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Effects of Different Seed Beds and Intercropping Systems on Weed Growth and Productivity of Sorghum and Sunflower at Badeggi, Central Nigeria

Ibrahim, P. A, Gbanguba, A.U*, Eze, J, N and Yabagi A. Abdullah

National Cereals Research Institute. Badeggi. PMB 8 Bida, Niger State
*Corresponding author: augbanguba@gmail.com

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ABSTRACT: *The trial was carried out at the experimental field of National Cereals Research Institute Badeggi during the 2020 and 2021 cropping seasons. The main objective was to determine the effects of different seed beds and intercropping system on weed growth and productivity of Sorghum (Sorghum bicolor) and Sunflower (Helianthus annuus). The different seed beds were: ridge, flat and broad bed while the cropping systems were sole Sorghum, sole Sunflower and Sorghum / Sunflower intercrop. The results showed highest weed density and dry matter/m^2 were recorded in sole Sorghum planted on ridge while the least weed density and dry matter/m^2 were found in Sorghum /Sunflower intercrop planted on broad bed. Tallest Sorghum plants were recorded when intercropped with Sunflower on flat while the highest Sorghum grain yield was obtained in sole plots planted on broad bed. The height of Sunflower was not affected by both seed bed types and intercrop while the highest and least grain yield of Sunflower were obtained when planted sole on flat and ridge respectively. Planting of Sorghum/Sunflower intercrop on broad bed controlled weed most and sole Sorghum on broad bed gave the highest Sorghum grain yield while maximum Sunflower grain yield was produced in sole planting hence be practiced by farmers*

KEY WORD: Different, Seed bed, intercropping system, weed growth.

INTRODUCTION

Tillage (disturbance) and herbicide regimes are the most influential selective forces that act on a weed community (Michael, 2008). Tillage systems, cultured crops, machinery and soil coverage by residues been seen that the main factors controlling sustainability of resources (Lanca *et al.*, 2009). Knezevic *et al.*,(2003) stated that soil tillage systems are

found to be important factors in the conservation of soil physical, chemical, and biological properties since they are able to control, or even reduce weed incidence, erosion and loses by runoff Tillage practices have been reported to have a significant and positive impact on crop production especially through the improvement of soil properties with attendant provision of a suitable seed bed for good seed germination, ease emergence and good establishment of seedling through enhanced root growth by encouraging vertical and horizontal proliferation of roots and reduction in soil strength in the sub-soil(Awe and Abegunri, 2009) The application of less intensive tillage practices in cropping systems brings some changes in weed populations and weed control efficiency (Buhler, 1995).

The adoption of the intercropping system is usually justified by its better use of environmental resources, compared to monocropping (Fukai and Trenbath, 1993). Traditionally, farmers within the Nigerian savanna intercrop maize (*Zea mays* L.) with other crops such as cowpea (*Vigna ungniculata* (L) Walp) and soybean (*Glycine max* (L) Merr.). It has been reported that intercropping offers farmers the opportunity to engage nature's principle of diversity on their farms. Awe and Abegunri, (2009) stated that intercrops can be more productive than growing pure stands. Sorghum is not usually planted sole under traditional cropping system in order to minimize soil erosion and loss in fertility. Sorghum is usually intercropped with variety of crops for a variety of purpose such as cultural weed control, fertility and moisture conservation, land use maximization and improved cash returns from limited land holding (Awe and Abegunri, 2009).

One of the most important reasons to grow two or more crops together in the same place and time is the increase in productivity per unit of land (Preston, 2003)Weed management is an important component of production techniques as elimination of weeds is expensive and hard to achieve. Works has been done on non-chemical management techniques and environmentally safe alternatives to herbicides for weed control. Such eco-friendly techniques for weed control include intercropping, which is also indicated as an alternative to herbicide use, by reducing or suppressing weed growth (Liebman and Davis, 2000). Reduction in herbicide use is one of modern agriculture's main interests (Ngouajio *et al*., 1999). The interference effect between component crops is weaker than that between crops and weeds Daniel *et al.* (2001) stated that intercropping can suppress the growth of weeds better than sole cropping The effects of cover crop are achieved by a rapid occupation of the open space between rows of the main crop, which prevents germination of weed seeds and reduces weed growth and development. Germination of weed seeds may be inhibited by complete light interception by the cover crop or by secretion of allelo-chemicals. After the establishment of the weed seedlings, resource competition becomes the cover crop's main weed suppressing mechanism (Hollander *et al*., 2007).

One of the most common herbicide used for weed control in maize is atrazime. It was observed that biotypes of more than 50 weed species over the world have proved to be resistant to herbicides (Ritter *et al.,* 1985). An increased concern in the environmental side-effects of herbicides and development of herbicide resistance in weeds led to an increasing interest on integrated weed management systems (IWM) based on the use of precision weed control in space and time (Swanton and Murphy, 1996). It is widely assumed that higher spatial and temporal coverage by intercrops enable them to have better weed suppression than monocultures. Ayeni *et al.*(1984) observed higher weed biomass under intercropping than monoculture, while Moody (1978) found higher weed biomass in the monoculture than intercrop. Such contrasting results appear to indicate that the levels of weed control achieved depend on the type of intercrop, the component crops, the weed flora and the season. This study was therefore carried out with the objective of testing the effect of seed bed type and cropping system on weed growth and productivity of Sorghum and Sunflower.

MATERIALS AND METHODS

The trials were carried out during the 2020 and 2021 cropping seasons at the experimental field of National Cereals Research Institute, Badeggi ($9^0$45'N, $60^0$7'E) in the southern Guinea savannah zone of Nigeria to determine the effect of different seed bed and cropping systems on weed growth and productivity of Sorghum and Sunflower. The physico-chemical properties of the soils of experimental site are presented in Table 1. The experimental site was ploughed and harrowed using tractor and latter marked into plots of 5 m x 5 m (25 m^2). The bed treatments were then constructed manually by relevelling the harrowed place for flat bed treatment, while the soil was raised to 20 cm height for raised broad bed treatment. Ridges of about 50 cm height were also constructed manually.

The seed bed treatments were: ridge, flat and broad bed, while the cropping systems were sole Sorghum, sole Sunflower and Sorghum / Sunflower intercrop. The following treatment combinations were used: sole Sorghum on ridge, sole Sorghum on flat, sole Sorghum e on bed, sole Sunflower on ridge, sole Sunflower on flat, sole Sunflower on bed. Other treatments included Sorghum Sunflower on ridge, Sorghum/ Sunflower on flat and Sorghum / Sunflower on bed. The planting was done at ratio 1:1 in all the intercrop. On ridges, Sunflower was planted on top and Sorghum was planted by the side while one row of Sunflower to one row of Sorghum was planted on the flat and broad bed.Spacing for Sorghum and Sunflower as sole crops were 0.25 m x 0.75 m and 0.25 m x 0.75 m intra and inter – rows respectively. The spacing was maintained in the intercrops for Sunflower and replicated three times in a Randomized Complete Block Design.

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Data collection

Weed data: Determination of weed density and dry matter was done by throwing one m^2 quadrant in each plot, and the weeds inside were counted for weed density, and uprooted and dried for weed dry matter. This was done at four and eight weeks after planting.

Plant height: The height of five randomly sample plants of sorghum and sunflower in each plot was measured from ground level to tip of the leaf at maturity.

Grain yield: Yield was determined at harvest. Harvested Sorghum heads and also the Sunflower from the net plots were sun - dried, shelled and clean grains weighed.

Land equivalent ratio (LER)

This is the ratio of the land area needed under sole cropping to the land area under intercropping, which give equal amounts of yield at same management level. It is used to determine the benefit of area covered by intercrop or sole crops. This was calculated using the procedure of Onwueme and Sinha (1991).

$$\text{LER} = \frac{\text{intercrop yield of crop A}}{\text{sole crop yield of crop A}} + \frac{\text{intercrop yield of crop B}}{\text{sole crop yield of crop B}} + \frac{\text{intrcrop yield of crop a}}{\text{sole crop yield of crop a}}$$

= relative yield crop A + relative yield crop B + relative yield crop[a]

Data analysis

All data collected were subjected to analysis of variance (Snedecor and Cochran 1967) using statistical package M-Stat-C Version 1.3and the means were separated using the Duncan's New Multiple Range Test (DNMRT) (Duncan, 1955) at 5% level of probability.

RESULTS

Soil properties

Analysis of soil of experimental site showed that it was moderately acidic, texturally sandy with low clay, low organic matter and nitrogen content. It also contained low phosphorus and, while its CEC was moderate (Table 1).

Weed density/m^2:

Weed density at four weeks after planting was higher in sole Sorghum planted on ridge but was not significantly different with weed density recorded in sole Sorghum on flat and the mean in 2008 while in 2009 sole sorghum on ridge and sorghum/sunflower produced similar weed density (Table 2). Also in 2009 sole sunflower on ridge and sole sunflower on bed produced similar weed density. The least weed density at 4 WAP was found in sorghum/sunflower planted on bed in both year of the study and the mean. There was no significant difference in weed density at 8 WAP among the treatments in both years of the study and the mean.

Weed dry matter g/m^2:
At 4 WAP, sole Sorghum planted on ridge gave highest weed dry matter that was similar to that found in Sorghum/Sunflower on ridge but was at par with weed dry matter observed in sole sunflower on ridge in both years of study and mean (Table 3). Sole sorghum on bed and sole sunflower on bed produced similar weed dry matter that was lower and significantly different from that recorded in sole Sunflower on flat at 8 WAP. Sorghum/sunflower on bed gave least weed dry matter throughout the sampling periods and the means.

Plant heights:
Sorghum grew taller in the intercrop compared with sole crop in both years of study and the mean regardless of the seed bed types (Table 4). Sunflower height was not significantly different in both years of study and the mean.

Grain yield:
Higher Sorghum grain yield was recorded in sole sorghum planted on bed but was similar to the grain yield observed in sole Sorghum planted on ridge and flat in both years of the study and the mean (Table 5). The lowest sorghum grain yield was recorded in Sorghum/Sunflower planted on flat.

Sunflower grain yield was higher in sole cropping than intercropping regardless of seed bed type except in 2009 when similar Sunflower grain yield was observed in sorghum/sunflower intercrop planted on flat. The least sunflower grain yield was obtained in Sorghum/Sunflower intercrop planted on bed in both years of study and the mean.

Sorghum/sunflower intercrop planted on flat bed gave the highest land equivalent ratio in both years of the study which was followed by sorghum/sunflower planted on ridge while least LER was found in Sorghum/Sunflower planted on broad bed.

DISCUSSION

The soil of the experimental site was low in nutrient and CEC as common with soils of the savanna because of intensive land use and inherent parent material (Dudal, 2002). The higher weed density recorded in sole Sorghum plots might be due to existing space between Sorghum plants which gave weeds chance to grow with less suppression from Sorghum and also showed that sole cropping do not suppress weed as compared to intercropping. This result agreed with the findings of Daniel *et al* (2001) that intercropping can suppress the growth of weeds more than sole cropping. Weed growth was generally low in the intercrop due to quicker and better ground cover by Sunflower,

which resulted in the suppression of weed growth. Akobundu (1980) reported that crops like soybean, melon and sweet potatoes could provide early ground cover and shade out weeds when intercropped with other crops. The least weed density recorded in the intercrop might be due to competition between the component crops and weeds, thereby give them least chance of growth. This is in consonance with the findings of Awe and Abegunrin (2009), Hollander *et al*. (2007) and FAO (1980) that weeds are usually kept under control through (a) growing a vigorous companion crop (b) close seeding or thick sowing, thereby allowing the least space for weeds to grow. A combination of deep tillage and competitive crops has given encouraging results in the control of various classes of weeds including perennials.

The insignificant differences in weed density at 8 WAP might be due to the fact that the component crops had developed canopy that covered and suppressed weeds. The least weed dry weight recorded in the plot planted with Sunfower/ Sunflower intercrop might be due to competition between the component crops and weeds for nutrient, light and space, which gave least chance for weed growth. This result was in line with report of Migue (1999) that cover crops smother aggressive weeds, thus minimizing the need for weeding. This result is also in consonance with the statement by Hollander *et al*. (2007) that germination of weed seeds may be inhibited by complete light interception by the cover crop or by secretion of allelo-chemicals. The result contrasted that of Ayeni *et al.* (1984), which observed higher weed biomass under intercropping than monoculture though is in consonant with Moody (1978) that found higher weed biomass in the monoculture compared with the intercrop.

The least weed number and dry matter on beds may be due to proper tilling that occurred which was in line with report of Keith (1992) that tillage served only as a temporary means of weed control because the soil contained many ungerminated weed seeds. Plowing may bury weed seeds at a depth that prevents germination but may also expose others and some weed seeds may be deeply buried to conditions inconducive to germination.

Taller sorghum plants recorded in Sorghum/ Sunflower intercrop might be as a result of the stronger competitive ability of the sorghum crop for growth resources such as light, moisture, nutrients and space. This result agreed with the findings of Montha and De (1980), which recorded higher growth character of sorghum in sorghum/Sunflower intercrop that was attributed to high competitive ability of sorghum over sunflower However, this result disagreed with the work of Massave *et al.* (2001) which found the highest Sorghum height in sole sorghum when it was intercropped with cowpea. The result also contrasted the work of Muoneke *et al.* (2007) which found insignificant differences in sorghum height in sorghum/sunflower intercrop.

Higher grain yield in sole sorghum could be attributed to the lack of inter specific competition as a result of absence of sunflower. This is in consonance with findings of Oyewole and Magaji (2006) which reported significantly higher yield of millet in sole plot than in mixture that they attributed to lack of inter – specific competition as a result of absence of cowpea. This result also agreed with the statement of Reddy *et al.* (1990) that sole sorghum seemed to suffer little or no competition from Sunflower, a legume, especially for light, which was identified as the major factor for dry matter production of cereals in the mixture. The same finding was recorded by Massave *et al.* (2001) when maize was intercropped with cowpea.

The least sorghum grain yield recorded in sorghum/sunflower intercrop on flat might be due to competition between the component crops. This was in line with the statement of Daniel *et al.* (2001) that intra- and inter specific competition that occurs in the intercropping system affects the performance of the component crops with respect to yield. These results also agreed with Keith (1992) that a poorly prepared field does not provide a suitable medium for optimum plant growth. If the field is not leveled, the seedlings cannot establish quickly in the low spots while weeds will grow abundantly in the high spots. These conditions will result in stunted plants with low production.

The height of sunflower was not affected by different seed beds and intercroppings. This result disagreed with Muoneke *et al.* (2007) which reported taller Sunflower plants in intercrop than sole crop. Sole sunflower gave higher grain yield than Sorghum/ sunflower intercrop. This might be due to lack of inter specific competition as a result of absence of sorghum in the population. Lower Sunflower grain yield obtained in sorghum/sunflower intercrop might be due to inter specific competition. This result was similar to that of Adeniyi and Omotunde (2001) which reported a decrease in cowpea yield as a result of intercropping with maize.

The land equivalent ratio values obtained were greater than 1.0 and this showed that all the sorghum/sunflower intercrops on each seed bed yielded more than their sole crops. According to Onwueme and Sinha (1991) an LER greater than 1.0 implies that for that particular crop combination, intercropping yielded more than growing the same number of stands of each crop as sole crops.

From the results of this study, intercropping of sorghum/ and sunflower on broad seed bed is best for weed control. Broad seed bed is also good for high Sorghum grain yield while flat seed bed is best for high Sunflower grain yield.

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Table 1: Physico - Chemical properties of the soils of experimental site.

Soil Characteristics	2020	2021
Physical		
Sand g kg^{-1}	740	735
Silt g kg^{-1}	120	122
Clay g kg^{-1}	140	141
Textural Class	Sandy	Sandy
Chemical		
pH (H_2O)	5.4	5.4
Organic matter (g kg^{-1})	3.2	3.3
Total N (g kg^{-1})	0.05	0.06
Available P (mg kg^{-1})	33.28	33.36
Exchangeable bases ($cmolKg^{-1}$)		
Ca	2.3	2.4
Mg	2.5	2.5
K	0.75	0.76
Exchangeable acidity ($cmolKg^{-1}$)	0.19	0.19
CEC($cmolKg^{-1}$)	6.01	6.03

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Table 2: Effect of seed bed types and cropping system on weed density/m^2 at 4 and 8 weeks after planting

Treatments	Number of weeds			
	4 WAP		8WAP	
	2020	2021	2020	2021
Sole Sorghum on Ridge	233[a]	170[a]	80	78
Sole Sorghum on Flat	224[a]	166[ab]	81	78
Sole Sorghum on Bed	210[ab]	158[ab]	82	80
Sole Sunflower on Ridge	160[ab]	136[c]	84	81
Sole Sunflower on Flat	179[ab]	136[b]	85	80
Sole Sunflower on Bed	160[b]	96[c]	74	65
Sorghum/ Sunflower on Ridge	109[a]	87[a]	53	51
Sorghum/ Sunflower on Flat	104[ab]	69[b]	52	50
Sorghum/ Sunflower on Bed	100[c]	35[d]	44	40
Significant	*	*	NS	NS
SE±	13.3	12.9		
CV%	11.4	10.3	6.7	6.2

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (DNMRT).

N.S. Not significant

* = Significant at P ≤ 0.05

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Table 3: Effect of seed bed types and cropping system on weed dry matter g/m^2 at 4 and 8 weeks after planting

Treatments	Dry weed weight			
	4 WAP		8 WAP	
	2020	2021	2020	2021
Sole Sorghum on Ridge	154.3^{a}	143.6 ^{a}	63.3^{a}	60.3^{a}
Sole Sorghum on Flat	16.7^{a}	124.1^{b}	64.3^{a}	61.4^{a}
Sole Sorghum on Bed	133.6^{b}	118.8^{b}	60.7^{d}	50.7^{c}
Sole Sunflower on Ridge	122.3^{C}	111.6 ^{c}	56.7^{b}	46.6^{b}
Sole Sunflower on Flat	119.0^{a}	110.3^{a}	55.3^{a}	40.4^{a}
Sole Sunflower on Bed	117.0^{b}	100.2^{b}	43.3^{d}	34.5^{c}
Sorghum/ Sunflower on Ridge	111.3^{a}	93.3^{a}	45.7^{b}	30.5^{b}
Sorghum/ Sunflower on Flat	106.3^{ab}	91.5^{b}	35.3^{a}	20.4^{a}
Sorghum/ Sunflower on Bed	104.3^{d}	81.4^{d}	29.3^{e}	18.2^{d}
Significant	*	*	*	*
SE±	11.8	10.3	4.8	3.2
CV%	9.9	11.6	15.5	17.2

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (DNMRT).
N.S = Not significant
* = Significant at P ≤ 0.05

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Table 4: Effect of seed bed types and cropping system on plant heights (cm) at maturity

Treatments	Plant height			
	Sorghum		Sunflower	
	2020	2021	2020	2021
Sole Sorghum on Ridge	134.0^{c}	141.2^{d}	-	-
Sole Sorghum on Flat	148.3^{bc}	150.3^{bc}	-	-
Sole Sorghum on Bed	160.9^{b}	165.7^{b}	-	-
Sole Sunflower on Ridge	-	-	157.8	161.3
Sole Sunflower on Flat	-	-	168.9	173.1
Sole Sunflower on Bed	-	-	138.5	140.8
Sorghum/ Sunflower on Ridge	212.4^{a}	214.5^{a}	149.6	150.1
Sorghum/ Sunflower on Flat	213.1^{a}	216.1^{a}	149.5	104.9
Sorghum/ Sunflower on Bed	210.9^{b}	210.4^{a}	150.2	146.1
Significant	*	*	NS	NS
SE±	12.2	11.3		
CV%	19.3	17.4	11.3	12.6

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (DNMRT).
N.S = Not significant
* = Significant at P ≤ 0.05

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Table 5: Effect of seed bed types and cropping system on grain yields(t/ha)

Treatments	Grain yield			
	Sorghum		Sunflower	
	2020	2021	2020	2021
Sole Sorghum on Ridge	1.51[a]	1.61[a]	-	-
Sole Sorghum on Flat	1.20[b]	1.30[b]	-	-
Sole Sorghum on Bed	2.13[a]	2.51[a]	-	-
Sole Sunflower on Ridge	-	-	0.53[a]	0.61[a]
Sole Sunflower on Flat	-	-	0.63[a]	0.69[a]
Sole Sunflower on Bed	-	-	0.40[b]	0.50[a]
Sorghum/ Sunflower on Ridge	1.08[b]	1.12[b]	0.40[c]	0.40[b]
Sorghum/ Sunflower on Flat	1.08[c]	1.42[c]	0.41[b]	0.51[a]
Sorghum/ Sunflower on Bed	1.9[b]	1.21[b]	0.51[b]	0.40[b]
Significant	*	*	*	*
SE±	0.22	0.16	0.07	0.09
CV%	20.6	19.7	21.3	18.3

Means followed by the same letter(s) within a column are not significantly different at 5% level of probability (DNMRT).
N.S = Not significant
∗ = Significant at $P \leq 0.05$

Table 6: Effect of seed bed types and cropping systems on land equivalent ratio.

Treatments	2020	2021
Sorghum/Sunflower ridge	1.12	1.12
Sorghum/Sunflower on flat	1.23	1.21
Sorghum/Sunflower on bead	1.19	1.20