

The experimental treatments included:

(i) Two cowpea varieties (Potiskum and Ife brown).
(ii) Spray of Sherpa plus 280EC. (30g/litre cypermethrine plus 250g/litre dimethoate).
(iii) Spray of neem emulsion (Natural/Plant insecticide).
(iv) Soil treated with furadan 10 G (synthetic granular insecticide).
(v) No insecticide treatment.

Sherpa plus 280 EC.

The rate of dilution was 4ml/ litre of water. Therefore 6 litres of water was used to dilute 24 ml of Sherpa plus for a single spray using manually operated knapsack sprayer.

Furadan 10 G

This was applied around each plant one week after germination at the rate 100 $kgha-^{1}$.

Neem

Neem emulsion was prepared by harvesting and air drying properly of neem leaves, which was also ground into powder. Water was added to the powder and left over night after which it was also filtered. Emulsion of the dose 1.15 kg of neem powder to 20.25 kg of water weight by weight (W/W) was prepared, and used as a single spray at 6 litres per spray. This was stored in refrigerator and used within two weeks. Spraying interval was weekly till harvest.

Experimental Design

The experimental design was a split plot in randomized complete block (RCB) with three replications and four treatments.

Field Layout and Treatment Combinations

The main plots contained 3 insecticidal treatments and a control whereas the subplots contained two cowpea varieties (Ife brown and Potiskum).

Method of Planting

The crops were spaced 0.5 m within rows and 0.5 m between rows. Main plots were separated by 1m pathway, whereas subplots were separated by 0.5m. Each main plot measured 5.5m x 5m (27.5m2) and consisted 5 rows of cowpea plants at 1 seed per stand. Weed control was carried out manually with hoe at three weeks interval.

Data were collected on:

- The number of flowers produced per plant.
- The percentage aborted flowers per plant.
- The number of pods produced per plant.
- The percentage aborted pods per plant.
- The percentage of pods damaged by pod borers and pod sucking bugs.
- The number of plants that died during the experiment were recorded together with the developmental stage in which death took place. The plant mortality factors were identified through field observation.
- Assessment of yield losses in the crop yield components in each replicate were estimated using the formula developed by Pincaco, (2006) as follows:

Loss estimate due to plant mortality during the vegetative phase

The potential crop yield was estimated in the beginning of vegetative phase using the formula PdpIV = PIV x FI/PI x Wfr x F, where PdPIV = yield estimate at the beginning of the vegetative phase (tonha-1), PIV = number of live plant in each replicate at the beginning of the vegetative phase, FI/PI = total number of flowers per plant, Wfr = average weight of pods (ton) and F = conversion factor for the yield from the area of each replicate to 1 hectare. The losses by each plant mortality factor in the plant vegetative phase were estimated using the formula: LsPIVi = PIVLSi X FI/PI X Wfr X F, where: LSPIV; estimated loss by each mortality factor (i) in the vegetative phase, PIVLSi = number of plants killed by each factor in the vegetative phase, and i = plant mortality factor in the vegetative phase (weeding, rainfall). The remaining components of the formula (ie Wfr and F) were as previously described.

Loss estimate due to plant mortality during the reproductive phase

The crop productivity at the beginning of the reproductive phase was estimated by the formula PdPIr = PIr X FI/PI x Wfr X F, where: PdPIr = yield estimate at the beginning of the reproductive phase (tonha-1), and PIr = number of live plants in each replicate at the beginning of the reproductive phase, FI/PI = total number of flowers per plant, Wfr = average weight of pods (ton), and F = conversion factor for the productivity from the area of each replicate to 1 ha.

The losses by each mortality factor were estimated using the formula:

LSPIri = PIrLSi X FI/PI x Wfr x F, where: PIrLSi = estimated loss caused by each mortality factor(i) in the plant reproductive phase, LSPlri; = number of plants killed by each factor in the plant reproductive phase. i = plant mortality factor in the reproductive phase (rainfall) and Wfr and F as previously described.

Loss estimate due to flower abortion

The production of flowers as yield component was estimated using the formula: PdFI = PIh x FI/PI x Wfr x F, where: PdF1 = yield estimate based on flower as yield component (tonha-1), and PIh = number of plants in each replicate at the harvest. The remaining components of the formula were the same as previously indicated. The losses by flower abortion were estimated using the formula: LSFIAb = FIAb X Wfr X F where: LSFIAb = estimate of loss by flower abortion in each replicate (tonha-1), and FIAb = number of flowers aborted. The remaining components of the formula were the same as previously indicated.

Yield loss estimate due to pod loss

The pod yield was estimated using the formula: Pd TFr = PIh x Frt/PI x Wfr x F, where: PdTFr = estimate of total pod yield (tonha-1), Frt/Pl = average number of total pods per plant, and the remaining components of the formula were the same as previously indicated. The pod loss was estimated using the formula: LSFri = FrLsi x Wfr x F, where: LSFri = loss of pods by each factor (i) FrLsi = number of pods lost in each replicate due to each factor (i) i = factor of pod loss (pod abortion, pod borers, and pod sucking bugs), and the remaining components of the formula were the same as previously described.

Assessment of losses by flower abortion

Flowers were marked by tagging every two days for registering the number of aborted flowers.

Assessment of pod losses

The pods were marked by tagging every two days for registering the number of pods lost by different causes (pod abortion, pod borers and pod sucking bugs).

Data Analysis

Table of crop losses

Table of crop losses were built for each replicate with the following yield components: Plants in vegetative stage, plants in reproductive stage, flowers, total pods, cumulative losses(%), and non cumulative losses (%). The non-cumulative losses (100ncl) were calculated using the formula: 100ncl = Lsi/pdi x 100, where: Lsi = loss estimate by each factor(i) for the yield components, and pdi = yield estimate (tonha-1) in each yield component. The cumulative losses (100cl) were calculated using the formula: 100cl = Lsi /pdPIV x 100 where: PdPIV = yield estimate at the beginning of the vegetative phase.

Lsi = loss estimate by each factors (i) for the yield component.

Determination of the critical components of yield loss

The critical components of yield loss were recognized as such when their non-cumulative losses did not differ significantly from those of the component which had the heaviest losses using the Kruskal-Wallis test (p = 0.05) (Hollander and Wolfe, 1999).

Determination of key factors of yield loss

The key factors of yield loss were recognized as those in which the non-cumulative losses did not differ significantly from the factors causing the heaviest loss by the non-parametric test of Kruskal Wallis at (P = 0.05), (Hollander and Wolfe, 1999). Alternatively, the critical component of yield is the component that suffers the highest losses.

The key factor of loss is the factor that had the heaviest losses among those factors that did not differ significantly from the critical component of yield loss.

The data collected were also subjected to regression analysis to establish a relationship between yield losses and climatic factor (rainfall).

Results and Discussion

Non-cumulative crop losses (%) by each causal factor of yield losses in Nsukka and Enugu agro-environments during the 2007, 2008, and 2009 cropping seasons

The result of the experiment in Nsukka agro-environment during the 2007, 2008 and 2009 cropping seasons of cowpea crops showed that rainfall recorded the highest mean non-cumulative crop losses of 69.70%, followed by flower abortion with a mean of 45.03%, pod abortion 30.80%, bush fowls and rodents 9.73%, pod borers and sucking bugs 7.23% and lastly weeding with a mean of 5.25% (Table 1).

In Enugu agro-environment, flower abortion recorded the highest mean non-cumulative crop losses of 77.55%, followed by rainfall with a mean of 76.90%, pod abortion 69.96%, rodents and bush fowls 48.39%, pod borers and sucking bugs 19.97% and lastly weeding with a mean of 3.35% (Table 1).

Record of rainfall and non-cumulative crop losses(%) in Nsukka and Enugu agro-environments during the 2007, 2008 and 2009 cropping seasons of cowpea crops.

Result showed that Nsukka agro-environment recorded a lower annual rainfall of 1681.53mm with a mean non-cumulative crop loss of 56.65%, whereas Enugu agro-environment recorded a higher mean annual rainfall of 1804.81mm with a non-cumulative crop loss of 59.99% which indicated that a higher rainfall lead to a higher crop loss (Table 2).

Result also showed a direct relationship between ($y = 88.55 + 0.003x$; $p = 0.05$; and $r = 0.99$) rainfall and non-cumulative crop losses in both Nsukka and Enugu agro-environments (Table 2). This result therefore explains why cowpea does better in the northern parts of Nigeria where there is less rainfall than in the southern parts where there is more rainfall per annum.

Table 1: Non-cumulative losses(%) by each causal factor of yield losses in Nsukka and Enugu agro-environments during the 2007, 2008, and 2009 cropping seasons

Location	Causal factor of yield loss	Years 2007	2008	2009	Mean
	Weeding	2.44	5.63	7.68	5.25
	Rainfall	76.92	59.01	73.17	69.70
Nsukka	Flower abortion	25.00	19.62	57.14	45.03
	Pod borers and pod sucking bugs	5.88	6.56	10.53	7.23
	Pod abortion	17.65	22.13	52.63	30.80
	Rodents and bush fowls	8.82	9.84	10.53	9.73
	Weeding	3.03	4.32	2.69	3.35
	Rainfall	88.89	49.14	92.68	76.90
Enugu	Flower abortion	76.47	75.82	80.35	77.55
	Pod borers and pod sucking bugs	10.00	4.76	45.16	19.97
	Pod abortion	80.00	46.00	83.87	69.96
	Rodents and bush fowls	-	-	-	48.39

Table 2: Record of Rainfall (mm) and non-cumulative losses(%) in Nsukka and Enugu agro-environments during the 2007, 2008, and 2009 cropping seasons

Location	Year	Rainfall(mm)	Non-Cumulative losses(%)
	2007	1570.48	76.92
Nsukka	**2008**	1627.10	18.02
	2009	1847.00	75.00
Mean		**1681.53**	**56.65**
	2007	1911.20	88.89
Enugu	**2008**	1768.60	28.57
	2009	1734.64	62.50
Mean		**1804.81**	**59.99**

$Y = 88.55 + 0.003x$; $p = 0.05$; $r = 0.99$.

X = Rainfall

Y = Non-Cumulative losses

r = Coefficient of determination

Yield components of losses in Nsukka and Enugu agro-environments during the 2007 cropping season of cowpea crops.

Results in table 3 showed that in Nsukka and Enugu agro-environments, rainfall caused the highest cumulative crop losses of 48.78% and 48.48% respectively, followed by flower abortion with 13.41 and 39.39 respectively. And lastly pod borers and pod sucking bugs with 2.44% and 0.30% respectively.

Table 3. Yield component of losses in Nsukka and Enugu agro-environments during the 2007 cropping season of cowpea crops.

Yield Component	Estimated yield ± S.E. (tonha-1)		Causal Factors of yield loss	Yield loss+ S.E. (tonha-1)		Non-Cumulative losses (%)		Cumulative losses(%)	
	Nsukka	**Enugu**		**Nsukka**	**Enugu**	**Nsukka**	**Enugu**	**Nsukka**	**Enugu**
Plant (vegetative phase)	0.082 ± 0.003	0.033±0.002	**Weeding**	0.002±0.0001	0.01± 0.003	2.44	3.03	2.44	3.03
Plant (Reproductive phase)	0.052±0.003	0.018±0.001	Rain fall.	0.04±0.002	0.016±0.001	76.92	88.89	48.78	48.48
Flowers	0.044+0.002	0.017+0.001	Flower abortion.	0.011+0.0004	0.013+0.001	25.00	76.47	13.41	39.39
Pods	0.034±0.002	0.001±0.0001	Pods borers and Sucking bugs.	0.002±0.0001	0.0001±0.00001	5.88	10.00	2.44	0.30
			Rodents and bush fowls.	0.003±0.0008	-	8.82	-	3.66	-
			Pod abortion	0.006±0.003	0.0008±0.00006	17.65	80.00	7.32	2.42

Yield component of losses in Nsukka and Enugu agro-environments during the 2008 cropping season of cowpea crops.

Result of the experiment showed that in Nsukka and Enugu agro-environments, cumulative crop losses of 14.08% and 27.03% respectively were caused by rainfall, and flower abortion caused cumulative crop losses of 10.92% and 37.30% respectively whereas pod borers caused the least cumulative crop loss of 2.82% and 0.54% respectively (Table 4).

Table 4. yield component of losses in Nsukka and Enugu agro-environment during the 2008 cropping season of cowpea crops.

Yield Component	Estimated yield ± S.E. (tonha-1)		Causal Factors of yield loss	Yield loss+ S.E. (tonha-1)		Non-Cumulative losses (%)		Cumulative losses(%)	
	Nsukka	Enugu		Nsukka	Enugu	Nsukka	Enugu	Nsukka	Enugu
Plant (vegetative phase)	0.284 ± 0.003	0.185±0.01	Weeding	0.016±0.003	0.008± 0.0004	5.63	4.32	5.63	4.32
Plant (Reproductive phase)	0.222±0.029	0.175±0.01	Rain fall.	0.04±0.002	0.016±0.001	18.02	28.57	14.08	27.03
Flowers	0.158±0.004	0.091±0.006	Flower abortion.	0.031±0.001	0.069±0.004	19.62	75.82	10.95	37.30
Pods	0.122±0.004	0.021±0.0007	Pods borers and Sucking bugs.	0.008±0.0007	0.001±0.0008	6.56	4.76	2.82	0.54
			Rodents and bush fowls.	0.012±0.0005	-	9.84	-	4.22	-
			Pod abortion	0.027±0.011	0.0046±0.0007	22.13	46.00	9.51	2.49

Yield component of losses in Nsukka and Enugu agro-environments during the 2009 cropping season of cowpea crops.

Results in table 5 showed that in Nsukka and Enugu agro-environments, the highest cumulative crop losses of 53.57% and 56.72% respectively were caused by rainfall, followed by flower abortion with 21.43 and 20.90% respectively, and lastly pod borers and pod sucking bugs with 1.79% and 2.09% respectively.

Table 5. Yield component of losses in Nsukka and Enugu agro-environments during the 2009 cropping season of cowpea crops.

Yield Component	Estimated yield ± S.E. (tonha 1)		Causal Factors of yield loss	Yield loss+ S.E. (tonha-1)		Non-Cumulative losses (%)		Cumulative losses(%)	
	Nsukka	Enugu		Nsukka	Enugu	Nsukka	Enugu	Nsukka	Enugu
Plant (vegetative phase)	0.0056 ± 0.003	0.0067±0.0002	Weeding	0.00043±0.00002	0.00018± 0.00002	7.68	2.69	7.68	2.69
Plant (Reproductive phase)	0.0041±0.0007	0.0041±0.0001	Rain fall.	0.003±0.001	0.0038±0.0009	75.00	62.50	53.57	56.72
Flowers	0.0021±0.0001	0.0017±0.00005	Flower abortion	0.0012±0.009	0.0014±0.00005	57.14	82.35	21.43	20.90
Pods	0.00095±0.00005	0.00031±0.00001	Pods borers and Sucking bugs.	0.0001±0.000004	0.00014±0.00002	10.53	45.16	1.79	2.09
			Rodents and bush fowls.	0.0001±0.000002	0.00015±0.00002	10.53	48.39	1.79	2.24
			Pods abortion	0.0005 ± 0.00001	0.00026±0.000008	52.63	83.87	8.93	3.88

Recommendations

Base on the results of this research, we recommend the following to cowpea farmers in Enugu State:

- Since the critical yield component of cowpea is plant at reproductive phase, and the key loss factor is flower abortion, cowpea farmers in Enugu area should not plant Ife brown or Potiskum at the beginning of rainfall in order to have a reduced rainfall during the reproductive phase, and not too late each year to avoid the danger of early end to rains before maturity of the crop. This recommendation agrees with Dujge *et al* (2009), who noted that cowpea performs well in agro-environment where the rainfall range is between 500 mm and 1200 mm per annum. They also went further to state that farmers establishing cowpea farms, should not plant to early so that the crop does not mature during the rains or too late to avoid the danger of early end to rains. This recommendation is only for farmers whose emphasis are on grain than fodder yield.
- For farmers whose interests are on folder yield, planting cowpea crops should start at the beginning of rainfall each year because cowpea planted early in the cropping season produces luxuriant vegetation for a long period before flowering or reproductive phase.

Contributions of this Research to Knowledge

This research work contributed much to knowledge in the following ways.

1. The critical yield component of cowpea was determined to be plant at reproductive phase in both Nsukka and Enugu agro-environments.
2. Also the key loss factor of cowpea was determined to be flower abortion in both Nsukka and Enugu agro-environments.

These findings therefore suggest that efforts to reduce cowpea crop losses should be more during reproductive phase than during vegetative phase.

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