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FORAGE DRY MATTER YIELD OF INTERCROPPED MAIZE (*Zea mays*) AND COWPEA (*Vigna unguiculata* (L.) Walp) IN VARIOUS SPRAY REGIMES AND SEASONS

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ABSTRACT

The demand for crop residues is rising in response to increasing consumption of animal protein while productivity of natural pastures is declining due to adverse effects of climate change, overgrazing and population pressure on land. Although the use of forage crop can complement natural pastures, it is essential that the fodder potential of these crops be assessed. Five varieties of cowpea and one variety of maize were studied with the aim of evaluating their forage dry matter yield under different cropping systems, sowing dates and agro-chemical treatments. Treatments were laid out in split-split plot and arranged in randomized complete block design with three replications across the two years in Ako, South Eastern Nigeria. The results obtained indicated that intercropping cowpea with maize produced more total forage dry matter than sole crop of cowpea and maize. Early season cropping and long duration cowpea significantly (P=0.05) supported higher cowpea fodder dry matter yield in both years. Lowered application of agro-chemical (≤one spray) resulted in higher cowpea fodder production. Significantly (P=0.05) higher dry matter yield was obtained in maize when two insecticide sprays was applied in both sole and intercropping. The higher stover yield obtained in maize with higher insecticide application as against lower cowpea fodder yield with higher chemical application suggested the existence of physiological compensation among the component crops used in this study.

Key words: Cowpea, maize, fodder, intercrop, insecticide spray, planting date

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Introduction

Cowpea (*Vigna unguiculata* (L) Walp) is a major component of the traditional cropping systems in Africa, Asia, and Central and South America, where it is widely grown in mixtures with maize (*Zea may* L.), millet (*Pennisetum glaucum* L.) and sorghum (*Sorghum bicolor* L. Moench) in various combinations (Olufajo and Singh 2002). Cowpea cultivation not only contributes to soil fertility but also provides nutritious fodder for livestock and cash income to resource poor farmers. Maize is regarded as the most important cereal crop in sub-Saharan Africa (IITA, 2009). It is rapidly replacing millet and sorghum in the Savanna agro-ecological zone of Nigeria (Fakorede *et al.* 2003).

Intercropping of forage legumes with cereals offers opportunity for increasing forage yield and consequently livestock production. Liu *et al.* (2006) pointed out that fodder yields of a given crop in the mixture are less than the yields of the same crop grown alone, but the total productivity per unit of land is usually greater in intercropping than in sole cropping. The advantage of intercropping has been attributed mainly to environmental resources such as water, light and nutrients which can be utilized more efficiently in intercropping than in sole cropping system. Willey, (1991) and Tadesse *et al*. (2012) noted that the underlying principle of better use of environmental resource in intercropping is that if crops differ in the way they utilize resources when grown together, they can complement each other and make better combined use of resources than when they are grown separately. Potential of raising other crops such as forage legumes and non-legumes in association with major staple cereal crops could therefore be substantially enhanced through intercropping (Saeed *et al.,* 1999). Intercropping also enhance soil fertility, efficient use of nutrients, protect the soil against soil erosion and ensure economic utilization of land, labor and capital.

The crop residues of such crops as maize, groundnut, cowpea, cassava, and sorghum are important feed resources for small holder livestock farmers in Nigeria. The residues of these crops consist of leaves, vines, pod walls, stems, immature pods and grains which are often sold in local markets (Oroka, 2012). Some farmers obtain as much as 25% of their annual cash income from the sale of grain legume forage which are often used in fattening ram prior to important festivals (ICRISAT, 1991). During the wet season especially between May to September, animal graze mainly natural pastures but depend mostly on crop residues in the dry season between October and April. In other to meet up with nutritional demands of ruminant livestock at this time of scarcity, farmers have to store crop residues from previous harvest or leave crops in the field to be grazed by livestock. However, in Southern Nigeria, agro-pastoralists graze their ruminant livestock on residues from the cropping system, particularly in the dry season (Tarawali *et al.,* 2002).

As farming becomes more intensive and land resources becoming scarcer owing to rapid increase in human population, livestock may no longer have access to free grazing. This scenario will force livestock farmers to shift to a system of “cut-and-carry for feeding”. This process not only allow for more control over livestock diets and improves the ability to target feeding towards specific market for meat and milk but also provide opportunity for the improvement of forage production. Crop residues make up a major component of livestock diets in mixed crop-livestock systems and therefore, improving the yield of fodder crop is important to enhancing farm productivity and profitability. Cowpea is an important component of mixed systems and is valued for its potential to produce high levels of nutritious fodder for livestock in addition to grain for human consumption. Residue of maize is nutritionally inadequate to produce high quality and quantity manure, meat and milk. Introduction of cowpea as a supplement not only provide nitrogen to the rumen microbes, allowing them to improve utilization of low quality cereal forage but also increase the availability of energy through increased digestibility (Chakeredza *et al*., 2002). Demand for crop residues is rising in response to increasing consumption of animal protein especially in urban centers in developing countries while conversely, the productivity of most pasture crops is dwindling in some regions of the world owing to adverse effects of climate change, poor soil fertility status and depleted underground water sources (Ezeaku *et al*., 2016). This circumstance has created opportunity for crop-livestock integration with

Table 1: The origin and description of the genotypes used in this study

Genotype	Origin	Photo-Sensitivity	Maturity	Growth habit
IT 98K-131-2	IITA	NPS	Medium	Prostrate, indeterminate
IT 97K-568-18	IITA	NPS	Medium	Prostrate, indeterminate
IT 97K-499-35	IITA	NPS	Early	Semi-Prostrate, determinate
IT 93K-452-2	IITA	NPS	Early	Semi-Prostrate, determinate
Local check	Landrace	PS	Late	Prostrate, indeterminate

NPS= Non-photosensitive **PS**=Photosensitive

Table 2: Effect of season and cropping system on forage dry matter (kg ha^{-1}) of cowpea cultivars combined over two years in Ako, Enugu State, Nigeria

	Early season		Late season	
Cultivar	Sole cropping	Intercropping	Sole cropping	Intercropping
IT 97K-499-35	825.04	796.26	928.68	720
IT 97K-568-18	1592	1296.09	862.08	560.33
LOCAL	1350.01	1192	1283.11	743.11
IT 98K-131-2	1670.55	1103.48	862	679.35
IT 93K-452-1	658	575.03	867.37	666.49
Mean	1219.1	996	961.09	673.86

F-LSD (0.05) for comparing the systems = 124.1

Table 3: Effect of cropping system and agro-chemical spray regime on forage dry matter (kg ha^{-1}) of cowpea cultivars combined over two years in Ako, Enugu State, Nigeria

	Sole cropping				Intercropping			
Cultivar	No spray	One spray	Two sprays	Three sprays	No spray	One spray	Two sprays	Three sprays
IT 97K-499-35	1333.11	867	100.11	733.06	633	667	767	767.04
IT 97K-568-18	533	1013	550	767	267.21	333.24	300.21	183
LOCAL	1616.05	1223.02	1067	1154.15	285.11	253.14	233	433.12
IT 98K-131-2	1200.13	1000	600	567.22	567.31	800	533	400
IT 93K-452-1	1033	900.17	667	900	700	767	600.02	500.05
Mean	1141.14	1001	777	824	490	564	487	457

F-LSD (0.05) for comparing chemical spray regimes = 275.7

particular emphasis on fodder innovation and sustainable management option (Ezeaku *et al.,* 2015). Integrating agro-chemical treatment with appropriate planting dates of component crops in a system can contribute significantly to improving the forage yield as it modifies the relative periods of complementarities and competitiveness of component crops (Midmore 1993). The objective of this study was to evaluate the yield of cowpea and maize fodder when exposed to different cropping systems, sowing dates and agro-chemical treatments. The result will provide information required to optimize crop residue production for sustainable livestock feed management.

Materials and methods

The experiment was conducted in Ako (06^0 34'N, 07^0 35'E; 154 m above sea level) location in South Eastern Nigeria over a period of two years and two seasons in each year. In the first year early sowing was carried out on June 18 while late season sowing was done on August 30. Similarly, in the second year early season was sown on June 18 while late season was sown on August 30.

The experiment was laid out in split-split plot arranged in randomized complete block design (RCBD) with each treatment replicated three times on four rows plot of 2 m long with 1m alley. Cropping system constituted the main-plot treatment, number of insect control as the sub-plot treatment while genotypes constituted the sub-sub-plot treatment. The five genotypes used for the study include; IT97K-499-35, IT97K-568-18, IT98K-131-2, IT93K-452-1 and a local variety used as control. An open pollinated maize variety (ACR 9931) was used for the intercrop along with the selected cowpea genotypes. Each replicate is made up of two blocks consisting of either intercrop or sole crop systems as main plot. Each level of the system was sub-divided into four plots with the four levels of insecticide treatment (i.e. zero spray, one spray at flower bud initiation, two sprays one at flower bud initiation and full bloom, and three sprays one at flower bud initiation, full bloom and 50 percent podding) randomized and assigned to each of the plots as sub-plot treatment. Also each of the levels of insecticide treatment were further split into five plots and the five genotypes assigned to each plot randomly as sub-sub-plot treatment.

The experimental plots for both cowpea and maize were ploughed, harrowed and manually ridged. Prior to ridging, a basal dose of 200 kg NPK 15-15-15 per hectare plus 1000 kg per hectare of well cured cow dung were broadcast uniformly and later incorporated into the soil before ridging. Cowpea and maize intercrop row arrangement consisted of two rows of maize to two rows of cowpea per plot, while cowpea and maize sole crop were established on a four row plot each. Inter-row spacing of 75 cm and intra row spacing of 25 cm were adopted for both crops and systems. Two seeds of cowpea and one seed of maize per hill were sown at 3-5 cm depth. Cowpea and maize were sown simultaneously. Urea fertilizer @ 100 kg per hectare was top dressed to only maize three weeks after planting. Weeds were manually controlled as regularly as they appeared, while other agronomic practices were carried out as recommended. Insecticide was applied during crop growth stages when insect pest pressure was usually high (flower bud initiation, full bloom and 50 percent podding) which are the critical periods for insect control (Taylor, 1978). Insect pests were managed with the application of full dose of 100 ml of insecticide, cypermethrin and dimethoate mixture containing 30 g and 250 g active ingredients respectively, using 15 litres knapsack sprayer**.**

Data on growth, reproductive and grain yield components were sampled from the inner two rows. Dry fodder weight was determined from the net plot after pods were harvested. The cowpea forage and maize stover were cut, tied and sun dried thereafter, they were weighed and expressed in kilograms using weighing scale. The data collected were subjected to analysis of variance (ANOVA) using GENSTAT Discovery Edition 2 (GENSTAT, 2005) procedures as outlined for RCBD. Means of cultivars were separated using fishers least significant difference (F-LSD) (P = 0.05).

Results

The origin and description of the genotypes used in this study is presented in Table 1. The improved genotypes were sourced from International Institute of Tropical Agriculture

Table 4: Effect of season and agro-chemical spray regime on forage dry matter (kg ha^{-1}) of cowpea cultivars combined over two years in Ako, Enugu State, Nigeria

	Early season				Late season			
Cultivar	No spray	One spray	Two sprays	Three sprays	No spray	One spray	Two sprays	Three sprays
IT 97K-499-35	867	852	725	825	983	742	883	750
IT 97K-568-18	1450	1500	1383	1392	608	887	654	696
LOCAL	1158	1325	1367	1233	1150	1062	875	965
IT 98K-131-2	1475	1383	1342	1350	958	950	692	483
IT 93K-452-1	758	630	525	550	867	817	667	717
Mean	1142	1138	1068	1070	913	891	754	722

F-LSD (0.05) for comparing spray regimes = 175.5

Table 5: Effect of year and season on forage dry matter (kg ha^{-1}) of cowpea cultivars in Ako, Enugu State, Nigeria

	2009		2010	
Cultivar	Early season	Late season	Early season	Late season
IT 97K-499-35	1117	783	504	833
IT 97K-568-18	1692	493	1196	929
LOCAL	1383	846	1158	1243
IT 98K-131-2	1617	708	1158	833
IT 93K-452-1	858	758	375	775
Mean	1333	718	878	923

F-LSD (0.05) for comparing seasons = 111.0

Table 6: Effect of season and cropping system on stover dry matter (kg ha^{-1}) of maize combined over two years in Ako, Enugu State, Nigeria

	Early season		Late season	
Intercrop combination	Sole cropping	Intercropping	Sole cropping	Intercropping
ACR9931/97K-499-35	1344	1353	1254	1250
ACR9931/ 97K-568-18	1420	1212	1324	1233
ACR9931/LOCAL	1371	1366	1218	1217
ACR9931/98K-131-2	1375	1250	1317	1283
ACR9931/93K-452-1	1266	1151	1281	1258
Mean	1355	1266	1278	1248

F-LSD (0.05) for comparing the systems = 152

(IITA), Ibadan, Nigeria, while the local check was obtained from the location of the trial. All the improved genotypes are non-photosensitive and either early or medium maturing while local check was both photosensitive and late maturing. Medium and late maturing genotypes exhibited prostrate indeterminate growth habit, while early maturing genotypes expressed semi-prostrate determinate. Based on the above features the genotypes used for this study varied considerably from each other with respect to key cowpea plant traits. Table 2 showed the effect of season and cropping system on forage dry matter of cowpea genotypes. Results showed that the two medium maturing genotypes, IT98K-131-2 and IT97K-568-18 gave the highest forage production in both cropping system in early season indicating that they were adapted to both systems in early season.

On the other hand, early maturing genotypes, IT97K-499-35 and IT93K-452-1 maintained significantly lower forage dry matter in both systems in early seasons but higher forage yield in both systems in late season suggesting that late season stimulated higher forage production in early maturing genotypes. The local check which is long duration produced above average forage dry matter yield in both seasons and systems indicating broad adaptation to all the environments studied with respect to the trait under consideration. Table 3 showed the effect of cropping system and agro-chemical spray regime on forage dry matter of cowpea cultivars combined over two years. Lower application of agro-chemical gave significantly higher cowpea forage with zero application stimulating highest forage yield in all the genotypes than the rest spray regime in sole cropping while one spray produced higher forage in intercropping. Across the entire spray regimes in sole cropping, local variety supported significantly higher forage dry matter yield than the rest genotypes. The effect of season and agro-chemical spray regime on forage dry matter of cowpea cultivars combined over two years is presented in Table 4. Higher application of agro-chemical resulted in lower forage dry matter yield with the highest forage yield recorded in zero application of insecticides in both seasons. The two medium maturing genotypes produced significantly higher forage dry matter in early season while local check produced significantly higher forage dry matter in late season across the entire spray regimes. Table 5 referred to the effect of year and season on forage dry matter of cowpea cultivars in Ako. Response of genotypes to year effect with respect to season did not follow definite pattern since genotypes produced significantly higher mean forage dry matter yield in early than late season in 2009, while year 2010 on the other hand recorded highest forage dry matter yield in late season than in early season. The results suggested that year and season interaction affected the overall performance of genotypes differently with respect to the trait under consideration justifying the evaluation of the genotypes in different environments. However, IT97K-568-18 and IT98K-131-2 produced the highest forage dry matter in early season in 2009 and 2010, while local check produced the highest forage dry matter in late season in both years.

Effect of season and cropping system on stover dry matter of maize combined over two years in Ako is presented in Table 6. In both seasons significantly higher stover dry matter was realized under sole cropping condition. However, components of maize and cowpea in intercropping system gave significantly higher overall residues over the sole cropping. Maize stover dry matter yield was higher when intercropped with early maturing cowpea genotypes in late season. Table 7 indicated the effect of cropping system and agro-chemical spray regime on stover dry matter of maize combined over two years in Ako. Significantly higher dry matter yield was obtained when two insecticide sprays was applied in both sole and intercropping. This result revealed that the higher stover yield obtained in maize with two insecticide application was due to reduced cowpea forage dry matter production suggesting physiological compensation and relative complementarities and competitiveness of component crops. The effect of year and season on stover dry matter of maize in Ako is presented in Table 8. Early season influenced higher expression of maize stover yield in both years, with year 2010 producing marginally higher stover dry matter than year 2009, while in the late season stover dry matter across both years did not differ significantly among the intercrop combinations except intercropping involving ACR9931 and IT98K-131-2 that produced significantly higher stover. Intercropping maize with local cowpea variety gave significantly

Table 7: Effect of cropping system and agro-chemical spray regime on stover dry matter (kg ha^{-1}) of maize combined over two years in Ako, Enugu State, Nigeria

	Sole cropping				Intercropping			
Intercrop combination	No spray	One spray	Two sprays	Three sprays	No spray	One spray	Two sprays	Three sprays
ACR9931/97K-499-35	1315	1328	1332	1220	1159	1335	1496	1215
ACR9931/ 97K-568-18	1400	1313	1466	1307	1323	1193	1202	1173
ACR9931/LOCAL	1374	1326	1326	1151	1307	1264	1425	1170
ACR9931/98K-131-2	1310	1264	1600	1210	1254	1147	1426	1240
ACR9931/93K-452-1	1226	1178	1440	1249	1152	1239	1241	1187
Mean	1325	1282	1433	1227	1239	1236	1358	1197

F-LSD (0.05) for comparing the chemical spray regimes = 107.8

Table 8: Effect of year and season on stover dry matter (kg ha^{-1}) of maize in Ako, Enugu State, Nigeria

	2009		2010	
Intercrop combination	Early season	Late season	Early season	Late season
ACR9931/97K-499-35	1348	1252	1397	1212
ACR9931/ 97K-568-18	1316	1278	1256	1206
ACR9931/LOCAL	1369	1217	1411	1365
ACR9931/98K-131-2	1313	1300	1294	1220
ACR9931/93K-452-1	1209	1270	1196	1100
Mean	1311	1263	1319	1221

F-LSD (0.05) for comparing seasons = 150.6

Table 9: Effect of season and agro-chemical spray regime on stover dry matter (kg ha^{-1}) of maize combined over two years in Ako, Enugu State, Nigeria

	Early season				Late season			
Intercrop combination	No spray	One spray	Two sprays	Three sprays	No spray	One spray	Two sprays	Three sprays
ACR9931/97K-499-35	1296	1304	1492	1300	1178	1359	1337	1135
ACR9931/ 97K-568-18	1369	1265	1449	1180	1354	1241	1219	1300
ACR9931/LOCAL	1366	1318	1529	1263	1315	1272	1223	1059
ACR9931/98K-131-2	1324	1273	1407	1245	1239	1138	1618	1205
ACR9931/93K-452-1	1182	1178	1280	1195	1197	1239	1402	1241
Mean	1307	1268	1431	1237	1257	1250	1360	1188

F-LSD (0.05) for comparing the chemical spray regimes = 189.5

higher stover dry matter in both years and seasons probably due to differences in the time of soil resource utilization by the two crops as the maize variety used is early maturing while the cowpea is long duration that matures into the dry season. Moreover, the local cowpea landrace may have improved the soil micro-climate around the maize making the environment conducive for high stover dry matter production. On the other hand, intercropping involving early maturing cowpea, IT93K-452-1 gave significantly lower maize stover dry matter in both years possibly due to competition between the two crops for space and essential soil resources as both are early maturing. Table 9 refers to the effects of season and agro-chemical spray regime on stover dry matter of maize combined over two years in Ako. Interactions between season and spray regime gave similar results with interactions between cropping system and spray regime. Two sprays gave significantly higher stover dry matter of maize in early and late seasons indicating that cropping system and season effects on stover yield did not differ relative to agro-chemical treatment.

Tables 2 and 6 indicated that intercropping produced higher forage yield in early and late seasons. For instance, in early season intercropping produced 2262 kg ha^{-1} while sole crop of cowpea and maize individually produced 1219.1 kg ha^{-1} and 1355 kg ha^{-1} respectively. In late season however, intercropping produced 1921.9 kg ha^{-1}, while sole crop of cowpea and maize produced 1278 kg ha^{-}1and 961 kg ha^{-1}, respectively.

Discussion

Early season was found to promote significantly higher cowpea and maize residues than the late season. This result was supported by Javid *et al*. (2005) and Karungi *et al.* (2000), who attributed the yield differences to higher solar radiation and leaf area index. The differences in forage production between the two seasons could also be attributed to adequate moisture in early season due to longer rainfall duration.

Intercropping gave significantly higher residues than the sole cropping in this study. Lui *et al*. (2006) pointed out that fodder yields of a given crop in the mixture are less than the yields of the same crop grown alone, but the total productivity per unit of land is usually greater in intercropping than in sole cropping. The fodder advantage of intercropping has been attributed mainly to environmental resources such as water, light and nutrients which can be utilized more efficiently in intercropping than in sole cropping system.

The intercropping involving maize with local cowpea gave higher stover dry matter yield in both years and seasons indicating that local climbing type of cowpea rather than suppress maize stover production enhanced it. This result could be attributed to differences in the time of critical soil resources demand by both crops and the ability of the local cowpea to conserve soil moisture around maize through provision of effective ground cover. Willey, (1991) and Tadesse *et al.* (2012) noted that the underlying principle of better use of environmental resource in intercropping is that if crops differ in the way they utilize resources when grown together, they can complement each other and make better combined use of resources than when they are grown separately. Lal and Maurya (1982) reported that the total root mass of the maize/cowpea intercrop was larger than either of the monoculture. In a humid forest experiment, it was observed that water-use efficiency was higher in maize/cowpea intercrop than in sole crop when water was not limiting, but in drought conditions the water use efficiency of sole maize was greater than that of the intercrop (Hulugalle and Lah, 1986). Similarly, Ofori and Stern (1987) stated that cereal and legume intercrops used water equally, and that competition for soil water may not be a detrimental factor for most growth traits in intercrop systems. On the other hand, intercropping involving early maturing cowpea, IT 93K-452-1 gave significantly lower maize stover dry matter yield in both years probably due to competition between the two crops for space and essential soil resources as both are early maturing crops. Also, the cowpea genotype being early maturing could not provide adequate soil cover necessary to maximize soil moisture retention for use by maize. It has been suggested that component crops in intercrops system should possess complementary plant traits such as different rooting systems, maturity and other morphological characteristics.

The local variety produced significantly higher forage dry matter yield in both systems, and seasons, supporting those reported by Ng (1995) that local cowpea co-evolved with cereals in a traditional cropping system and was grown primarily for fodder. Blade *et al.* (1997) also noted that local cowpea varieties are highly adapted to intercropping systems than improved varieties but that they possess very low harvest index but high fodder.

In this study, zero application of agro-chemical resulted in higher fodder yield in sole cropping while three sprays gave lowest fodder production. In intercropping however, one spray gave higher overall fodder production than other spray regimes, confirming that lowered application of agro-chemical resulted in higher fodder production owing to reduced protection of the crop against insect pest attack which consequently favored forage yield. Alghali (1991) found that fodder production was enhanced by non application of insecticides. When pest attack is heavy and grain yield is minimized, fodder production for animal nutrition guarantees the supply of animal protein for human diet. For instance, fodder production is not reduced by flower thrips and *M. vitrata* damage (Suh and Simbi 1983). They rather stimulate higher fodder production because photosynthates that would have been invested in flowers and pods are used for foliage development. This result is also in agreement with those obtained by Ajeigbe *et al.* (2005), who reported that the reduction in fodder yield was partly because of greater grain yield and delay in cutting of the fodder due to multiple grain harvest resulting in the loss of leaves due to senescence. This was also the conclusion of Tarawali *et al.* (1997) and Tarawali *et al.* (2002). Furthermore, Schulzet *et al.* (2001) reported that if cowpea is not adequately protected from insect damage, it produced less grain and more leaf and vine dry matter.

Significantly higher dry matter yield was obtained in maize when two insecticide sprays was applied in both sole and intercrop. This result revealed that the higher stover yield obtained in maize with two insecticide application was due to reduced cowpea forage dry matter production suggesting physiological compensation and relative complementarities of component crops.

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