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Full Length Research Paper

Economic assessment of some pre- emergence herbicides in the Sudan Savanna Zone of Nigeria

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Field trials were conducted in 2006 and 2007 cropping seasons at the University of Maiduguri Teaching and Research Farm located in Maiduguri (11°50'N; 13°10'E) to carry out an economic analysis of the use of some pre-emergence herbicides for the production of sesame. The experiment consisted of 22 treatments which included 4 different pre-emergence herbicides applied at 5 different rates viz: butachlor, metolachlor, diuron and pendimethalin at 0.5, 1.0, 1.5, 2.0 and 2.5 kg a.i. /ha, weeding at 3 and 6 weeks after sowing (WAS) and weedy check. The treatment was laid out in randomized complete block design (RCBD) replicated 3 times. Result showed that although two hoe weedings resulted in the highest yield, percentage yield increase over check and income in both years, it was less beneficial and profitable than butachlor at 1.5 and 2.0 kg a.i /ha in 2006 and metolachlor at 1.5 kg a.i./ha in both years. Therefore, metolachlor at 1.5 kg a.i. /ha was more economical, profitable and beneficial than two hoe weedings in the production of sesame in the Sudan Savanna Zone of Nigeria.

Key words: Cropping seasons, pre-emergence herbicides, millet-cowpea intercrop.

INTRODUCTION

Sesame (*Sesamum indicum L.*) had been grown for the superior edible oil and nutritious food since before 2360BC (Klingman and Martin, 1954). In Nigeria, sesame is mainly grown in areas of southern Guinea Savanna Ecological Zone, notably in Benue and Kogi States and Federal Capital Territory, Abuja (Philips, 1977). Ingawa et al. (1986) reported that most of the north eastern parts of Nigeria are also involved in the production of sesame which include a stretch from Gumel in Kano State extending to Potiskum in Yobe State, Gwoza in Borno State, and Madagali, Lassa, Yola curving northward to Mubi areas of Adamawa State respectively and then into Bauchi State.

The importance of sesame lies in the variety of useful materials that can be extracted from it. The seed contains about 50 - 51% oil, 17 - 19% protein and 16 - 18% carbohydrate and the oil is edible, odourless and semi-drying containing oleic, stearic and palmitic acids (Yermanos et al., 1972). In sesame growing areas of Nigeria, the seeds and leaves are used for the preparation of soups. Sesame seed is eaten raw or fried in the form of cakes, or fried, pounded and mixed with sorghum and millet flour to a pastry or fried, pounded and mixed with water to give a sustaining drink (Van Rheenem, 1973). The constraint imposed by weeds on high yield in sesame had been well documented. Jain et al. (1985) and Sharma (1985) have stressed that early growth of sesame is slow, so it is important to suppress weed growth at an early stage. Balyan (1993) and Sinha et al. (1992) reported weed- induced yield reduction up to 135% and need for a critical weed free period of 50 days after planting.

The traditional method of weed control, namely, hoe-weeding is the commonest method of weed control by farmers in the Sudan savanna zone of Nigeria. This method is not only labour intensive, expensive and strenuous, but can also cause mechanical damage to growing branches and roots of plants. In addition to high cost, labour availability is uncertain thus making timeliness of weeding difficult to attain, leading to greater yield loss (Adigun et al., 2003).

Chemical weed control has revolutionized farmers approach to weed control in the world. It is one of the recent developments in crop production. It is more adapted to large scale crop production than other weed

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control methods and it is labour saving (Anon, 1994). Also, herbicide use has been reported to be more profitable than hoe-weeding in the production of various crops in Nigeria (Shrock and Monaco, 1980; Okereke, 1983; Usoroh, 1983; Sinha and Lagoke, 1984; Ogungbile and Lagoke, 1986; and Adigun et al., 1993). Judicious use of herbicides has been reported to reduce labour requirements for and cost of weed control, increased crop yields by reducing weed competition and consequently increased profitability (Ogungbile et al., 1982; Sinha et al., 1982). Nazeer et al. (2004) recommended Buctril-M herbicide over hoe-weeding for the management of broadleaf weeds in wheat as a result of the ability of the herbicide to produce higher grain yield compared to hoe-weeding and the attractive benefit-cost ratio of the use of this herbicide. Also, Kehinde (2002) had noted that although controlling weeds with pre- and post-emergence herbicides in upland rice was more expensive than two hoe-weeding, it gave the best weed control and had the highest net returns.

Fadayomi (1991) noted that there was adoption of chemical weed control option to large extent in Nigeria. However, it should be noted that many problems are associated with chemical weed control method in developing countries to make it as an alternative to hand weeding. It was observed by Akobundu (1997) and Fadayomi (1991) that a cross-section of Nigerian farmers do not have formal education, secondly, the chemical and spray equipment are largely imported, hence making price control by government difficult. In the case of herbicide use for example, other than perceived high cost and availability of chemicals, ownership and operation of knapsack sprayers are limiting factors to adoption in areas surveyed in the states of Nigeria (Ikuenobe et al., 2005). Adedzwa and Ortese (2004) reported that while farmers in Benue State of Nigeria acknowledge the efficiency of herbicides in the control of *Imperata cylindrical* the adoption of herbicides was limited by availability and cost.

While the beneficial effects of herbicide applications are well known, the risks to man and the other living organisms that he considers beneficial to himself or his environment should not outweigh the benefits associated with the use of these chemicals. Therefore, distribution should be made between the consequences of an abuse and the benefits from a recommended use of chemical (Akobundu, 1987). Some of the risks posed by herbicide use include, spray drift to sensitive crops, contamination of drinking water especially herbicides that are not bio-degradable and easily leached from the surface of light soil, the reduction and killing of the population of soil-inhabiting animals, the development of resistance in weeds due to repeated treatment of weeds with a particular class or family of herbicides, etc. (Akobundu, 1987).

In order to make farming more attractive and economical to the present and future generations of farmers and to increase food production, there is need to carry out an economic assessment of some pre-emergence herbicides to find out the one that will not only give higher yield but that which is most economical and profitable in the production of sesame in the Sudan Savanna Zone of Nigeria, so as to improve the socio-economic well-being of the farmers.

MATERIALS AND METHODS

Field trials were conducted during the rainy seasons (July - October) of 2006 and 2007 on the Teaching and Research Farm of the Faculty of Agriculture University of Maiduguri, Maiduguri (11°50'N, 15°10'E) located in the Sudan Savanna Zone of Nigeria. The experimental site, which measured 12 × 88 m, was harrowed, leveled properly using a hand hoe, and marked out. The plot size was 4 × 4 m leaving a distance of 1 and 0.5 m between replications and plots respectively. NPK 15:15:15 was applied to each plot to provide 50 kg P and 75 kg N. The full rate of P was applied before sowing and incorporated into the soil. The application of N however, was done in 2 equal split doses. The first dose was applied before planting as starter dose and the second dose was applied at 6WAS by drilling the fertilizer into the soil 15 cm away from the stand in a continuous band.

The experiment consisted of 22 treatments, which included 4 different pre-emergence herbicides applied at 5 different rates viz: butachlor, diuron, metolachlor and pendimethalin at 0.5, 1.0, 1.5, 2.0 and 2.5 kg a.i. /ha, weeding at 3 and 6WAS and a weedy check. The treatments were laid out in randomized complete block design (RCBD) with 3 replications.

Information on the cost of all the cultural practices from land preparation to harvesting and processing was collected from Borno State Agricultural Development Programme (BOSADP), Maiduguri, an agency responsible for extension services in Borno State, Nigeria. The current price of a big Mudu measure was found out from the open market to calculate the selling price or income. The economic assessment was done for different rates compared with hoe-weeded control and weedy check to find out the most cost-effective or profitable rate for the production of sesame.

The following methods (Joshua and Gworgwor, 2001) were used to assess the economics of production of sesame using different pre-emergence herbicides:

Cost of production

This include the cost of all the cultural practices, seeds, herbicides and transportation per net plot (0.00216 ha) and later converted to per hectare.

Yield increase over check

This was obtained by subtracting the check yield from yield of each treatment. This result was then divided by the yield of each treatment and multiplied by 100 to give percentage yield increase according to the following equation.

$$\text{Yield increase} = \frac{Yt - Yc}{Yt} \times 100$$

Where, Yt = Yield of grain in kg/ha of treatment.
Yc = Yield of check in kg/ha.

Selling price (Income)

Yields obtained from the experiments were sold at the prevailing market price of the commodity in Maiduguri.

Profit /loss

This was determined by subtracting the total cost of production from the selling price (Income) as represented by this equation:

Profit/loss = Sp – TCp,

Where Sp = Selling price (Income)
TCp = Total cost of production.

Cost-benefit ratio

This was determined by dividing the total cost of production by the selling price (income) as represented by this equation.

$$\text{Cost-benefit ratio} = \frac{TCp}{Sp}$$

Where TCp = Total cost of production
Sp = Selling price.

RESULTS AND DISCUSSION

The economic assessment of the use of different herbicide in the production of sesame in Maiduguri is presented in Table 1. The table shows the grain yield of sesame in kilograms per hectare produced by different herbicide rate, two hoe-weeding and weedy checks. It also shows percentage grain yield increase over weedy check, total cost of production per hectare, income per hectare, profit and loss per hectare and the cost-benefit ratio of the use of different pre-emergence herbicides vis-à-vis hoe- weeding and weedy check in the production of sesame in 2006 and 2007 cropping seasons. With regards to sesame production, the highest yield (331.4 kg/ha) was produced under hoe-weeding, followed by butachlor at 2.0 kg a.i./ha (330.4 kg/ha), diuron at 1.0 kg a.i./ha (330.4 kg/ha), diuron at 1.5 kg a.i./ha (317.5 kg /ha), butachlor at 1.5 kg a.i./ha (295.9 kg/ha) and metolachlor at 1.5 kg/a.i./ha (286.6 kg/ha), while the lowest yield (12.1 kg/ha) was produced under pendimethalin at 2.5 kg a.i/ha in 2006. Similarly, in 2007, hoe-weeding recorded the highest yield (543.7 kg/ha), followed by metolachlor at 1.5 kg a.i./ha (529.7 kg/ha), butachlor at 2.0 Kg a.i./ha (464.2 Kg /ha), metochlor at 1.0 kg a.i./ha (456.4 kg/ha) and butachlor at 1.5 kg a.i./ha (443.4 kg/ha) compared to the rest of the treatments, while the lowest yield (1.0 kg/ha) was observed under pendimethalin at 2.0 and 2.5 kg a.i./ha. The above results could be due to the little or no phototoxic effect of hoe-weeding and these herbicides on sesame and their effectiveness in the control of weeds which minimized weed competition with the crop and led to better utilization of growth resources (mineral nutrients, moisture and light) and better crop growth compared to the other treatments. The poor yield by pendimethalin herbicides at higher rates could be due to the phytotoxic effects of this herbicide and its ineffectiveness to control weeds (Imoloame, 2009).

In 2006, hoe-weeding produced the highest percentage yield increase (40.5%) over weedy check treatment, followed by butachlor at 2.0 kg a.i./ha and diuron at 1.0 kg a.i./ha (40.3%), diuron at 1.5 kg a.i./ha (37.9%), butachlor at 1.5 kg a.i./ha (33.3%) and metolachlor at 1.5 kg a.i./ha (31.2%) compared to other treatments, while the lowest grain yield increase over check (-1,532.6%) was recorded under pendimethalin at 2.5 kg a.i./ha. Similarly, in 2007, percentage yield increase over weedy check was highest (63.5%) under hoe-weeding, followed by metolachlor at 1.5 kg a.i./ha (62.5%), butachlor at 2.0 kg a.i./ha (57.2%), metolachlor at 1.0 kg a.i./ha (56.5%) and butachlor at 1.5 kg a.i./ha (55.2%), compared with the other treatments, while pendimethalin at 2.0 and 2.5 kg a.i./ha recorded the lowest percentage yield increase over check (-19,753.2%). The above results show the advantage of effective weed control by hoe-weeding and the above herbicides over weedy check and the unsuitability of pendimethalin at high application rates in the production of sesame. This agrees with the findings of Grichar et al. (2001a) that pendimethalin at higher rates reduced sesame plant stands by 8 - 98% when compared with untreated check.

Although hoe-weeding resulted in the highest yield and percentage yield increase over weedy check, it recorded the highest cost of production (₦55, 574.07), followed by pendimethalin at 2.5 kg a.i./ha (₦53, 44.44) and pendimethalin at 2.0 Kg a.i./ha (50, 962.93), while the lowest cost of production (₦35, 574.07), was observed under weedy check, diuron at 0.5 kg a.i./ha (₦37, 648.15), diuron at 1.0 kg a.i./ha (₦38, 513.89), and diuron at 1.5 kg a.i./ha (39, 384.26) compared with the other treatments in 2006. Similarly in 2007, the highest cost of production (₦55, 574.07) was recorded under hoe-weeding, pendimethalin at 2.5 kg a.i. /ha (₦53, 740.74) and pendimethalin at 2.0 kg a.i. /ha (50, 962.93), while the lowest (₦35, 574.07), (₦37, 994.44) and (₦38, 810.19) were recorded under weedy check, diuron at 0.5 and 1.0 kg a.i. /ha respectively compared with the other treatments. These results show the advantage of herbicide application over hoe-weeding in the reduction of cost of production of sesame. This agrees with the finding of Nazeer et al. (2004) that a very lucrative cost-effective gain was recorded due to the application of Buctril-M on wheat and that the gain in yield from the hand weeded plots was nullified with the additional cost of weeding.

Despite its high cost of production, hoe-weeding in 2006, resulted in the highest income (₦77, 981.48), followed by butachlor at 2.0 kg a.i. /ha and diuron at 1.0 kg a.i./ha (₦77, 745.37), diuron at 1.5 kg a.i./ha (₦74, 703.70), butachlor at 1.5 kg a.i./ha (₦69,606.48) and

Table 1. Economic assessment of the use of different pre-emergence herbicides on sesame production in Maiduguri in 2006 and 2007.

Herbicide	Rates kg/ha	Yield (kg/ha)		%yield increase over check		Total cost of production per hectare (₦)		Selling price /ha(Income) per hectare (₦)		Profit or loss/ha (₦)		Cost benefit ratio	
		2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Butachlor	0.5	105.2	210.9	-87.5	5.7	38,976.85	39,273.15	24,750.00	49,550.93	-14,226.85	10,277.78	1:1.575	1:0.793
“	1.0	128.0	392.7	-54.0	49.4	41,175.93	41,472.22	30,129.63	92,393.52	-11,046.30	50,921.30	1:1.367	1:0.449
“	1.5	295.9	443.4	33.3	55.2	43,375.00	43,671.30	69,606.48	104,324.07	26,231.48	60,652.77	1:0.623	1:0.419
“	2.0	330.4	464.2	40.3	57.2	45,574.07	45,870.37	77,745.37	109,199.07	32,171.30	63,328.70	1:0.586	1:0.420
“	2.5	182.7	401.3	-8.0	50.5	47,333.33	47,629.63	42,986.11	94,412.04	-4,347.20	46,782.41	1:1.101	1:0.504
Metolachlor	0.5	202.7	311.8	2.5	36.3	38,444.44	38,740.74	47,592.59	73,370.37	9,148.15	34,629.63	1.0.808	1:0.528
“	1.0	263.1	456.4	25.0	56.5	39,555.55	39,851.85	61,916.67	107,384.26	22,361.12	67,532.41	1:0.639	1:0.371
“	1.5	286.6	529.7	31.2	62.5	41,222.22	41,518.52	67,495.37	124,634.26	25,162.04	83,115.74	1:0.611	1:0.333
“	2.0	195.2	225.2	-1.0	11.8	42,333.33	42,629.63	45,935.20	52,986.11	3,601.87	10,356.48	1:0.922	1:0.805
“	2.5	189.4	189.6	-4.2	41.2	44,000.00	44,296.30	44,564.81	79,500.00	564.81	35,206.70	1:0.987	1:0.557
Diuron	0.5	239.6	227.0	17.7	12.5	37,648.15	37,944.44	56,370.37	53,398.15	18,722.22	15,453.71	1:0.668	1:0.711
“	1.0	330.4	374.1	40.3	46.9	38,513.89	38,810.19	77,754.37	88,027.78	39,240.74	49,217.59	1:0.495	1:0.440
“	1.5	317.5	302.1	37.9	34.3	39,384.26	39,680.56	74,703.70	71,064.81	35,319.44	31,384.25	1:0.527	1:0.558
“	2.0	68.7	207.6	-186.9	4.3	40,250.00	40,546.30	16,175.93	48,833.33	-24,074.07	8,267.03	1:2.488	1:0.830
“	2.5	115.0	201.1	-71.8	-11.4	41,129.63	41,425.93	27,023.15	47,314.81	-14,106.48	5,888.88	1:1.522	1:0.876
Pendimethalin	0.5	214.4	430.0	8.0	53.8	40,250.00	40,546.30	50,449.07	101,175.93	10,199.07	60,629.63	1:0.798	1:0.400
“	1.0	110.0	64.1	-79.3	-209.8	43,722.22	44,018.51	25,893.52	15,074.01	-17,828.70	-28,944.50	1:1.689	1:2.920
“	1.5	66.0	7.9	-198.8	-2,421.0	47,194.44	47,490.74	15,532.41	1,851.85	-31,662.03	-45,638.89	1:3.038	1:25.645
“	2.0	19.9	1.0	-893.2	-19,753.2	50,666.67	50,962.93	4,671.30	236.11	-45,995.37	-50,726.82	1:10.846	1:215.843
“	2.5	12.1	1.0	-1532.6	-19,753.2	53,444.44	53,740.74	2,870.37	4671.30	-50,574.07	-49,069.44	1:18.619	1:227.608
Weeding at 3 and 6 WAS		331.4	543.7	40.5	63.5	55,574.07	55,574.07	77,981.48	127,939.81	22,407.41	72,365.74	1:0.713	1:0.432
Weedy check		197.3	198.5	-	-	35,574.07	35,574.07	46,416.67	46,708.67	10,842.60	11,134.26	1:0.766	1:0.769

*Cost-benefit ratio is based on N235.29 per kg, the prevailing cost of sesame in Maiduguri.

metolachlor at 1.5 kg a.i./ha (₦67,495.37), compared to the rest of the treatments. Similarly in 2007, the income from sesame was highest (₦127, 939.81) under hoe-weeding, followed by metolachlor at 1.5 kg a.i./ha (₦124, 634.26), and lowest (₦235.29) under pendimethalin at 2.0 and 2.5 kg a.i./ha.

In 2006, the highest profit (₦39,240.74) was observed under diuron at 1.0 kg a.i./ha, followed by diuron at 1.5 kg a.i./ha (₦35,319.44), butachlor at 2.0 kg a.i./ha (₦32,171.30), butachlor at 1.5 kg a.i./ha (₦26,231.48) and metolachlor at 1.5 kg a.i./ha (₦25,162.04) compared with hoe-weeding and lowest profit (-₦50, 574.07) was recorded under pendimethalin at 2.5 kg a.i./ha. However, in 2007, the highest profit (₦83, 115.74) was observed under metolachlor at 1.5 kg a.i./ha, followed by hoe-weeding (₦72, 365.74) compared to the rest of the treatments and lowest (-₦50,726.82) and (-₦49,069.44) under pendimethalin at 2.0 and 2.5 kg a.i./ha respectively. The results show that the use of herbicide is more profitable in the production of sesame than hoe-weeding. This is similar to the findings of Warade et al. (1995), Saikia et al. (1997), Kehinde (2002) and Khan et al. (2005) who reported optimum and highest net returns obtained with the application of herbicides compared with the other methods of weed control treatment. It also confirms the report of Shrock and Monaco, 1980; Okereke, 1983; Usoroh, 1983; Sinha and Lagoke, 1984; Ogungbile and Lagoke, 1986; Adigun et al., 1993 that herbicide use is more profitable than hoe-weeding in the production of various crops in Nigeria. However, the above result is contrary to the findings of Chinaka and Enyinnia (1980) who reported highest profit (N1, 528.20) with manual weeding and lowest (N398.10) with the use of herbicides at Umudike in the eastern part of Nigeria.

The cost benefit ratio in 2006 was highest (1:18.619) and (1:10.846) under pendimethalin at 2.5 and 2.0 kg a.i./ha respectively and lowest (1:0.586) under diuron at 1.0 kg a.i./ha, diuron at 1.5 kg a.i./ha (1:0.522), butachlor at 2.0 kg a.i./ha (1:0.586), metolachlor at 1.5 kg a.i./ha (1:0.611), butachlor at 1.5 kg a.i./ha (1:0.623), metolachlor at 1.0 kg a.i./ha (1:0.639) and diuron at 0.5 kg a.i./ha (1:0.688), compared to hoe-weeding and other treatments. Similarly, in 2007, the highest cost: benefit ratio (1:227.608) and (1:215.843) was observed under pendimethalin at 2.5 and 2.0 kg a.i./ha respectively and the lowest (1:0.333) under metolachlor at 1.5 kg a.i./ha, pendimethalin at 0.5 kg a.i./ha (1:0.400), butachlor at 1.5 kg a.i./ha (1:0.419) and at 2.0 kg a.i./ha (1:0.420), respectively compared to hoe-weeding. The lower cost: benefit ratio recorded by the above herbicide rates compared to hoe-weeding in the two years of study signify that the use of herbicides is more beneficial and economical than hoe-weeding in the production of sesame in the Savanna Zone of Nigeria. This is similar to the findings of Nazeer et al. (2005) and Khan et al. (2005) who reported optimum cost: benefit ratio with the application of herbicides compared to weedy check and other weed control methods.

From this study, it can be concluded that hoe-weeding produced the highest sesame grain yield closely followed by metolachlor at 1.5 kg a.i. /ha and butachlor at 2.0 kg a.i./ha in the two years of study. However, hoe-weeding was more expensive and resulted in the highest cost of production of sesame than all the herbicide treatments and weedy check. Metolachlor at 1.5 and 1.0 kg a.i./ha, butachlor at 1.5 and 2.0 kg a.i./ha, diuron at 0.5 - 1.5 kg a.i./ha had lower cost: benefit ratio compared to hoe-weeding in the two years of study. Therefore for lower cost, higher yield, and better economic returns, metolachlor at 1.5 kg a.i./ha and butachlor at 2.0 kg a.i./ha are recommended to the farmers in the Sudan Savanna Zone of Nigeria as an alternative to two hoe-weedings.

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