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INFLUENCE OF CROPPING SYSTEM AND WEED MANAGEMENT PRACTICE ON EMERGENCE, GROWTH OF WEEDS, YIELD OF MAIZE (*Zea mays* L.) AND COWPEA (*Vigna unguiculata* L.)

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SUMMARY

The effects of cropping system and weed management practice on weed seedling emergence, weed biomass production and yield of maize and cowpea were examined at Ilorin, in the southern Guinea savanna (9º29' N, 4º35' E and 307 m ASL) of Nigeria. Weed emergence occurred throughout the 3-15 weeks after planting (WAP). Forty-three weed species belonging to 38 genera within 20 families were encountered. Fimbristylis littoralis Gaudet, Tridax procumbens L and Eleusine indica Gaertn were the most prevalent weed species. Cropping system and weed management practice significantly affected weed emergence. Significantly ($p \leq 0.05$) lower number of weeds emerged in the intercropped and herbicide treated plots while higher weed densities and weed biomass were recorded in the uncropped and unweeded control plots than in the other plots. While aggregate crop yields were significantly higher in the intercropped than in the sole plots, component crop yields were higher under the sole cropping than in the intercrop. The implication of the results on weed management is discussed.

Key-words: cropping system, intercropping, weed control, weed growth, yield

INTRODUCTION

Weed prevention systems seek to limit weed population growth and are predicted to be most successful when they combine several management tactics (Liebman and Gallandt, 1997). Cropping system is characterized by the fact that reduce weed population growth rates may provide a weed suppressive foundation upon which to layer complementary management tactics (Davis et al., 2003).

Since the cropping system characteristics can fundamentally alter the abiotic and biotic features of the agroecosystem in which weed populations exist, they may influence the rates of growth of weed species and the entire weed life cycle.

Cropping systems across southern Guinea savanna (SGS) of Nigeria are experiencing changes towards intensive landuse, changing crop preferences and cropping patterns. Consequently, agriculture in the moist SGS is faced with many production constraints depending on socio-economic and agro-ecological conditions (Smith and Weber, 1994). Weeds and labor demands required for weed control are among the most important production constraints in this region. Despite the recent development of highly intensive crop production systems in SGS of Nigeria, little is known about the relationship between weed communities and intensification process in this agro ecological zone. Therefore the study was aimed to document the emergence of weed communities in different cropping systems in order to improve the planning and timing of weed management.

MATERIAL AND METHODS

Site description

This study was conducted on the University of Ilorin Teaching and Research Farm during the 2009 and 2010 cropping seasons. The farm is located at Ilorin in

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the southern Guinea savanna ecological zone (9°29' N, 4°35' E) of Nigeria and is 307 m ASL. The area recorded a bimodal rainfall pattern with peaks in April and July in 2009 and May and September in 2010 and gradually decreased to a dry spell in December.

Experimental design

The experiment was designed as a randomized complete block with a split-plot arrangement and three replicates. The main plots consisted of four cropping systems, made up of a maize and cowpea intercrop (MZCP), a sole crop of maize (SMZ), a sole crop of cowpea (SCP) and a no- cropping (NCRP) treatment while the sub plots consisted of three weed control methods, which included: 1. Chemical weed control (CWC); 2. Hand weeding (HWC) and 3. No weed control (NWC).

Field establishment

The trial occupied an area of 2250 m^2 (75 m x 30 m) which was divided into three replicates of 750 m^2 (75 m x 10 m). The site was disc ploughed, harrowed and ridged. Each replicate comprised of twelve (12) sub-plots. Each sub plots had seven (7) ridges, 5 m long and 1.0 m apart with a gross area of 35 m^2 (approximately). The maize seeds (SUWAN 1) were sown at 1.0 m x 0.30 m, two plants/hill to give a density of 66,667 plants ha^{-1}. The cowpea seeds (IFE BPC) were sown at a spacing of 1.0 m x 0.25 m at two plants per hill to give an approximate density of 80,000 plants ha^{-1}. For the intercrop, maize was sown at 1.0 m x 0.3 m and cowpea at 1 m x 0.3 m within the same row using the 1:1 replacement model to give a combined plant population of 133,334 plants/ha^{-1} (66,667 plant ha^{-2} of each component plant density).

Crop maintenance

Primextra Gold$^{(R)}$ (a proprietary mixture of metolachlor and atrazine) was applied at the rate of 2.5 kg ai/ha to the sole maize and the maize-cowpea intercrop plots while pendimethalin was applied at the rate of 1.5 kg ai/ha to sole cowpea plots. Fertilizer (NPK 20:10:10) was applied in two splits, at the rate of 200 kg ha^{-1} at 3 WAP and 100 kg ha^{-1} at 7 WAP of maize. The cowpea plants were sprayed with 1.2 kg ha^{-1} of Karate® (cypermethrin 10% EC) at weekly intervals from two weeks after planting until harvest to control foliage and pod insect infestations.

Data collection

Weed seedling emergence was monitored in two scenarios. In one scenario, weed seedling emergence was monitored in the same fixed quadrats at 3, 6, 8, 10, 12 and 15 WAP in each sub plot, hereafter referred to as continuous emergence. In the second scenario, weed seedling emergence was monitored in different fixed quadrats at 5, 9 and 12 WAP within each sub plot, hereafter referred to as discrete emergence. In both scenarios seedling emergence was assessed in two fixed 0.5 m^2 quadrats per sub plot. On each sampling date, weed seedlings were identified to species level using the weed identification manual of Akobundu and Agyakwa (1998), counted and pulled out after enumeration. Weed dry matter production was determined from the harvested weeds within each quadrat during each of the sampling periods, for each of the scenarios stated above. Samples from the same plot were bulked and oven-dried to a constant weight. Grain yield of crops was estimated at harvest.

Data analysis

Data collected on weed density, weed biomass and crop parameters were subjected to analysis of variance (ANOVA) using Genstat Discovery Edition 3 and where F-ratios were significant ($P \leq 0.05$), means were separated using the Least Significant Difference.

RESULTS

Weed species composition

A total of 43 weed species belonging to 38 genera and 20 families were enumerated during the 2009 and 2010 growing seasons on the experimental site (Table 1). Twenty-six of the total weed species were enumerated in the 2009 cropping season while thirty-nine were identified during the 2010 growing season. About 58 % of all the weed species belonged to the Poaceae (12), Euphorbiaceae (5) and Cyperaceae and Rubiaceae (4 species each) families. About 63% of the weeds were broadleaved species, 28% were grasses while 9% were sedges. Annual weed species accounted for 56% while 37% were perennials and about 7% were annuals/ perennials. Thirteen weed species having frequency of occurrence of 5% and above were identified during the two seasons and thereafter referred to as prevalent weed species. Six of the thirteen weed species were enumerated during 2009 growing season; and there were: *Fimbristylis littoralis* (12.95%), *Pycerus lanceolatus* (11.59%), *Eleusine indica* (9.95%) and *Euphorbia heterophylla* (8.30%), *Tridax procumbens* (6.89%) and *Dactyloctenium aegyptium* (6.38%); while in the 2010 growing season, seven of the prevalent weed species: *Tridax procumbens* (8.67%), *F. littoralis* (6.46%) *Brachiaria deflexa* (6.29%), *E. indica* (5.89%), *Rottboellia cochinchinensis* (5.57%), *Digitaria horizontalis* (5.38%), *and Cynodon dactylon* (5.09%) were encountered. Three of the thirteen prevalent weed species: *F. littoralis, T. procumbens* and *E. indica* were encountered in both years.

Weed seedling emergence

In the continuously sampled quadrats, weed seedling population was significantly affected by cropping system at 6, 8 and 12 WAP while weed management practice significantly affected the population of weed seedling at all the sampling periods except at 12 and 15 WAP (Table 2). The uncropped (NCRP) plots had significantly higher weed seedlings in periods where significant differences were observed and the emerged weed population was similar to what was obtained in sole maize plots although the later plots were similar to the intercropped and sole cowpea plots. The density of emerged weed seedling obtained from herbicide treated plots was similar to that in hand weeded plots except at 3 and 8 WAP, and significantly lower than the weed density obtained from the unweeded control plots.

In the discreetly sampled quadrats, weed seedling population was significantly affected by cropping system at 5 and 9 WAP. The uncropped plots had significantly higher weed density than the cropped plots, except with sole maize plots at 9 WAP. The intercropped plots had significantly lower weed seedling population followed by sole cowpea plots. The weed density obtained from the hand weeded plots was similar to those from the herbicide-treated plots. The unweeded control plots (NWC) had significantly higher weed seedling population.

Table 1. Frequency of occurrence (%) of weed species encountered in the experimental plots in 2009 and 2010

Tablica 1. Učestalost pojave korova na pokusnim parcelama u 2009. i 2010. godini

Family	Weed species	LC/M	2009	2010
Amaranthaceae	*Gomphrena celosioides* C.Mart	AP/B	0.19	0.81
Asteraceae	*Aspilia africana* pers C.D. Adams	P/B	1.11	0.78
	Tridax procumbens L.	A/B	6.89	8.67
Caesalpinaceae	*Cassia obtusifolia* L.	A/B	-	0.70
Cleomaceae	*Cleome viscosa* L.	A/B	2.11	2.31
Commelinaceae	*Commelina benghalensis* L.	P/B	-	0.94
Convovulaceae	*Ipomoea involucrata* P. Beauv	A/B	-	0.88
Cyperaceae	*Cyperus tuberosus* Rottb	PS	4.64	2.79
	Fimbristylis littoralis Gaudet	AS	12.95	6.46
	Mariscus alternifolia Vahl	PS	2.88	3.51
	Pycereus lanceolatus (poir) C.B.Cl	PS	11.53	3.74
Euphorbiaceae	*Euphorbia heterophylla* L.	A/B	8.30	3.56
	E. hirta L.	A/B	1.39	1.47
	E. hyssopifolia L.	A/B	3.81	1.33
	Phyllantus amarus Schum. & Thonn.	A/B	4.18	1.66
	Croton lobatus L.	A/B	0.31	-
Fabaceae	*Tephrosia bracteolata* Guill. & Perr.	A/B	0.51	-
Lamiaceae	*Hyptis suaveolens* Poit	A/B	-	1.34
Loganiaceae	*Spigellia anthelmia* L.	A/B	0.74	-
Malvaceae	*Sida rhombofolia* L.	P/B	-	0.66
Nyctaginaceae	*Boerhevia coccinea* Mill	P/B	-	1.20
	B. diffusa L.	P/B	-	1.09
Poaceae	*Brachiaria deflexa*(Schumach) C.E Hubbard	A/G	4.76	6.29
	Cynodon dactylon (L.) Pers.	P/G	2.78	5.09
	Dactyloctenum aegyptum L.	AP/G	6.38	-
	Digitaria horizontalis Willd	A/G	-	5.38
	Eleusine indica Gaertn	A/G	9.95	5.89
	Hypparhenia involucrata Stapf	P/G	1.05	2.68
	Panicum maximum Jacq	AP/G	2.52	4.12
	Paspalum conjugatum Berg	P/G	-	3.26
	P. orbicolare Forst	P/G	1.79	3.60
	P. vaginatum SW	P/G	-	2.26
	Rottboellia cochinchinensis Lour	A/G	1.91	5.57
	Seteria barbata (Lam) Kunth	A/G	-	3.42
Portulacaceae	*Portulaca oleracea* L.	A/B	-	1.01
Rubiaceae	*Diodia scadens* SW	P/B	-	3.42
	Mitracapus villosus (SW) DC	A/B	2.79	1.95
	Oldelandia corymbosa L.	A/B	3.81	1.20
	Richardia brasilliensis Gomez	A/B	-	0.85
Solanaceae	*Physalis angulata* L.	A/B	-	1.17
Sterculiaceae	*Melochia corchhorifolia* L.	P/B	-	0.61
Urticaceae	*Fleurya aestuans* (L.) ex Miq	A/B	-	1.26
Verbenceae	*Vernonia galamensis* (Cass.) Less.	A/B	0.46	0.76

LC/M = Life cycle/ Morphological group, A= Annual, P= Perennial, AP = Annual/ Perennial, B = Broadleaf, G = Grass, S = Sedge, - = absent

Table 2. Effect of cropping system and weed management practice on weed seedling emergence in the continuously and discreetly sampled quadrats in 2009 and 2010 growing seasons

Tablica 2. Utjecaj sustava biljne proizvodnje i načina suzbijanja korova na njihovu pojavu u kontinuirano i povremeno uzorkovanim površinama tijekom vegetacijskog razdoblja u 2009. i 2010. godini

Weed seedling emergence (no/m^2)									
	Continuously sampled quadrat						Discreetly sampled quadrat		
Treatment	3WAP	6WAP	8WAP	10WAP	12WAP	15WAP	5WAP	9WAP	13WAP
Cropping System (C)									
MZCP	209	117	138	132	122	67	366	431	265
SCP	242	125	141	139	116	88	427	565	315
SMZ	231	146	153	154	132	82	428	597	367
NCRP	284	152	186	156	166	115	485	608	433
Sed	70.92	9.93	18.53	20.07	15.47	18.95	15.82	10.32	78.43
LSD	NS	19.86	38.51	NS	30.24	NS	34.56	21.67	NS
Weed Control (W)									
CWC	116	101	116	141	126	87	369	372	296
HWC	291	96	173	125	132	86	201	443	241
NWC	318	207	176	170	145	91	710	836	499
Sed	49.03	24.53	59.93	3.45	10.59	6.97	101.32	90.02	57.04
LSD	99.81	49.92	51.09	27.40	NS	NS	206.44	183.62	116.11
Interaction									
C x W	NS	NS	NS	NS	NS	NS	NS	*	NS

MZCP = maize-cowpea intercrop, SMZ= sole maize, SCP= sole cowpea, NCRP= no cropping, CWC= chemical weed control, HWC= hand weeding, NWC= no weed control, WAP= weeks after planting

Weed dry matter production

Cropping system significantly affected weed dry matter production in the continuously assessed quadrats at 3, 6 and 12 WAP and at 9 and 13 WAP in the discretely sampled quadrats (Table 3). Weed dry biomass in the cropped plots was similar and significantly lower than weed dry biomass obtained in uncropped plots. The later plots and sole maize plots had similar weed weights at 3 WAP in the continuously sampled quadrats and 13 WAP in the discretely sampled quadrats.

Weed management practice significantly affected weed dry matter production in the continuously assessed quadrats except at 10, 12, 15 WAP and at all assessment periods in the discreetly sampled quadrats. The weed biomass obtained in the herbicide-treated and hand weeded plots were similar and significantly lower than those from plots where no weed control measure was applied. At 3 WAP the sole maize plots had similar weed biomass with the unweeded control plots.

Table 3. Effect of cropping system and weed management practice on weed dry matter production in the continuously and discreetly sampled quadrats in 2009 and 2010 growing seasons

Tablica 3. Utjecaj sustava biljne proizvodnje i načina suzbijanja korova na proizvodnju suhe tvari na kontinuirano i povremeno uzorkovanim površinama tijekom vegetacijskog razdoblja u 2009. i 2010. godini

Weed dry biomass (g/m^2)									
	Discreetly sampled quadrat						Discreetly sampled quadrat		
Treatment	3WAP	6WAP	8WAP	10WAP	12WAP	15WAP	5WAP	9WAP	13WAP
Cropping system(C)									
MZCP	43.45	49.90	9.34	7.66	4.93	3.59	64.33	698.30	793.42
SCP	69.03	45.73	10.49	7.27	3.52	3.38	63.03	871.92	806.75
SMZ	92.32	53.53	9.88	7.25	3.94	2.99	137.04	907.05	1151.39
NCRP	105.82	88.52	13.09	10.70	16.32	5.96	143.27	1257.67	1650.64
Sed	12.83	13.59	1.73	1.75	4.24	0.77	73.56	154.92	289.83
LSD(0.05)	27.95	29.62	NS	NS	9.24	1.68	NS	320.24	631.53
Weed control (W)									
CWC	19.23	52.42	7.48	6.36	5.43	3.67	73.02	981.24	816.56
HWC	93.12	34.36	9.48	8.40	10.11	3.46	16.78	313.62	735.98
NWC	120.63	91.45	15.13	9.90	5.92	4.81	216.89	1505.42	1751.53
Sed	14.24	19.59	2.42	1.66	3.80	0.47	63.40	159.12	306.52
LSD(0.05)	29.01	39.90	4.92	NS	NS	NS	129.22	324.09	624.38
Interaction									
C x W	NS	NS	NS	NS	NS	*	NS	*	NS

MZCP = maize-cowpea intercrop, SMZ= sole maize, SCP= sole cowpea, NCRP= no cropping, CWC= chemical weed control, HWC= hand weeding, NWC= no weed control, WAP= weeks after planting

Grain yield

Cropping system had no significant effect on grain yield of maize or cowpea in both years whereas weed control practice significantly affected the grain yield of both crops (Table 4). Sole maize and sole cowpea grain yields were not significantly different from their respective yields in the intercropped plots. The aggregate crop yields were, however, significantly higher in the intercropped plots than in the sole crop plots. In 2009, unweeded control plots had significantly lower maize grain yield while hand weeded and herbicide treated plots had similar and significantly better maize grain yield. Cowpea grain yield in the same growing season was better in hand weeded plots while the other two plots, which were similar, had significantly lower cowpea grain yield. In 2010 growing season, cowpea grain yield followed a similar trend to that of 2009 while maize grain yield differed across the weed control plots with hand weeded plots having a significantly higher maize grain yield followed by herbicide treated and unweeded control plots.

Table 4. Effect of cropping system and weed control practice on grain yield (t/ha) of maize and cowpea in 2009 and 2010 growing seasons

Tablica 4. Utjecaj sustava biljne proizvodnje i načina suzbijanja korova na prinos zrna kukuruza i stočnog graška tijekom vegetacijskog razdoblja u 2009. i 2010. godini

Treatment	2009 cropping season			2010 cropping season		
	Maize	Cowpea	Total	Maize	Cowpea	Total
Cropping system (C)						
MZCP	2.31	0.75	3.06	1.49	0.41	1.90
SMZ	1.79	-	1.79	1.30	-	1.30
SCP	-	1.01	1.01	-	0.57	0.57
NCRP	-	-	-	-	-	-
Sed	0.798	0.402	0.389	0.312	0.139	0.209
LSD	NS	NS	1.190	NS	NS	0.458
Weed control (W)						
CWC	2.54	0.73	3.29	1.43	0.51	1.94
HWC	2.31	1.32	3.63	1.94	0.57	2.51
NWC	1.31	0.58	1.89	0.82	0.38	1.20
Sed	0.423	0.174	0.443	0.209	0.068	0.148
LSD	0.975	0.531	1.026	0.483	0.149	0.372
Interaction						
C x W	NS	NS	NS	NS	NS	NS

MZCP = maize-cowpea intercrop, SMZ= sole maize, SCP= sole cowpea, NCRP= no cropping, CWC= chemical weed control, HWC= hand weeding, NWC= no weed control

DISCUSSION

Weed density differed significantly within cropping system at 6 - 8 WAP in the continuously assessed quadrats while in the discretely sampled quadrat, significant effect was observed at 5 and 9 WAP on fields that were cropped. This period corresponded to that of heavy canopy formation by the crops, the shading effect resulting from the crop canopy limiting the availability of resources required for weed germination. This effect is more pronounced in intercrops because of the combined foliage of the component crops which intercepted most of the green and red light leaving far red to reach the ground. Far red light is known to be inhibitory to weed germination (Clark and Francis, 1985) and could be responsible for the better weed suppression by the intercropped fields. The reduction in weed densities of intercropped treatments could also be as a result of limited availability of resources to weed species. The interrow spaces provide room for weeds to flourish in monocrops compared to the intercrops, therefore increasing weed density in monocrops.

Weed biomass reduction in this period can be explained by the reduction in total incoming Photosynthetic Active Radiation (PAR) reaching the ground (Katsaniware and Manyanhaure, 2009). The increase in weed density and biomass at physiological maturity stage and thereafter can be attributed to an increase in the amount of incident PAR reaching ground late in the season due to leaf stripping, thereby encouraging the germination of late weeds (Mashingaidae, 2004). Another possible reason for the reduced weed emergence and growth could be due to allelopathy effect. The suppression of weeds through allelopathy in a mixture of legumes and cereals has been shown to be species sensitive (Kruidhof et al., 2008).

Weed management practices had significantly different effect on total weed seedling emergence and growth at the beginning of the growing season to either 8 or 10 WAP. Pre-emergence herbicide treatment caused an enormous increase in weed population after 6 WAP, thus, could not provide season long weed control because of their short persistence. Akobundu (1987) reported that most pre-emergence herbicide gives early weed control of emerging weed seedlings but easily lose their efficacy. Hoe weeded fields recorded adequate weed control between 3-6 WAP but the soil disturbance associated with hoeing stimulated more weed seedling emergence at 8 WAP and thereafter.

Although many authors reported that the resurgence of high weed seedling emergence at the later stage of crop life they are likely to have minimal effects on the total crop yield. However, they could contribute to the buildup of the soil seedbank and increase weed pressure on subsequent crops. This also could explain the high weed density observed in this study at the beginning of the second cropping season as compared to weed density at the same period in the previous season. The relatively similar population of weed seedling observed in the discretely sampled quadrats suggest that the micro-environment in the quadrats had reached their carrying capacities, thus additional seedlings are destroyed through allelopathy, competition (self-thinning), prevention of germination due to the shading provided by the previously emerged weeds. This observation is similar to the findings of Takim and Fadayomi (2010) in the same agro ecological zone.

CONCLUSION

Based on the above results, it could be concluded that cropping system and weed management method significantly influence weed emergence on the field. The period of high emergence of weed seedlings was between 3 and 8-10 WAP of crops. Therefore, for small holders and/or resource limited farmers in West Africa, two hoe weedings between 2-3 and 6-7 WAP or pre-emergence herbicide application and a supplementary hoe weeding at 6-7 WAP might eliminate the bulk of weed infestation in arable crops.

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UTJECAJ BILJNE PROIZVODNJE I NAČINA SUZBIJANJA KOROVA NA NJIHOVU POJAVU, RAST TE PRINOS KUKURUZA (*Zea mays* L.) I STOČNOGA GRAŠKA (*Vigna unguiculata* L.)

SAŽETAK

Utjecaj sustava biljne proizvodnje i načina suzbijanja korova na njihov rast, proizvodnju biomase te prinos kukuruza i stočnoga graška ispitivao se u Ilorinu, u savani južne Gvineje (9º29' N, 4º35' E i 307 m nadmorske visine) u Nigeriji. Korov se pojavio 3-15 tjedana nakon sadnje (TNS). Utvrđeno je 43 vrste korova i 38 rodova unutar 20 porodica. Fimbristylis littoralis Gaudet, Tridax procumbens L i Eleusine indica Gaertn bile su najzastupljenije vrste korova. Sustav biljne proizvodnje i način suzbijanja korova značajno su utjecali na njegovu pojavu. Značajno manji broj korova ($p \leq 0.05$) zabilježen je u međuusjevima i parcelama tretiranim herbicidima, dok su veća gustoća i biomasa korova zabilježeni u neobradivim i zakorovljenim kontrolnim parcelama u odnosu na druge parcele. Ukupni prinosi usjeva bili su značajno viši na površinama s međuusjevom u odnosu na one bez, a komponente prinosa usjeva bile su veće kod sjetve bez međuusjeva u odnosu na one s međuusjevom. U radu se raspravlja o mogućim primjenama rezultata ispitivanja na suzbijanje korova.

Ključne riječi: sustav biljne proizvodnje, sjetva s međuusjevom, suzbijanje korova, rast korova, prinos

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