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Research Paper

Control of *Striga hermonthica* using NPK fertilizer in combination with maize-cowpea intercrop

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One of the biotic constraints causing yield losses of maize in Nigeria is *Striga* infestation. Field experiment was conducted during the 2014 and 2015 wet seasons at the Research and Demonstration Farm, Ibrahim Badamasi Babangida University, Lapai, Nigeria; to assess different NPK fertilizer rates in combination with maize-cowpea intercrop for *Striga hermonthica* control in maize. The treatments consisted of sole-maize + 0 kg NPK ha^{-1}, maize-cowpea + 0 kg NPK ha^{-1} , sole-maize + 60 kg NPK ha^{-1}, maize-cowpea + 60 kg NPK ha^{-1}, sole-maize + 120 kg NPK ha^{-1}, maize-cowpea + 120 kg NPK ha^{-1} , sole-maize + 180 kg NPK ha^{-1} , maize-cowpea + 180 kg NPK ha^{-1}, arranged in a Randomized Complete Block Design (RCBD) with four replications. The result showed that *Striga* shoot counts was lowest in plots planted with sole-maize + 120 kg NPK ha^{-1} followed by plots planted with maize-cowpea + 60 kg NPK ha^{-1} . Sole-Maize + 120 kg NPK ha^{-1} produced higher stand count and taller maize plants respectively than all the other treatments. Application of 180 kg NPK ha^{-1} significantly ($P<0.05$) produced the highest dry cob weight, 100 grain weight and grain yield in this study. It is therefore suggested that for *Striga hermonthica* control, sole-maize + 120 kg NPK ha^{-1} and maize-cowpea + 60 kg NPK ha^{-1} can be recommended. For increased grain filling and yield of maize, application of 180 kg NPK/ha with sole-maize is recommended in this study.

Key words: maize-cowpea, *Striga*, NPK fertilizer, grain yield, maize stover yield

INTRODUCTION

Striga hermonthica has been rated as farmers most serious weed problem which leads to crop failure, especially in maize. Most farmers in the affected areas have abandoned the growing of maize for less *Striga* susceptible crops or do not crop on the affected land at all. '*Striga*' is a Latin word for witch and that qualified it because of the symptoms displayed by affected plants such as stunted growth and overall drought-like phenotype long before the emergence of the *Striga* plants (Hayeloma, 2014). Atera *et al.* (2013) reported that *Striga* spp. is a root parasitic weed which is often referred to as farmers' nightmare due to its negative impacts on cereal crops especially maize. *Striga* species are obligate hemi-parasite plants that attached themselves to the roots of the host plant (sorghum, maize, millet, rice and sugar cane, as well as pasture and wild grasses) by diverting essential nutrients and leaving the host stunted and yielding little or no grain (Ellis-Jones *et al.*, 2004;Van Ast, 2006).

Striga hermonthica (Del.) Benth and *S. asiatica* (L.) Kuntze affecting cereals (maize, sorghum, millet and upland rice) and are the major agricultural *Striga* species, and *S. gesneriodes* (Willd.) Vatke affect legumes such as cowpea and tobacco in sub Sahara Africa while other species such as *S. forbesii* (Benth.) and *S. aspera* (Willd.) Benth have been reported to have sporadic effects on cereal crops in their limited locations (Parker, 2009). The geographic regions with the greatest diversity and concentration of *Striga* in Nigeria was reported by Dugje *et al.* (2006) as being the Northern Sahel and Sudan savanna and *S. hermonthica* is the most endemic extending Southern Guinea Savanna agro-ecological zone with significant increase towards the Northern-most part of the country.

Striga hermonthica is of serious economic importance in cereal production (Isah *et al*., 2011) causing huge losses in grain yield (Atera *et al*., 2013). It is estimated that 50 million hectares and 300 million farmers in sub-Saharan Africa (SSA) were affected yearly (Parker, 2008). In Kenya, *Striga* infestation is most severe in Nyanza and Western provinces (Manyong *et al*., 2008a;) and is found in over 210,000 ha of farmland (AATF, 2006). In monetary terms, about US$ 29 million per *annum* worth of maize is reportedly lost in the country (Woomer and Savala, 2007). It was reported in Nigeria to have caused 10 – 100 % grain yield losses (Isah and Niranjan, 2012).

Kunle et al, (2002) reported that the complex biological relationship between *Striga* spp. and the host plants coupled with its microscopic seed size, longevity and propensity for proliferation has made the control of *Striga* so difficult to eliminate. Westerman *et al*. (2007) reported variety of control options to reduce the menace caused by *Striga* such as hand and mechanical weeding, use of trap crops, application of nitrogen fertilizers, herbicide application, biological control, crop rotations, intercropping with non-hosts or biological control. The application of high nitrogen (N) increases the performance of cereal crops under *Striga* infestation. This is due to the fact that N reduced the severity of *Striga* attack while simultaneously increasingly the host performance (Lagoke and Isah, 2010).

However, Ashish *et al*. (2015) reported that legumes also enrich the soil by fixing the atmospheric nitrogen by converting it from an inorganic form to forms that are available for plants uptake. Cowpea intercropping leads to higher grain yield of sorghum as a result of the benefits of N fixation under cowpea intercropping as well as to stimulate suicidal germination of *Striga* seeds away from the host roots (Seran and Brintha, 2010).

MATERIALS AND METHODS

Source of material

The seeds of maize (*Zea mays* L.) and cowpea (*Vigna unguiculata* L.) which were used in this research were collected from the farmers' store in Lapai. The maize is a local variety and its native name in the study area is Kabako, while the cowpea variety is the Kananado.

Experimental site

Field trials were conducted in Lapai during the 2014 and 2015 cropping seasons at the Teaching and Research Farm of Ibrahim Badamasi Babangida University, Lapai, Niger State. Lapai lies between Latitude 9° 2'N and Longitude 6° 34'E (Garba *et al*., 2015a).

Experimental design and treatments

The experiment were laid out in a Randomized Complete Block Design with eight (8) treatments (sole-maize + 0 kg NPK ha^{-1}, maize-cowpea + 0 kg NPK ha^{-1}, sole-maize + 60 kg NPK ha^{-1} , maize-cowpea + 60 kg NPK ha^{-1}, sole-maize + 120 kg NPK ha^{-1} , maize-cowpea + 120 kg NPK ha^{-1}, sole-maize + 180 kg NPK ha^{-1} , maize-cowpea + 180 kg NPK ha^{-1}) replicated 4 times. Each plot consists of 4 ridges at 3m ×3m ($9m^2$) and 75cm inter-row spacing. Five maize plants were sampled for data collections from each net plot. Plots were manually weeded at 3 and 6 weeks after sowing (WAS). Side placement of half-dose of NPK (15:15:15) fertilizer was applied 3 WAS at the rate of 60, 120 and 180 kg NPK ha^{-1} and the remaining half dose was applied at 6 WAS. The parameters evaluated include maize stand count, plant height, number of leaves per plant, dry cob weight, 100 grain weight and grain yield. At harvest, the middle 2 rows (Net plot, 3 m^2) were harvested separately and the cobs were removed, dehusked and dried. They were later weighed, threshed and winnowed to obtained clean grains and weighed again. Data collected were subjected to analysis of variance (ANOVA) using statistical analysis software (SAS, 2002) and Duncan's multiple range test (DMRT) was used to separate treatment means at 5% levels of probability.

RESULTS AND DISCUSSION

Stand count, plant height and number of leaves per plant of maize under *Striga hermonthica* were significantly affected using NPK 15:15:15: and cowpea intercrop as control at 10 WAS (Table 1).

Stand count

In 2014, plots planted with sole-maize and treated with 120 kg NPK ha^{-1} significantly suppressed *Striga hermonthica* and recorded the highest number of maize stands and produced similar higher number of stand count with increasing fertilizer rate up to 180 kg NPK ha^{-1} under sole and maize-cowpea intercrop. The result was also at par with those sown in plots with sole and maize cowpea at 60 kg NPK ha^{-1}. This result could be due to the

Table1. Effect of *Striga hermonthica* on stand count, plant height and number of leaves using NPK 15:15:15: and cowpea intercrop with maize at 10 WAS during 2014 and 2015 wet season.

Treatments	Stand Count		Plant height		No. of Leaves	
	2014	2015	2014	2015	2014	2015
SMZ + 0 Kg NPK ha^{-1}	86.25c	90.95	119.17c	161.08ab	9.17	10.50
MZ + CWP + 0 Kg NPK ha^{-1}	88.70bc	93.00	146.42ab	143.00b	10.17	10.25
SMZ + 60 Kg NPK ha^{-1}	94.23ab	92.83	136.17bc	153.75ab	8.92	11.00
MZ + CWP + 60 Kg NPK ha^{-1}	92.78ab	90.40	140.92abc	149.33ab	8.92	10.58
SMZ + 120 Kg NPK ha^{-1}	96.65a	94.73	166.83a	170.25ab	10.33	10.33
MZ + CWP +120 Kg NPK ha^{-1}	97.63a	96.65	143.83abc	162.33ab	8.56	10.58
SMZ + 180 Kg NPK ha^{-1}	98.58a	95.73	156.59ab	176.57ab	10.42	9.75
MZ + CWP+ 180 Kg NPK ha^{-1}	98.08a	96.65	146.42ab	183.50a	9.34	10.92
SE±	3.71	4.65	62.72	133.25	0.50	0.26

Means with the same letter(s) in a treatment column are not significantly different using Duncan Multiple Range Test (DMRT) at 5% level of probability. MZ = maize, CWP = cowpea, SMZ = sole-maize.

optimum rate of fertilizer required to suppress *Striga hermonthica* infestation under maize field. This result corroborates the report of Dzomeku and Murdoch (2007) who stated that application of 120 kg N ha^{-1} significantly reduced *Striga* infestation and damages. The plots with no application of NPK fertilizer and sole-maize produced the least number of maize stands in this study and this demonstrates the poor inherent soil fertility status of experimental site which is one of the factors that favours *Striga* infestation. In 2015, there was no significant difference among all the treatments (Table1).

Plant height

Plant height of maize responded significantly in 2014 such that application of 120 kg NPK ha^{-1} in plots planted with sole maize drastically suppressed *Striga hermonthica* and produced taller plant height which is at par with all other treatments except the results obtained in plots with sole-maize at 0 kg NPK ha^{-1} which also is at par with plots with maize-cowpea intercrop at 60 kg NPK ha^{-1}. Production of taller plants could be due to adequate and balance supply of plant nutrients. This confirms the findings of Garba *et al*. (2015a) who reported an increase in Nitrogen fertilizer up to 120 kg ha^{-1} recorded taller plants under *Striga hermonthica* infestation. However, number of leaves in both years was statistically not significant in this study (Table 1).

Dry cob weight

The effect of *Striga hermonthica* control treatments on dry cob weight, 100 grain weight and grain yield using NPK 15:15:15 and cowpea intercrop with maize shows significant significance as presented in (Table 2). In 2014, application of 180 kg NPK ha^{-1} on sole-maize recorded the highest dry cob weight. Increasing NPK fertilizer rate from 60 – 120 kg NPK ha^{-1} in both sole and maize-cowpea intercrop produced similar dry cob weight, while results of non application of NPK fertilizer in plots planted with sole and maize-cowpea intercrop produced the lowest dry cob weight. In 2015, combination of maize-cowpea intercrop at 180 kg NPK ha^{-1} produced higher dry cob weight and all other treatments thought at par with an increasing NPK fertilizer rates from 60 – 180 kg NPK ha^{-1}. The lowest dry cob weight of maize was obtained from plots administered without any fertilizer application. High dosage of fertilizer and cowpea intercrop with maize played a vital role in suppressing *Striga* infestation in maize field. This corroborates the result of Ibrahim *et al.* (2010) who reported assertion by several authors that applying high dosage of fertilizer can help to control *Striga*. The high dry cob weight obtained in 2015 with the combination of maize-cowpea intercrop and 180 kg NPK ha^{-1} may be due to the shedding effects of the canopy from cowpea. This result confirm the report of Kureh *et al*. (2006) who reported that any spatial arrangement that increases cowpea ground cover at the base of maize or sorghum can reduce the density of *Striga* (Table 2).

Grain yield

In terms of grain yield of maize, it was observed from the data in (Table 2) that *Striga hermonthica* was reduced with variation from different rates of NPK fertilizer application. In 2014, *Striga hermonthica* was drastically reduced with application of 180 kg NPK ha^{-1} in plots planted with sole-maize and produced the highest grain yield which is at par with plots planted with cowpea intercrop at 180 kg NPK ha^{-1}. Results obtained with sole-maize at 60 kg NPK ha^{-1} were similar to those in plots

Table2. Effect of *Striga hermonthica* on dry cob weight, grain yield and 100 grain weight using NPK 15:15:15 and cowpea intercrop with maize during 2014 and 2015 wet season.

	Dry Cob Weight kg ha^{-1}		**Grain Yield kg ha^{-1}**		**100 grain weight (g)**	
Treatments	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**
SMZ + 0 Kg NPK ha^{-1}	1375.0c	1958.3b	1125.0d	1687.5c	7.50b	20.25
MZ + CWP + 0 Kg NPK ha^{-1}	1500.0c	2354.2b	1250.0d	2083.3bc	7.00b	25.75
SMZ + 60 Kg NPK ha^{-1}	1937.5b	2545.8ab	1666.7c	2125bc	11.50b	25.00
MZ + CWP + 60 Kg NPK ha^{-1}	1875.0b	3187.5ab	1645.0c	2258.3abc	10.25b	23.75
SMZ + 120 Kg NPK ha^{-1}	2062.5b	3104.2ab	1854.2bc	2868.3ab	11.25b	26.00
MZ + CWP +120 Kg NPK ha^{-1}	1895.8b	2768.3ab	1666.7c	2416.7abc	8.75b	24.50
SMZ + 180 Kg NPK ha^{-1}	2450.0a	3070.9ab	2145.8a	3020.8ab	18.25a	26.75
MZ + CWP+ 180 Kg NPK ha^{-1}	2337.5a	3775.0a	2083.3ab	3187.5a	18.00a	25.25
SE±	6886.56	17798.30	7660.0	88513.56	3.49	1.09

Means with the same letter(s) in a treatment column are not significantly different using Duncan Multiple Range Test (DMRT) at 5% level of probability. MZ :– Maize, CWP :– cowpea, SMZ :– Sole-maize.

planted with maize-cowpea intercrop at 60 and 120 kg NPK ha^{-1} which is at par with sole-maize at 120 kg NPK ha^{-1}, while the lowest grain yield was recorded in plots that did not received any fertilizer. This result could be due to the role played by adding more nutrients into the soil to help improve its inherent fertility. This attests to the report of Garba *et al*. (2015b) who stated that application of 180 kg NPK ha^{-1} was found adequate for *Striga* suppression and grain yield of maize. Olakojo and Olaoye, (2007) also revealed that addition of NPK (15: 15: 15) fertilizer to the soil at recommended dosage can reduce *Striga hermonthica* infestation in maize and possibly enhance higher grain yield. In 2015, plots with maize-cowpea intercrop at 180 kg NPK ha^{-1} produced the highest grain yield, the result is at par with increasing fertilizer rate from 60 – 180 kg NPK ha^{-1} in both combinations (Table 2). The lowest grain yield was produced at 0 kg NPK ha^{-1} which is at par with the results obtained in plots planted with maize-cowpea and sole-maize at 0 and 60 kg NPK ha^{-1} respectively. This result corroborates the report of Tsubo *et al*. (2005) who stated that intercropping cereals with leguminous crop helps maintain and improve soil fertility. The poor grain yield obtained in plots without fertilizer application clearly demonstrated that as long as maize is not supply with adequate fertilization (Musambasi *et al*., 2003) or the planting of trap crops that causes suicidal germination of *Striga* to improve soil fertility (Carsky *et al*., 2000; Schulz *et al*., 2003), the crop will not produce economic yield.

100 grain weight

Application of 180 kg NPK ha^{-1} on the plots planted with sole-maize produced the heaviest 100 grain weight which produced similar heavier grain weight in plots with maize-cowpea intercrop at 180 kg NPK ha^{-1}, while the lightest 100 grain weight is recorded with sole-maize at 0 kg NPK ha^{-1} which is at par with an increasing fertilizer rate up to 120 kg NPK ha^{-1}. Heaviest 100 grain weight obtained at 180 kg NPK ha^{-1} with sole-maize could be attributed to high dosage of fertilizer and nitrogenous fertilizer fixed from the atmosphere by cowpea was a combined effort which assists in the suppression of *Striga hermonthica* for the better grain filling of maize seeds. This result corroborates the report of Akbar *et al*. (2002) who stated that ever-increasing nitrogen levels have momentous effect on growth, development and yield parameters. All the treatments measured in 2015 on 100 grain weight of maize were statistically not significant.

Striga shoot counts

The effect of NPK (15:15:15) fertilizer and maize-cowpea intercrop on *Striga* shoot count and *Striga* incidence during the wet set season of 2014 and 2015 is presented in (Table 3). The results showed that the plot without fertilizer application had the highest number of *Striga* shoot counts and the result was at par with maize-cowpea intercrop at 0 kg NPK ha^{-1} which is similar with increasing levels of fertilizer from 60 – 120 kg NPK ha^{-1} in plots with sole- maize and maize-cowpea intercrop respectively. The less dominated *Striga hermonthica* infestation was found in plots planted with sole-maize and maize-cowpea intercrop at 180 kg NPK ha^{-1} respectively. Plots without fertilizer application (0 kg NPK ha^{-1}) in combination with cowpea intercrop was highly dominated with *Striga hermonthica* infestation in 2015 whose results were at par with plots planted with sole-maize at 0 kg NPK ha^{-1}, but also produced similar result with increasing levels of fertilizer up to 180 kg NPK ha^{-1}. The lowest *Striga* shoot counts were recorded in plots with maize-cowpea intercrop at 180 kg NPK ha^{-1} as shown in (Table 2).

This result attested that higher fertilizer dosage at 180 kg N ha^{-1} suppresses *Striga hermonthica* for better yield of maize (Garba, 2015). Higher *Striga* incidence in 2014 was recorded in plots planted with sole maize at 0 kg NPK ha^{-1} and at par with plots planted with maize-cowpea intercrop at 0 kg NPK ha^{-1}. The lowest *Striga*

Table3. Effect of *Striga hermonthica* on *Striga* shoot count and *Striga* incidence using NPK 15:15:15: and cowpea intercrop with maize at 10 WAS during 2014 and 2015 wet season.

	Striga shoot count		Striga incidence	
Treatment	**2014**	**2015**	**2014**	**2015**
SMZ + 0 Kg NPK ha^{-1}	20.75a	11.75ab	12.00a	7.00ab
MZ + CWP + 0 Kg NPK ha^{-1}	15.75ab	14.50a	10.00ab	7.75a
SMZ + 60 Kg NPK ha^{-1}	12.25ab	7.25ab	5.75bc	3.00c
MZ + CWP + 60 Kg NPK ha^{-1}	12.00ab	10.50ab	4.25c	5.25abc
SMZ + 120 Kg NPK ha^{-1}	7.00b	7.50ab	4.75bc	3.75bc
MZ + CWP +120 Kg NPK ha^{-1}	10.25ab	7,25ab	3.75c	4.50ab
SMZ + 180 Kg NPK ha^{-1}	5.00b	6.25ab	3.25c	3.75bc
MZ + CWP+ 180 Kg NPK ha^{-1}	9.00b	5.25b	4.75bc	3.00c
SE±	11.22	6.20	2.83	1.34

Means with the same letter(s) in a treatment column are not significantly different using Duncan Multiple Range Test (DMRT) at 5 % level of probability. MZ = maize, CWP = cowpea, SMZ = Sole-maize.

incidence was observed in plots planted with maize-cowpea intercrop at 60 kg NPK ha^{-1} producing similar *Striga* incidences with plots planted with maize-cowpea intercrop and sole-maize at 120 and 180 kg NPK ha^{-1} respectively. The result is at par with plots planted with sole-maize at 60 and 120 kg NPK ha^{-1} and maize-cowpea intercrop at 180 kg NPK ha^{-1}. In 2015, the plots dominated with higher *Striga* incidence were plots planted with maize-cowpea intercrop at 0 kg NPK ha^{-1} and at par with sole-maize at 0 kg NPK ha^{-1} which also produce similar results with an increasing fertilizer rate at 60 and 120 kg NPK ha^{-1} in combination with maize-cowpea intercrop.

The lowest *Striga* incidence is recorded in sole-maize at 60 kg NPK ha^{-1} with similar results obtained at 180 kg NPK ha^{-1} in combination with maize-cowpea intercrop. The result is at par with the result obtained in sole-maize at 120 kg NPK ha^{-1} and maize-cowpea at 180 kg NPK ha^{-1}.

This result has demonstrated the role of inorganic fertilizer which replenished soil loss nutrients and as an antagonist to *Striga hermonthica* infestation. This result cited the report of Tsubo *et al*. (2005) who reported that intercropping of cereal and legume crops help to maintain and improve soil fertility. In addition, Khan *et al.* (2002) reported that cereals and cowpea intercropping has been observed to reduce *Striga* infestation significantly and therefore recommended it as one of the practical approach that is compatible with the low-cost input requirements of small-scale farmers.

The control of *Striga hermonthica* is more favoured with the combination of sole-maize with application of 120 Kg NPK ha^{-1} or maize-cowpea intercrop with application of 60 Kg NPK ha^{-1} is adequate, while for increase grain yields under *Striga* infestation, sole-maize at 180 Kg NPK ha^{-1} or cowpea intercrop with maize at 180 Kg NPK ha^{-1} can be recommended.

Conclusion

Appropriate *fertilizer application* is an important management practice that improves *soil* fertility for optimum crop yield. *Striga hermonthica* infestation is always favoured and therefore strongly supported where the soil is infertile. Application of inorganic fertilizer in addition to the use of intercrop with legume play greater role in soil nutrient restoration for efficient utilization of plants. From the result in this study, it can be concluded that both morphological attributes and yield and yield components of maize were more influenced by the use of NPK 15:15:15 for the management of *Striga hermonthica*. Therefore, the application of 180 kg NPK ha^{-1} in maize-cowpea intercrop can be recommended for *Striga* control.

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