ISSN 1996-3351

Asian Journal of Biological Sciences

http://knowledgiascientific.com

Knowledgia SCIENTIFIC
A Place to Publish Outstanding Research

OPEN ACCESS Asian Journal of Biological Sciences

ISSN 1996-3351
DOI: 10.3923/ajbs.2019.73.80

Research Article
Competition Between Cowpea (TVU-180) and Selected Local Grasses Abundant in a Typical Ultisol in Benin City, Nigeria

[1]Beckley Ikhajiagbe, [1,2]Edokpolor Osazee Ohanmu and [1]Mary Osasere Iguobaro

[1]Environmental Biotechnology and Sustainability Research Group, Department of Plant Biology and Biotechnology, University of Benin, Nigeria
[2]Department of Plant Biology and Biotechnology, Faculty of Science, Edo University Iyahmo, Nigeria

Abstract
Background and Objective: The problem caused by weeds are enormous and constitute a major constraint to crop production globally. Over the years, weed has contributed to the reducing in cowpea productivity either by releasing allelopathic compounds, providing a conducive environment for pest or competing for available soil nutrients. Therefore, the study examined the competition between the cowpea variety (TVu-180) and selected local weeds abundant in a typical ultisol in Benin city, Nigeria. **Materials and Methods:** There were 10 treatments and a control, namely; *Chrysopogon aciculatus* (WA), *Eleusine indica* (WB), *Cynodon dactylon* (WC), *Axonopus compressus* (WD), *Panicumn maximum* (WE), *Setaria bartata* (WF), *Sporobolus pyramidalis* (WG), *Commelina benghalensis* (WH), *Paspalum vaginatum* (WI), while WJ was a combination of all the weeds and control (CTR). Three seeds of TVu-180 was sown into each bowl per-treatments, laid out in a Randomized Block Design (RBD) with three replications. **Results:** From the results, the associated weeds delayed the first day of emergence in TVu-180 variety, however, there was no significant difference between the treatments and control. The emergent height of TVu-180 in WC, WE and WF were significantly higher than the TVu-180 variety in control. Weeds competitiveness with the TVu-180 variety resulted in a highly significant decrease in the plants' dry weight either singly or holistically when compared with the control. The shoot length, stem width and leaflet area of the TVu-180 variety in WA were higher than those in the control. However, the no. of leaves were reduced in all treatments, there was no significant difference in between the TVu-180 variety in the WA treatment and control. Weed competitiveness resulted in the highest percentage of foliar foraging, chlorosis and necrosis in TVu-180 variety of WG and WC, respectively. From the regression plot, there was an inverse relationship between foliar chlorosis and percentage N, P and K in the soil while the correlation showed a significant positive relationship between foliar foraging and foliar chlorosis and necrosis respectively. **Conclusion:** Weed competitiveness did not affect the emergence performance of the Tvu-180 variety, however, the variety was morphologically susceptible with a significant reduction in dry weight matter.

Key words: Weeds, foraging, competitiveness, emergence, cowpea, TVU-180 variety, soil NPK

Citation: Beckley Ikhajiagbe, Edokpolor Osazee Ohanmu and Mary Osasere Iguobaro, 2019. Competition between cowpea (TVU-180) and selected local grasses abundant in a typical ultisol in Benin city, Nigeria. Asian J. Biol. Sci., 12: 73-80.

Corresponding Author: Edokpolor Osazee Ohanmu, Department of Plant Biology and Biotechnology, Faculty of Science, Edo University Iyamho, Edo State, Nigeria Tel: +2347084059346

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is a major staple leguminous crop in many countries of the tropics particularly Asia and Africa. Cowpea constitutes a valuable source of protein as well as rich amino acid profile[1] and it is one of the widely cultivated leguminous crops in the savannah region of West Africa[2]. Cowpea (*Vigna unguiculata* L. Walp) is a dicotyledoneae, belonging to the order Fabales, family Fabaceae, sub-family Fabiodeae, tribe Phaseoleae, sub-tribe Phasiolenae and genus Vigna[3]. Cowpea has a high potential to increase farmers' and traders' incomes, thereby contributing to poverty reduction and food security[4] especially in Nigeria where the people are pre-dominantly farmers. The spreading indeterminate or semi-determinate growth of cowpea provides ground cover, thus suppressing weeds and giving some protection against soil erosion. Coupled with these attributes, its quick growth and rapid ground cover have made cowpea an essential component of sustainable subsistence agriculture, especially in the drier regions of Nigeria, where rainfall is erratic and scanty and soils are sandy with little organic matter. Their ability to fix nitrogen makes them an important component within the farming system[5].

Nigeria is the largest producer and consumer of cowpea with about 5 million ha area and 2.4 million t production annually. Growing cowpea in Nigeria has not been without some prevailing challenges in crop yield, pest and weed control. Expanse of land is lying fallow while many subsistence farmers are discouraged, especially when weeds compete with the cultivated cowpea varieties. In spite of the great economic potential of cowpea as both domestic and commercial crop, a number of constraints limits its production in West and many parts of Africa. These constraints include insect pests and diseases[6,7], inadequate knowledge of good cultural practices and high yielding varieties resulting in poor yield[8]. Other constraints include heavy metals[5], planting at sub-optimal plant density, low soil fertility and drought and weeds[8-10].

Weeds belongs to the Poaceae family and constitute a major constraint to crop production globally. Yield losses cause by weeds alone in cowpea production can range from 25-76% depending on the cultivar and environment[11]. Some of the challenges encounters by weed infestation in cowpea production include reduction in crop yield, less efficient land use, higher cost of production due to insects and plant disease control, reduction in crop quality, water management problems and less efficient utilization of labour[12-15]. Weeds possess a severe problem in cowpea production and if it is not managed with best management practices, can serve as hibernating agent for pests and reduce not only yield but also quality of the seed and fodder yield.

Cowpea being deep rooted and drought tolerant dual purpose leguminous crop adds significant amount of organic matter/nitrogen to the soil, becomes an integral part of the soils and subsistence crop production especially in Nigeria. The presence of weeds not only increase production cost but also intensify disease and insect pest problem by serving as alternative hosts and deteriorating the quality of produce through the physical presence of their seeds and debris. However, no study have extensively studied the response of a preferred variety of cowpea to a single or combined effect of weeds. Therefore, this study aimed to evaluate the effect of the prominent weeds on the emergence parameters and productivity of the cowpea TVU-180 variety.

MATERIALS AND METHODS

Experimental site and materials collection: An experiment was conducted in September, 2016 at the botanic garden of Plant Biology and Biotechnology, University of Benin, Nigeria, with the cowpea variety (TVU-180) (plate 1). The seeds were procured from the International Institute of Tropical Agriculture (IITA), Ibadan, while the different grasses used for the experiment were obtained from within the campus and from Santua Garden, Ugbowo, Nigeria.

Experimental design: Three seeds were sown in each bowl. The plants were watered regularly thrice a week. Hand weeding method was used to control the weed for enhanced cowpea productivity. This was done at various periods of 2, 4, 6 and 8 Weeks after Planting (WAP) to ensure that only those grass species that were required for the experiment were left in each experiment bowl with the cowpea plant. Nine grass species were propagated separately and in combination with the cowpea variety namely; *Chrysopogon aciculatus*, *Eleusine indica*, *Cynodon dactylon*, *Axonopus compressus*, *Panicumn maximum*, *Setaria bartata*, *Sporobolus pyramidalis*, *Commelina benghalensis*, *Paspalum vaginatum* and were labelled as WA-WI, respectively while WJ was a combination of all the weeds. The experiment consisted of 11 treatments replicated thrice in a Randomized Block Design (RBD). Each bowl were filled with 20 kg of the top soil obtained from ten different points in the botanic garden. The soil were adequately moistened before the different grasses were planted and left to adapt for 2 weeks before sowing cowpea seeds.

Plate 1: TVU-180 variety seeds

Data measurements: Data collection started 3 days after the seeds were sown, emergence parameters, namely; first day of emergence, final emergence (%) and height of emergent (cm) and dry weight of plant (g); above ground parameters namely; shoot length (cm), stem width (mm), No. of leaves/plant, leaflet area and internode; foliar forage, chlorosis and necrosis; and soil NPK effect on leaves response. Cowpea dry weight was taken by harvesting the above ground vegetative parts of three plants per treatment and oven dried using Memmert oven at 70°C to a constant weight and recorded in grams (g)[16].

Data analysis: Data collected were subjected to descriptive analysis. Difference between the means of the treatments were determined by analysis of variance (ANOVA) using SPSS version 20. Significance was set at 5% probability level (p<0.05). Where significant means were encountered, the data was further subjected to a *post hoc* test; Duncan's Multiple Range Test.

RESULTS

Emergence parameters: Although a little delay were observed in the first day of emergence of the cowpea (TVU-180) sown in various treatment and control (Table 1), there was no significant difference (p>0.05) in their emergence response. In terms of final percentage of emergence, WC, WE and control resulted to 100% emergence compared to WA, WG, WH and WJ h while the least percentage emergence was recorded in WB, WD, WF and WI, respectively. It was observed that the height of emergent of TVU-180 in WG had the least value when compared to the control. The other weeds (treatments) such as WA, WB, WC, WE, WF, WG and WJ had higher height emergence than the control. This is an indication that the competitive effect of the weeds when compared with the control was not significant (p>0.05).

Table 1: Effect of treatment on emergence parameters of cowpea TVU-180 at 7 days after sowing

Associated weeds	First day of emergence (days)	Final Emergence (%) FEP	Height of emergent (cm)
WA	3.67±0.33	91.67±8.33	4.57±0.30
WB	3.67±0.33	83.33±8.33	4.47±0.29
WC	3.33±0.33	100.00±0.00	5.23±0.12
WD	3.33±0.33	83.33±8.33	4.57±0.30
WE	3.33±0.33	100.00±0.00	5.60±0.31
WF	3.33±0.33	83.33±8.33	5.07±0.58
WG	3.00±0.00	91.67±8.33	3.63±0.88
WH	3.67±0.33	91.67±8.33	4.23±0.62
WI	3.33±0.33	83.33±8.33	4.17±0.17
WJ	3.33±0.33	91.67±8.33	4.63±0.32
CTR	3.00±0.00	100.00±0.00	4.40±0.46
F-value	0.60	0.95	1.47
Sig.	p>0.05	p>0.05	p>0.05

WA: *Chrysopogon aciculatus*, WB: *Eleusine indica*, WC: *Cynodon dactylon*, WD*: Axonopus compressus*, WE: *Panicumn maximum*, WF: *Setaria bartata*, WG: *Sporobolus pyramidalis*, WH: *Commelina benghalensis*, WI: *Paspalum vaginatum*, WJ: Combination of all the weeds, CTR: Control, p>0.05 - Not significant, p<0.05 - Significant, p<0.01 - Highly significant, different superscript across the columns shows that means are significant from each other

Dry plant weight: The plant dry weight of cowpea (TVU-180) sown in the various weed treatments and control were shown in Fig. 1. The dry weight of TVU-180 in the treatments were significantly decreased (p<0.01) when compared with the control. The highest reductions in the dry weight of TVU-180 variety were observed in WG, WF and WI, respectively.

Above ground parameters: The effect of treatment on the above ground parameters of the cowpea was presented (Table 2). There was a significant effect of the weeds on shoot length, stem width, no. of leaves, leaflets area and internode. The shoot length of WA was increased over the control compared to the other treatments. The shoot length of TVU-180 in WF was significantly reduced; an indication that the weed had the highest competitive impact on the cowpea productivity. In terms of stem width, WA treatment resulted in a significantly wider stem width than the control. Among other associated weeds, the competitive effect was significantly observed in the lean nature of the stem. An indication that the associated weeds had a negative

Table 2: Effect of treatment on above ground parameters of cowpea at 20 weeks after sowing

Associated weed	Shoot length (cm)	Stem width (mm)	No. leaves/plant	Leaflet area (cm^2)	Internode (cm)
WA	82.13±9.94[a]	3.70±0.17[a]	174.00±16.26[a]	33.70±0.85[a]	2.87±0.13[d]
WB	25.23±3.60[d]	2.70±0.3[c]	44.33±5.81[c]	21.70±3.35[b]	3.40±0.31[d]
WC	29.20±3.31[d]	2.70±0.3[c]	60.33±4.81[c]	18.33±2.85[c]	2.30±0.15[d]
WD	40.73±1.79[c]	2.80±0.31[c]	115.33±11.61[b]	16.30±2.43[d]	4.67±0.33[a]
WE	25.47±3.07[d]	2.53±0.26[c]	56.67±4.91[c]	14.73±1.39[d]	2.93±0.07[d]
WF	23.30±5.52[d]	2.13±0.47[c]	66.00±6.03[c]	15.93±2.15[d]	3.37±0.37[d]
WG	26.63±4.48[d]	2.17±0.22[c]	59.00±2.52[c]	12.47±1.27[d]	2.83±0.17[d]
WH	32.27±2.03[d]	2.45±0.13[c]	58.33±3.93[c]	18.37±1.77[c]	2.67±0.33[d]
WI	41.67±1.33[b]	3.00±0.58[c]	62.67±7.69[c]	11.07±2.83[d]	3.67±0.63[b]
WJ	30.47±2.59[d]	2.40±0.3[c]	118.67±6.89[b]	33.37±1.32[a]	3.57±0.43[c]
CTR	76.67±5.55[a]	3.43±0.38[b]	180.00±17.16[a]	31.23±1.69[a]	3.17±0.44[d]
F-value	20.49	2.17	28.08	15.25	3.35
Sig.	p<0.01	p>0.05	p<0.01	p<0.01	p<0.01

WA: *Chrysopogon aciculatus*, WB: *Eleusine indica*, WC: *Cynodon dactylon*, WD*: Axonopus compressus*, WE: *Panicumn maximum*, WF: *Setaria bartata*, WG: *Sporobolus pyramidalis*, WH: *Commelina benghalensis*, WI*: Paspalum vaginatum*, WJ: Combination of all the weeds, CTR: Control, p>0.05: Not significant, p<0.01: Highly significant, Different superscript across the columns shows that means are significant from each other

Table 3: Occurrence of foliar foraging, chlorosis and necrosis as a result of exposure to weed competition

Associated weed	Leaves eaten by ants (%)	Chlorosis in leaves (%)	Foliar necrosis (%)
WA	63.20±2.69[c]	77.40±5.55[d]	51.80±4.4[c]
WB	66.63±6.3[c]	73.87±4.44[d]	41.27±6.46[d]
WC	84.50±7.05[b]	86.47±4.51[b]	63.00±9.29[a]
WD	58.10±3.96[d]	58.63±3.76[e]	37.10±3.54[d]
WE	71.47±2.02[c]	79.67±8.57[c]	52.57±3.8[c]
EF	62.90±3.14[c]	62.17±9.31[e]	39.23±7.8[d]
WG	90.73±3.91[a]	95.00±3.61[a]	59.77±2.83[b]
WH	84.30±4.03[b]	68.90±3.12[d]	48.07±4.31[c]
WI	42.83±7.03[d]	43.37±2.93[e]	27.07±7.44[d]
WJ	43.20±9.46[e]	59.50±6.79[e]	39.43±7.28[d]
CT	26.80±5.12[e]	45.33±8.69[e]	23.07±6.35[d]
F-value	13.30	7.31	4.24
Sig.	p<0.01	p<0.01	p<0.05

WA: *Chrysopogon aciculatus*, WB: *Eleusine indica*, WC: *Cynodon dactylon*, WD: *Axonopus compressus*, WE: *Panicumn maximum*, WF: *Setaria bartata*, WG: *Sporobolus pyramidalis*, WH: *Commelina benghalensis*, WI: *Paspalum vaginatum*, WJ: Combination of all the weeds, p>0.05: Not significant, p<0.01: Highly significant, Different superscript across the columns shows that means are significant from each other

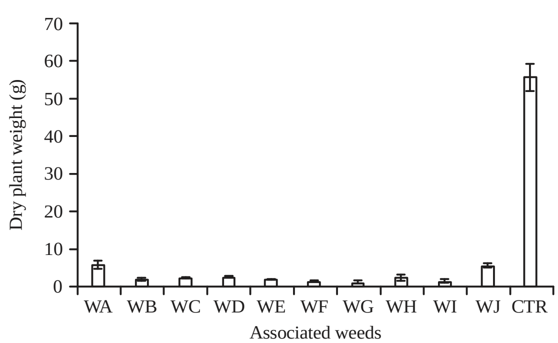

Fig. 1: Dry weight of the cowpea (TVU-180)

competitive role on the stem productivity of the cowpea; especially the WF, which had the most reduced cowpea stem width. The effect of weed competition had no significant difference (p>0.05) on number of leaves between the WA and control. However, the no. of leaves in WB and WE were reduced significantly compared to the control. The competitive effect on leaflet area was more pronounced in the associated weeds of WI. The cowpea internode was significantly longer in WD, WI and WJ than in the control.

Foliar morphology: The effects of foraging leaves, chlorosis and foliar necrosis on the cowpea productivity was shown in Table 3. The percentage of leaves eaten by ants were significantly higher in all treatments than the control. The highest percentage was recorded in WG, which was significantly higher than WC and WH. Likewise the percentage of leaves eaten recorded in WG, WC and WH were significantly higher than WA, WB and WE which were in turn significantly higher than WD and WI. This is an indication that the competitive effect of the associated weeds on the cowpea were significantly reduced when the weeds were combined (as recorded in WJ) than when the weeds were isolated. In terms of percentage of chlorosis in leaves there were significant effect on percentage chlorosis in some of the treatments. However, no significant difference (p>0.05) exist between WD, WI and WJ, respectively and the control. This is an indication that some selected weeds results to increased foliar chlorosis than others. In the same vein, there were significant percentage foliar necrosis in some selected associated weeds than the control. The highest effect was recorded in the following order WC>WG>WE>WA>WH. However no significant difference was recorded between WB, WI, WJ and the control.

The partial regression plots of foliar chlorosis as dependent variable and soil N, P and K as independent factor were shown below (Fig. 2-4). There was an inverse relationship between foliar chlorosis and soil N (%). The analysis showed

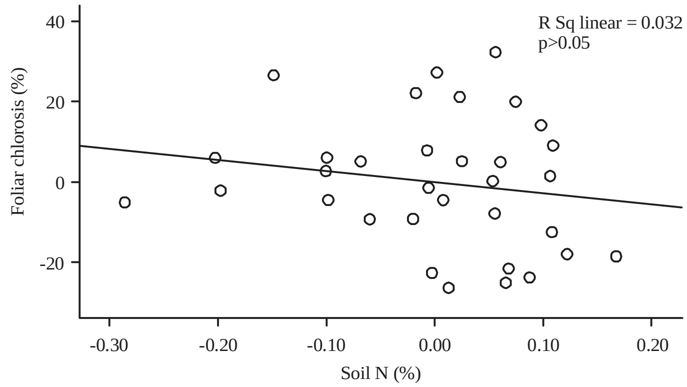

Fig. 2: Partial regression plots of soil N (foliar chlorosis as dependent variable)

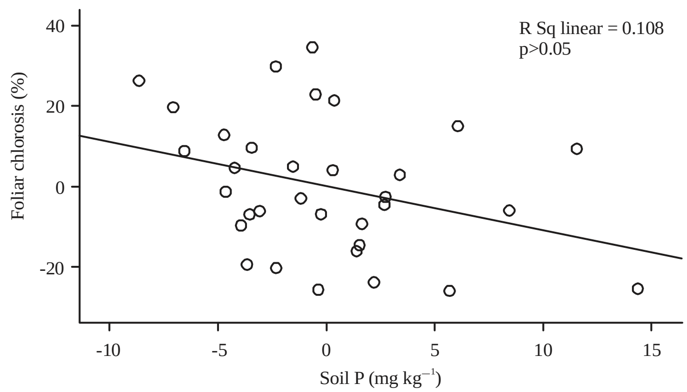

Fig. 3: Partial regression plots of soil P (foliar chlorosis as dependent variable)

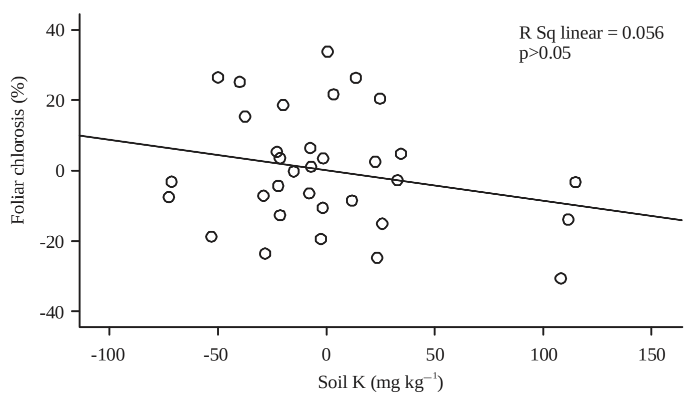

Fig. 4: Partial regression plots of soil K (foliar chlorosis as dependent variable)

that, every 3% increase in foliar chlorosis resulted in 1% decrease of soil nutrient ($r^2 = 0.032$). The relationship between foliar chlorosis and soil P showed an inverse relationship. However in this case, every 10% increase of foliar chlorosis resulted in 1% soil P loss ($r^2 = 0.108$). The relationship between foliar chlorosis and soil K (mg kg^{-1}) also exhibited an inverse relationship. It was observed from the statistics that, every 5% increase in foliar chlorosis resulted in 1% soil K loss ($r^2 = 0.056$).

The correlations between chlorotic and soil nutrients were shown in Table 4. Foraged LVS showed a significant positive relationship with ChloLVS and NecrLVS ($p<0.01$) while the same foraged LVS had negative relationship with Soil N and K ($p<0.01$). Likewise ChloLVS showed a significant positive relationship with NecrLVS ($p<0.01$) while showing negative relationship with soil P ($p<0.05$). The NecrLVS had negative significant relationship with soil N ($p<0.05$).

Table 4: Correlations between chlorotic features and soil nutrients

Parameters	Foraged LVS	Chlo LVS	Necr LVS	Soil N	Soil P	Soil K
Foraged LVS						
Pearson Corr. (r)	1	0.7255**	0.7253**	-0.459*	-0.313	-0.376*
Sig. (2-tailed)		0.000001	0.000001	0.0072	0.0757	0.031
Chlo LVS						
Pearson Corr. (r)		1	0.7919**	-0.276	-0.357*	-0.266
Sig. (2-tailed)			0.00001	0.1202	0.0413	0.135
Necr LVS						
Pearson Corr. (r)			1	-0.346*	-0.228	-0.338*
Sig. (2-tailed)				0.0486	0.2022	0.055
Soil N						
Pearson Corr. (r)				1	0.2052	0.202
Sig. (2-tailed)					0.252	0.259*
Soil P						
Pearson Corr. (r)					1	0.035
Sig. (2-tailed)						0.845
Soil K						
Pearson Corr. (r)						1
Sig. (2-tailed)						

Foraged LVS: Foraging leaves, Chlo LVS: Chlorosis in leaves, Necr LVS: Necrosis in leaves, Soil N: Soil nitogen, Soil P: Soil phosphorus
Soil K: Soil potassium

DISCUSSION

There have been a well-established competition between weeds and crops which is marked by alteration in growth and development of both species. However, no study has focused on the comparison of a specific cowpea variety to weed invasion either singly or holistically with a view of finding a resistant variety without the application of herbicides. Results of this study have shown that the different weed treatments singly or holistically did not significantly affect the emergence parameters of the cowpea (TVU-180). This is in line with the research by Das[17] who observed that weeds do not cause harm to crops equally all through the growing period. However in certain stages of crop growth cycle, weeds become more damaging to crop growth. It was observed that the delayed days to emergence in the weed treatments compared to the control was due to completion of available nutrient. However, this delays were not significant from the control. The TVU-180 crop varied in their responds. The 100% final emergence recorded in this study is in line with Madukwe *et al.*[18] who reported highest (93.0%) mean germination percentage recorded from plots that received herbicide, while the lowest germination percentage (80.6%) was recorded from the un-weeded plots in cowpea. However, in this study, the lowest germination percentage was 83.33% while highest germination was 100%. Weed competitiveness was also observed to increase the emergence height of the cowpea (TVU-180) compared to the control. This can also be attributed to the ability of the cowpea plant to compete favourably in the presence of the various species of weeds. This study is in contract to reports of Tripathi and Singh[19] whom pointed out that cowpea usually face critical growth challenges in the presence of weeds.

However, there was a marked difference in the dry weight of the TVU-180 variety in control compared to those in the weed treatment either singly or holistically. The reduction in the dry weight of the cowpea could be attributed to the plants adaptive mechanism to the competitive conditions created by the weed[20]. The significantly reduction in cowpea yields over 82% when exposed to weeds has been reported[19]. This is attributed to the oxidative stress created when plants becomes overwhelmed with stress[21]. The increased shoot length, no. of leaves and leaflet area recorded in the WA treatment compared to the control can be a survival mechanism of the TVU-180 variety against *Chrysopogon aciculatus*. The WF produced the highest competitive impact on the cowpea shoot length productivity as it was far reduced than the control. The competitive impact were also found in the other associated weeds except WA. It has been reported that *Commelina benghalensis*, *Bidens pilosa* and *Ipomoea triloba* caused a small reduction in the shoot dry matter of maize[22]. Weed competition also increased the number of leave and leaflet area of the TVU-180 variety in the associated weed[22], singly or holistically.

The foliar foraging in the TVU-180 variety was significantly increased in treatments especially in the WG treatment compared to the control. Increased foliar foraging are most likely caused by weakened signally response enacted by stress.

This was also indicated in the high rate of foliar chlorosis and necrosis observed. In contrast to the stress imposed by the associated weeds in the update of nutrient and the crop survival[5], foraging by ant was also a major factor. Presence of weeds not only increases the production cost but they also intensify disease and insect pest problem by serving as alternative hosts. The NPK plays a vital role in crop productivity and their ability to withstand environmental variability. The regression plot actually brought to light that the increased chlorosis observed is relatively related to the percentage of N, P and K present in the soil. All these are indication that foliar chlorosis like other symptoms of weed infestation causes nutrient loss and consequently yield loss. The magnitude of yield loss in any crop or cropping sequence, is determined by the weed density, type of the weeds, their persistence and crop management practices[23].

CONCLUSION

Based on the results of the current study, the TVU-180 variety varied in their response to the individual weeds. The early stage weed competition was most detrimental to the cowpea growth. The weeds weakened the cowpea resistant capacity by increasing pest infestation. The cowpea TVU-180 could be recommended in an ultisol infested by *Chrysopogon aciculatus* and *Panicumn maximum*, respectively as 100% final emergence was recorded. The cowpea showed remarkable resistance without the application of fertilizers. However, the experiments was conducted at one location in an ultisol and is not significant to make a final recommendation on its competitiveness against the aforementioned weeds. Therefore, further studies need to be conducted to over its biochemical and yield capacity to make final recommendation.

SIGNIFICANCE STATEMENT

This study discovered that the cowpea TVU-180 variety were competitive against the weeds; *Chrysopogon aciculatus* and *Panicumn maximum*, respectively. Generally, the weeds either singly or holistically increase foliar foraging and defoliated leaves via chlorosis and necrosis which could affect the plant photosynthetic capabilities. This study will lead scientists to investigate the role of antioxidant response of the TVU-180 variety and it possible role in food security without the use of fertilizer to boast productivity.

ACKNOWLEDGMENT

This study was performed at the Department of Plant Biology and Biotechnology, University of Benin, Benin city, Nigeria. Authors are grateful to Late Dr. (Mrs) Omoyemense K. Ohanmu and Environmental Biotechnology and Sustainability Research Group, in the University who provided a working laboratory.

REFERENCES

1. Ayodele, J.T. and I.R. Yalwa, 2004. Amino acid composition of *Vigna dekindtiana*. Biol. Environ. Sci. J. Trop., 1: 120-126.
2. Steel, W.M., 1996. Cowpea. In: Evolution of Crop Plants, Simmond (Ed.)., Longman, Essex, England, pp: 183-185.
3. Singh, B.B., 1993. Cowpea breeding archival report (1988-1992) of grain legume improvement program. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, pp: 10-53.
4. Kormawa, P.M., J.N. Chianu and V.M. Manyong, 2000. Cowpea demand and supply patterns in West Africa: The case of Nigeria. Proceedings of the 3rd World Cowpea Research Conference, September 4-7, 2000, IITA., Ibadan, Nigeria, pp: 376-386.
5. Ohanmu, E.O., B. Ikhajiagbe and B.O. Edegbai, 2018. Nitrogen distribution pattern of african yam bean (*Sphenostylis stenocarpa*) exposed to cadmium stress. J. Applied Sci. Environ. Manage., 22: 1053-1057.
6. Thio, I.G., E.P. Zida, M. Sawadogo and P. Sereme, 2016. Current status of *Colletotrichum capsici* strains, causal agents of brown blotch disease of cowpea in Burkina Faso. Afr. J. Biotechnol., 15: 96-104.
7. Abudulai, M., F. Kusi, S.S. Seini, A. Seidu, J.A. Nboyine and A. Larbi, 2017. Effects of planting date, cultivar and insecticide spray application for the management of insect pests of cowpea in northern Ghana. Crop Prot., 100: 168-176.
8. Kanteh, S.M., J.E. Norman and J. Sherman-Kamara, 2014. Effect of plant density and weeding regime on population and severity of aphids (*Aphis craccivora* Koch) and foliage beetles (*Ootheca mutabilis* Sahl) on cowpea in sierra leone. Int. J. Agric. For., 4: 24-33.
9. Adusei, G., T. Gaiser, O. Boukar and C. Fatokun, 2016. Growth and yield responses of cowpea genotypes to soluble and rock P fertilizers on acid, highly weathered soil from humid tropical West Africa. Int. Biol. Chem. Sci., 10: 1493-1507.
10. Osipitan, O.A., J.A. Adigun and R.O. Kolawole, 2016. Row spacing determines critical period of weed control in crop: Cowpea (*Vigna unguiculata*) as a case study. Azarian J. Agric., 3: 90-96.

11. Osipitan, O.A., 2017. Weed interference and control in cowpea production: A review. J. Agric. Sci., 9: 11-20.
12. Patil, B.C., L.A. Padanad, K.H. Yashvantkumar, S. Soumya and L. Ravi, 2014. Efficacy and economics of integrated weed management in vegetable cowpea [*Vigna unguiculata* (L.) Walp]. Agric. Update, 9: 124-127.
13. Prabhu, G., R. Srinivasan, S.R. Kantwa, D.R. Palsaniya and M. Chaudhary, 2015. Weed seed bank studies in the field of fodder cowpea [*Vigna unguiculata* (L.)]. Int. J. Applied Pure Sci. Agric., 1: 83-87.
14. Singh, M.C. and C.V. Sairam, 2016. Effect of spacing and intercropping with cowpea on weed growth in banana. Int. J. Environ. Sci. Technol., 5: 558-563.
15. Mekonnen, G., J.J. Sharma, T. Tana and L. Nigatu, 2015. Effect of integrated weed management practices on weeds infestation, yield components and yield of Cowpea [*Vigna unguiculata* (L.) Walp.]. Eastern Wollo, Northern Ethiopia. Am. J. Exp. Agric., 7: 326-346.
16. Ohanmu, E.O., S.P. Bako and M.A. Adelanwa, 2014. Effect of crude oil polluted soil on the growth and survival of pepper (*Capsicum annuum* L.). Ann. Exp. Biol., 2: 5-10.
17. Das, T.K., 2008. Weed Science: Basics and Applications. Jain Brothers, New Delhi, ISBN: 8183600964, pp: 901-902.
18. Madukwe, D.K., H.C. Ogbuehi and M.O. Onuh, 2012. Effects of weed control methods on the growth and yield of cowpea (*Vigna unguiculata* (L.) Walp) under rain-fed conditions of owerri. A merican-Eurasian J. Agric. Environ. Sci., 12: 1426-1430.
19. Tripathi, S.S. and G. Singh, 2001. Critical weed competition in summer cowpea (*Vigna unguiculata* L.). Indian J. Weed Sci., 33: 67-68.
20. Nangju, O., 2003. Effect of Plant Density, Spatial Arrangement and Plant Type on Weed Control in Cowpea and Soybean. In: Weeds and Their Control in the Humid and Sub-Humid Tropics: IITA Proceedings Series, 3, Akobundu, I.O. (Ed.)., IITA., Ibadan, Nigeria, pp: 288-299.
21. Ohanmu, E.O. and B. Ikhajiagbe, 2018. Enzymatic and non-enzymatic response of *Sphenostylis stenocarpa* to cadmium stress. Asian J. Applied Sci., 11: 125-134.
22. Lemos, J.P., J.C.C. Galvão, A.A. da Silva, A. Fontanetti and L.M.C. Lemos, 2012. [Effect of clearings of bidens pilosa and commelina benghalensis species on morphological characteristics of corn]. Rev. Bras. Agropecuaria Sustentavel, 2: 32-40.
23. Yadav, T., K.C. Nisha, N.K. Chopra, M.R. Yadav and R. Kumar *et al*., 2017. Weed management in cowpea-A review. Int. J. Curr. Microbiol. Applied Sci., 6: 1373-1385.