Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.4, No.18, 2013

An Agro-Economic Performance of Maize Under Different Weeding Regimes: A Case Study of Siam Weed (Chromolaena Odorata) Control in South Western Nigeria

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Abstract
Field experiments were carried out in 2009 and 2010 to evaluate the effects of Siam weed competition on the agro-economic performance of maize in South Western Nigeria. Two groups of treatments were applied. Firstly, plots were kept weed-free for timed periods only before allowing uncontrolled weed growth subsequently and second, weed growth was allowed for same periods before being continuously controlled afterwards. Average of yields over the two-year period was used for the measurement of output while the values of input and output were obtained from market surveys and through consumer panels approach. Partial farm budgeting analysis was employed. Results showed the first 8 weeks of maize field life (WAE) to be most critical for Siam weed control being as effective as keeping the plot weed-free throughout the crops field life. Delaying weeding for 6 weeks or more is as detrimental to yield as if plot is un-weeded for the entire growing period. The agro-economic indicators of performance employed-Yield, Net Returns and Benefit- Cost ratios were positive for the practice of keeping the maize plots Siam weed-free for the first 8 WAE. It gave a yield of 4.50 tonnes per hectare, net return ₦94,496.80 ($629.98) and highest Benefit/cost ratio of 1.9:1. In terms of the over-all economic contribution, an 8 WAE weeding programme timed at 4 weeks interval is recommended for maize farmers in South Western Nigeria.
Keywords: Control, critical time, siam weed, agro-economic, partial farm budget,weeding regime

INTRODUCTION

Maize (Zea Mays L.) a common cereal crop is grown in all parts of arable soils in Nigeria. It is also an important grain food for man and livestock being a very rich source of carbohydrates in diets. However, one of the major problems that confront the production of the crop is weed (Omotunde, 1998; Ngobo, et al., 2004; Iyagba, 2010).

The South-Western Nigeria is characterized by rainforest vegetation where various types of weeds grow luxuriantly. Moody (1973), Etejere (2004), Vissoh, et al., (2007) have identified the commonest weeds in the ecological zone to include Chromolaena odorata (Siam weed), the most predominant, Digitaria horizontalis, Brachiaria delfexa, Synedrella nodiflora, Spicelia anthelunia, Ageratum conizoides, Talinum traingulare, Eleusine indica and Setaria longisela.

Emergence of Siam weed on Nigeria's soil dated back to 1930's (Odukwe, 1965) and since then, it has spread fast among the various ecological zones colonizing nooks and corners of arable lands (Ige et al.,2008;Chokor, et al., 2008; Ikuenobe and Anoliefo,20003). The weeds grow aggressively fast and establish very thick mass colony thereby suppressing other neighouring slow-growing plants. These characteristics of Siam weed make it to be recognized as the most stubborn in South Western Nigeria. When fully mature, the weed grows to a height of about 6 metres, thickly established almost to an impenetrable mass on the soil, smothering and colonizing the entire area where it is established.

A lot of research works have been carried out to investigate the nature of the problems created by the weed to growing crops (Hall, et al. 1972; Olaoye, 1974, Edwards, 1974, Melander, et al., 2012a, b) and the control measures (Sheldrick, 1968, Schrodoer, 1979; Kayode and Ademiluyi, 2004; Sauerborn, et al., 2007). Hitherto, there is no quantifiable information to serve as benchmark for the agro-economic assessment of the effects of the weed on the cultivated crops and the critical time of its control. Researchers have also worked on the agronomic aspect of the critical period for weed competition and optimum time of removal in various crops in Nigeria (Remision, 1978, Abubakar, 1981, Abdalla and Mohamed, 2007; Ito, et al.,2007), however with little or no attention on time of siam weed control in maize crop. Thus, the main aim of the current study was to focus on the agro-economic assessment of the effects of siam weed competition on maize yield and to identify the proper time to control it so as to minimize competition with the crop thereby enhancing returns to farmers.

MATERIALS AND METHODS

The site of the experiments was the Agricultural Research Farm of Bowen University in Iwo, Osun State, Nigeria. Iwo, a city in Osun state, lies between latitude 7° to 38° North of the equator and between longitudes 4° to 11° East Greenwich meridian. The planting sites were located on a piece of land that had been left fallow for almost 5 years. Weed population as estimated by physical counts of weeds in 0.5 x 1.0m quadrant placed at random in segments of the plots ranged from 90-92% for C. odorata (Siam weed), 3-5% for Aspilia africana L and 2- 5% for D. horizontalis for the two year period covered by the experiments.

Land preparation and subsequent weeding operations on the plots were done manually by hoeing and there was no fertilizer application to the land.

Two experimental trials were conducted in the wet seasons of 2009 and 2010 respectively in a Randomized Complete Block Design with 14 treatments replicated four times. The soil of the experimental plot was a well-drained sandy loam with the soil physical and chemical characteristics of 'Iwo series' as described by Nwachokor and Uzu (2008) and Nwachokor et al. (2009). Maize TZSR-W, a late maturing cultivar (IITA, 1983) commonly grown in south Western Nigeria was planted at 75x30cm spacing to give a plant population of about 44,000 plants per hectare on 16th July 2009 and 20th July 2010 respectively for the first and second experiments.

In each experiment, the treatments consisted of two types of cultural operations carried out at different times after planting. The first set consisted of a control plot where weeds were controlled on the plot four times till harvest. For other treatments in the set, farms were kept free of weeds only for the first 2, 4, 6, 8, 10 and 12 weeks of the growing period and thereafter weeds were allowed to grow until harvest. In the second group, weeds were allowed to infest the plots for only the first 2, 4, 6, 8, 10 and 12 weeks of the growing period and then kept free of weeds afterwards until harvest. For the control plot in this group, weeds were allowed to grow until harvest. There was no incidence of insect attack, pathogenic disease or pilferage throughout the period of growing the crop on the field.

The experiment was terminated after 12 weeks of growing when the grains were about 90% dry on the field so as to prevent undue loss through rodents, insect attack and shattering. Twenty-five plants per replicate were sampled for the yield analysis. These were taken from the middle of each replicate treatment where crop component interactions were assumed to be highest.

Labour for weeding was valued at the prevailing hiring rate of ₦1,200 ($8.00) per man-day (8 hours) in the study area. Seeds planted were purchased at the prevailing price of ₦180.00 ($1.20) per kilogramme (kg) from retail outlets of the Oyo State Agricultural Development Project (OYSADEP) located in Ibadan, the state capital. Returns on maize yield were valued at the average price of ₦45 ($0.30) per kg. as obtained from the survey of markets and through consumer panel approach.

Treatment effects were assessed based on total grain yield, costs of labour for weed control and relative revenues advantage of the respective treatments using partial farm budgeting tools.

RESULTS AND DISCUSSION

The progressive eradication of siam weed from the control plots gave room for the emergence of new weeds that were less competitive and not as difficult to control. Weed count at different stages revealed that on the average, at each weeding regime, about 16.67% of siam weed was being displaced with new weeds such as Amaranthus spinosus (1.29%) Bidens pilosa (1.78%). Talinum triangulare (5.6%) and Euphorbia birta (8%).

The results of the agro-economic study on costs of production, yield response and economic performance of maize in response to the critical times of control of siam weed in the plots are presented in Tables 1, 2, and 3 respectively.

As shown in table 1, about 90 percent of the total production cost was incurred on farm labour while labour for weeding alone on the average accounted for between 58 and 75 percent of the latter. The cost of seeds and rent on land which was constant for all the treatments ranged between 3.83% and 11.08% of the total production cost. As expected, the cost of production increased with the frequency of keeping the plots weed-free.

As observed in table 2, the plots left weedy for a period beyond 6 weeks during the course of the experiment became progressively weedy with advancement of time and this had significant depressing effects on yield since no other factors such as pests, disease or perennial weeds were identified throughout the crop's field life. There was increase in total grain yield as the number of weeks of keeping maize plots free of siam weed increased. The trend was however reversed as the duration of weed infestation on the plots increased. The keeping of plots free of weeds for the first 8 weeks after seedling emergence (WAE) was as good as keeping it weed free throughout the growing period but significantly better than keeping it free only for the first 2, 4, or 6 WAE. However, when plots were left weedy for the same period especially during the early life of the crops on the field, there were severe reductions in grain yield.

Infestation of plots with siam weeds for 2 WAE before the initial weeding had no significant depressing effect on yield as those delayed further. Plots infested with weeds till after 4 WAE before the first weeding recorded

marked yield depressions the further away the time. Keeping the plots weedy for the first 6 weeks or more and weeding thereafter was as bad as keeping the plots weedy throughout the entire growing period which ultimately resulted in a grain loss of more than 96% relative to the 4.88 tonnes per hectare(t/ha) of grain recorded when the plots were kept weed-free throughout the growing period. An average grain loss of 54.91% resulted from leaving the plots infested with Siam weed for varying periods after sowing. This ranges between 7.85% and 39.32% for weed free plots at the first 6 weeks and 13.78%-96.04% for weed-infested plots for the same period. Early and effective weeding programme was thereafter better than delaying weeding till the latter part of the crop's field life.

After allowing five percent for harvesting/handling loss, the average maize yield ranged from 0.19 to 4.97 t/ha. among the treatments (Table 2). Highest yields were obtained from plots kept free of weeds for at least the first 8 weeks of the crop's field life and for shorter periods yields were significantly lower.

Using the average market price of ₦45,000 ($300.00) per tonne of maize, the economic returns for the various treatments as shown in table 3 showed that the highest net returns per hectare were obtained for treatments involving keeping the plots weed-free for at least 6 weeks within the first 8 weeks of the crop's field life. Thus, the returns at this regime ranged between ₦72,304.84 ($482.03) and ₦101,806.00 ($678.71). However, as the crops advanced in age, delays in weeding the field became dangerous as net revenue decreased progressively. When the plot was kept weedy beyond 6 weeks of the field life, a loss of more than ₦31,000.00 ($206.67) per hectare resulted. As the number of WAE for keeping the plots weed free increased, net revenues also increased.

The Benefit/Cost ratios were high (above 1.6:1) for all treatments involving keeping the plots weedy for only the first 2 WAE or weed free for at least the initial 8 weeks of the crop's field life. The highest Benefit/Cost ratio (1.9:1) was recorded however for the plots kept weed free for 8 WAE. Although the net revenues for treatments involving keeping the weed free for 12 WAE and above were higher, the fact that the benefit/cost ratio was highest for the former makes the labour used for keeping the plots weed free for the extra weeks superfluous economically more so when there was no significant difference between the yields (see table 2).

CONCLUSION

All the indicators for measuring the agro-economic performance in this study-Yield, Net Returns and Benefit/Cost Ratio were positive for the practice of keeping the maize plots free of siam weed for the first 8 WAE. In terms of the overall economic contribution, an 8 WAE weeding regime appropriately timed, such that the first weeding is carried out within the first 4 WAE is most efficient and therefore recommended for farmers in south western Nigeria.

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APPENDIX

Average Price of Input and Output used

Item	Unit	Price/unit (₦)
Maize seeds planted	kg	180.00*
Labour	man-day	1,200.00
Maize grains sold	kg	45.00

Note: ₦ means Naira (Nigeria Currency) $1 is equivalent to ₦150 at the time of study.
*Oyo State Agricultural Development Project (OYSADEP) and
Agricultural Input Supply Company (AISC), Zonal Office, Ibadan-Price list.

Table 1: Cost of production of maize at various levels of weed Control Naira (₦) per hectare): Average of 2009-2010 survey.

Treatment	Rent on land	Seeds	Farm Labour for:		Total
			Processing	Weeding	
Weed free first 2 weeks only	500	4,500	38,356.20	44,400	87,756.20
Weed free first 4 weeks only	500	4,500	35,107.92	44,400	84,507.92
Weed free first 6 weeks only	500	4,500	37,002.72	54,000	96,002.72
Weed free first 8 weeks only	500	4,500	49,003.20	54,000	108,003.20
Weed free first 10 weeks only	500	4,500	45,845.16	63,600	114,445.16
Weed free first 12 weeks only	500	4,500	53,244.00	63,600	121,844.00
Weed free throughout (control)	500	4,500	52,431.96	73,200	130,631.96
Weedy first 2 weeks only	500	4,500	46,386.60	63,600	114,986.60
Weedy first 4 weeks only	500	4,500	39,890.04	63,600	108,490.40
Weedy first 6 weeks only	500	4,500	29,062.56	54,000	88,062.56
Weedy first 8 weeks only	500	4,500	17,332.68	54,000	76,332.68
Weedy first 10 weeks only	500	4,500	11,919.00	44,400	61,319.00
Weedy first 12 weeks only	500	4,500	11,827.76	44,400	61,228.76
Weedy throughout (control)	500	4,500	10,114.38	30,000	45,114.38

Note: ₦ means Naira (Nigeria Currency) $1 is equivalent to ₦150 at the time of study.
Source: Field Experiments 2009-2010 and computations there from.

Table 2: Yield Response of maize at various levels of weed control: Average of 2009-2010 Experiments.

Treatment	Total grain yield (t/ha).
Weed free first 2 weeks only	3.32
Weed free first 4 weeks only	2.96
Weed free first 6 weeks only	3.17
Weed free first 8 weeks only	4.50
Weed free first 10 weeks only	4.15
Weed free first 12 weeks only	4.97
Weed free throughout (control)	4.88
Weedy first 2 weeks only	4.21
Weedy first 4 weeks only	3.49
Weedy first 6 weeks only	2.29
Weedy first 8 weeks only	0.99
Weedy first 10 weeks only	0.39
Weed first 12 weeks only	0.38
Weedy throughout (control)	0.19
LSD at 5%	0.83

Source: Field Experiments, 2009-2010 and computations there from.

Table 3: Economic performance of maize at various level of weed Control (Naira per hectare): Average of 2009-2010 Experiments

Treatment	Value of Yield	Cost of Production	Net Returns	Benefit/ Cost ratio
Weed free first 2 weeks only	149,400	87,756.20	61,643.80	1.7:1
Weed free first 4 weeks only	133,200	84,507.92	48,692.08	1.6:1
Weed free first 6 weeks only	142,650	91,002.72	51,647.28	1.6:1
Weed free first 8 weeks only	202,500	108,003.20	94,496.80	1.9:1
Weed free first 10 weeks only	186,750	114,445.16	72,304.84	1.6:1
Weed free first 12 weeks only	223,650	121,844.00	101,806.00	1.8:1
Weed free throughout (control)	219,600	130,631.96	88,968.04	1.7:1
Weedy for 2 weeks only	189,450	114,986.60	74,463.40	1.6:1
Weedy for first 4 weeks only	157,050	108,490.40	48,560.00	1.4:1
Weedy for first 6 weeks only	103,050	88,062.56	14,987.44	1.2:1
Weedy for fist 8 weeks only	44,550	76,332.68	-31,782.68	0.6:1
Weedy for first 10 weeks only	17,550	61,319.00	-43,769	0.3:1
Weedy for first 12 only	17,100	61,228.76	-44,128.76	0.3:1
Weedy throughout (control)	8,550	45,114.38	-36,564.38	0.2:1

Note: ₦ means Naira (Nigeria Currency) $1 is equivalent to ₦150 at the time of study.
Source: Field Experiments 2009-2010 and computation there from.