Niger Agric. J. 31 (2000): 13-22

FURTHER INVESTIGATIONS ON THE EFFECTIVENESS AND ECONOMICS OF SOME HERBICIDES IN GINGER.

A. A. MELIFONWU and G. N. ASUMUGHA[1]

Federal College of Agriculture
Ishiagu. Ebonyi State, Nigeria
(Accepted July, 1999)

ABSTRACT

Field trials were conducted during 1995 and 1996 wet seasons at Umudike (05^{O} 29^{1}N, 07^{O}33^{1}E; altitude 122m) in the rainforest ecological zone of Nigeria to provide further information on the relative performance and economics of primextra [1], and alachlor (2^{1}, 6^{1} – diethyl 1-N- (methoxy methyl) –acetanilide) herbicides and their mixtures with paraquat (1, 1^{1} – dimethy 1-4, 4^{1} –bipyridinium dichloride) and fluometuron (N^{1}-(3-trifluoromethy 1-pheny1)-N, Ndimethy 1 urea) for the control of weeds in ginger (Zingiber officinale Rosc.) cv. Maran.

Adequate weed control was achieved by all the herbicide treatments evaluated until 16 weeks after planting (WAP), except primextra and alachlor, whose activities at 2.0 and 4.0 kg a.i.ha $^{-1}$ declined after 12 WAP. Hand weeding four times at 4, 8, 12 and 16 WAP and all the herbicide treatments resulted in significantly lower weed dry weights, higher ehizome yields, marginal benefit: cost ratio (MBCR) and net revenue than the unweeded control. The highest yield of ginger rhizomes (10.68 and 9.32 kg ha $^{-1}$) and Marginal Benefit: Cost Ratio (0.87 and 0.57) were obtained from primextra + paraquat at 2.0 +1.0 kg a.i ha^{-1}, in 1995 and 1996 respectively. In the both years, the unweeded plots gave the poorest rhizome yields (5.47 and 4.38 kg ha $^{-1}$).

1. *National Root Crops Research Insitute Umudike, Abia State, Nigeria.*

INTRODUCTION

Ginger is an important spice and export crop. Research at improving production of the crop in Nigeria has continued at National Root Crops Research Institute (N.R.C.R.I.), Umudike with the introduction of new ginger varieties from India such as Maran, Himachal pradesh, Wyrad local and Rio-de-Jenairo, to improve the narrow gone base, as only the land races as Taffin giwa/Yellow ginger and Yatsun biri/Black ginger cultivars were available before 1982. The new varieties have been tested and found to grow well under Nigerian conditions (Okwuowulu, 1992). Among the exotic ginger varieties, Maran, has been reported to produce highest stem tuber (Okwuowulu, 1992)

Weed competition is a major constraint in the cultivation of ginger, reducing stem tuber yield By up to 76% (Orkwor and Melifonwu, 1988). The closed spacing of the crop makes hoe-weeding a labour intensive and delicate operation due to risk of crop damage. Efforts at commercializing production of ginger has led to the use of herbicides for weed control which have been reported to be cheaper and more attractive than manual hoe-weeding in field crop production (Akobundu, 1987).In earlier studies conducted at Umudike, fluometuron plus alachlor (0.75 + 0.75 and 1.50 + 1. 50 kg a. i/ha, primextra (3.0kg a.i/ha) and Chloramben plus paraquat (3.0 + 1.0kg a.i/ha) have been reported to give selective weed control in Yellow ginger grown from 5 to 10g setts in Nigerian Rain Forest (Melifonwu and Orkwor, 1990, 1994.

Various species of plants and varieties within the same species have been reported to show variations in their responses to applied herbicides in different locations (Akobundu, 1987). There is no information on the response of ginger variety Maran to applications of herbicides. This research was conducted over two years to further assess the efficacy and economics of recommended as well as new herbicide treatments in rainfed ginger variety Maran.

MATERIALS AND METHODS

The experiment was conducted during the 1995 and 1996 wet cropping seasons at the teaching and research farms of the Federal College of Agriculture and the National Root Crops Research Institute N.R.C.R.I), both at Umudike (05° 29[1]E 07°33[1]E altitude 122m) in the Rain Forest. (Ecological Zone of Nigeria. The prevalent grassy weeds at the sites of the experiment were Panicum maximum jacq., Digitarial horizontalis Wild and Brachiaria deflexa (Schumach) C. E. Hubband ex Robyns., while the major broad leaved weeds were Chromolaina odorata R. M King & Robinson, Dissotis rotundifolia (sm) and Calopogonium mucunoidis Desv., Ageratum conyzoides L., Cassia rotundifolia Beth and Aspilia africana L.

The common sedges were Cyperus esculentus L., Kyllinga nemoralis) (Forest), and Mariscus alternifolius Vahl. In 1995, the soil used was acid sandy loam with pH 5.6 and organic carbon 0.76%, while in 1996, the pH and organic carbon contents of the soil were 5.4 and 0.63% respectively (Table1).

Table 1. Physical and Chemical Properties of Soils

	1995	1996
Soil texture	Sandy Loam	Sandy Clay Loam
pH in H_2O	5.65	5.4
Organic Carbon (%)	0.76	0.63
Total Nitrogen (%)	0.10	0.09
Available P (ppm)	21.0	21.0
Exchangeable Ca^{++} (Me/100g soil)	1.60	1.40
Mg^{++}	0.40	1.0
Na^{+}	0.10	0.07
K^{+}	0.19	0.20
CEC (me/100g soil)	9.20	5.47

The mean annual rainfall at the location is 2159mm, with long and short wet seasons, March – July and September – November. There is a short dry period in August. Air temperatures varies from 22 to 32^{oC}. Ginger, variety Maran' setts weighing 15g were planted in 20 x 20cm rows on 2nd June, 1996. The plot size was 5m x 5m. The experiment was laid out as randomized complete block design with three replications. The weed control treatments consisted of applications of a formulated mixture of either atrazine plus metolachlor (primextra), at 2.0 and 4.0kg a.i/ha; primextra plus paraquat at 2.0 + 1.0 at 2.0 +1.0 and 4.0 + 1.0kga.i/ha; alachlor at 2.0 and 4.0kg a.i/ha and alachlor plus fluometuron at 2.0 + 1.0 and 4.0 + 1.0kg a.i/ha. The paraquat treatments were applied post-emergence three days after planting, while the rest of the herbicide treatments were applied as pre-emergence spraying one day after planting using a CP 3 knapsack sprayer fitted with a poliject nezzle calibrated to deliver rate of 250 litters spray volume/ha. Treatments containing more than one herbicide were applied as a tank mixtures. There was also a hoe-weeded control as well as a weekly check. The plots were mulched to 5 cm thickness with dry guinea grass (Panicum maximum Jacq.) either immediately after herbicide application or after planting in hoe-weeded and weedy checks. The trials received a basal fertilizer application of 120 kg N, 60kg P2 05 and kg k2/ha. Weed control effectiveness was determined at 4, 8, 12, and 16 weeks after planting (WAP) by visual rating on a scale of 0-10, (0 = no weed control, complete weed cover, 10 = perfect weed control, no weed cover), andcounting of the number of weed species inside centrally located 1m2 quadrates in each plot. The weed biomas in each plot was determined at 16 WAP by harvesting all the weeds inside a centrally located 1.0 m2 quadrats in each plot. The weights of the weeds were determined after drying for 48 hours at 80^{O}C. The effects of the treatments on the crop was measured by visual rating of phytotoxic effects at 6 and 12 WAP using a rating scale of 0 – 10, where 0 = no crop injury and 10 = complete crop kill.

Data obtained on weeds and crop yield were subjected to analysis of variance and the treatment means compared using the Duncan multiple range test where there were significant differences between treatments.

Labour requirements were as contained in Okwuowulu (1992). Costs and benefits were calculated using the data from 1995 and 1996 trials at the prevailing market prices for labour, herbicides, and ginger stem tuber. Net revenue was obtained by subtracting the total costs of weed control from the sales revenue (Upton, 1973, Wood, 1967). The ratio of net revenue/total weed control costs was used to determine the marginal benefits/cost ratio (MBCR) of each weed of control treatment (Kay, 1981).

RESULTS AND DISCUSSION

The effects of the different herbicide treatments on weed control, weed dry weight, and phytotoxicity rating in 1995 are presented in Table 2.

Table: 2 Effects of rates of Primextra applied alone and mixed with Paraquat, Alachlor applied alone and mixed with Fluometuron, on weed control, weed dry weigh and growth of ginger at Umudike, 1995 and 1996.

Weed Control treatment	Rate (kg a.i./ha)	Weed Control Rating 2 W A P 1995			1996			Weed Dry Wt Kg/ha at 16 WAP		Phytotoxicity Rating3 (%) W A P 1995		1996	
		8	12	16	8	12	16	1995	1996	6	12	6	12
Primextra + Paraquat	2.0 + 1.0	9.3	9.0	8.0	9.2	8.5	8.0	216.18d	230.07de	5.0	0.0	6.0	0.0
Primextra + Paraquat	4.0 + 1.0	9.5	9.2	8.8	9.4	9.0	8.4	120.20e	140.50e	12.0	0.0	14.0	0.0
Primextra	2.0	8.8	8.4	7.0	8.6	8.2	7.2	3.3.74cd	322.67cd	3.0	0.0	5.0	0.0
Primextra	4.0	9.5	9.0	7.8	9.2	8.9	7.5	184.82e	246.67de	11.0	0.0	12.0	0.0
Alachlor + Fluometuron	2.0 + 1-0	9.3	8.6	8.0	9.0	8.5	8.0	246.90d	311.83d	5.0	0.0	0.0	0.0
Alachlor + Fluometuron	4.0 + 1.0	9.6	9.0	8.4	9.3	9.0	8.2	161.43e	173.33e	12.0	0.0	15.0	0.0
Alachlor	2.0	8.5	8.2	7.0	8.3	8.1	7.0	333.35bc	403.17c	3.0	0.0	5.0	0.0
Alachlor	4.0	8.8	8.5	7.5	8.4	8.1	7.2	220.42d	296.10d	11.0	0.0	13.0	0.0
Manual weeding	4.8.12&16 WAP I	9.6	8.5	8.5	9.5	8.5	8.4	122.34e	141.47e	0.0	0.0	0.0	0.0
Unweeded control	-	0.0	0.0	0.0	0.0	0.0	0.0	601.60a	688.33a	0.0	0.0	0.0	0.0
SE±		1.6	1.4	1.3	1.7	1.6	1.4	81.71	93.7				

1. Means in columns followed by similar letter are not significantly different at $P \leq 0.05$, DMRT.
2. WAP = weeks after planting
3. Weed Control rating, 0 = no control; 10.0 = complete control
4. Phytotxicity rating (0 = no crop injury; 10 = complete crop kill)
5. WAT = weeks after herbicide treatment.

At 12 WAP, satisfactory weed control was obtained with all the herbicide treatments. Only primextra + paraguat and alachlor + fluometuron each at 2.0 + 1.0 and 4.0 + 1.0 kg a.i/ha gave satisfactory level of control up to 16 WAP. When applied alone at 2.0 and 4.0 kg a.i/ha, primextra and alachlor caused greater weed weight at 16 WAP, compared to the values obtained with theirmixtures. Some Researchers have recognized the importance of herbicide mixtures for provision of better spectrum of weed control (Fadayomi 1997· Ikuenobe, 1996; Lagoke and

Sinha, 1983; Lagoke et al., 1993). All the weed control treatments including the hand weeded control resulted in significantly lower weed biomas than the unweeded check. In general, the higher rates of herbicide treatments were more effective on weeds. In 1996, weed control and weed weight followed a similar trend as in 1995 (Table 2). Lower rates of herbicide treatments caused minimal (≤ 10%).crop injury at 6 WAP, while greater phytotoxicity (≤ 15%) was caused at higher herbicide rates. In all cases, phytotoxicity was overcome by the crop at 12 WAP. The different herbicide treatments have significant influence on ginger stem yield (Table 3).

Table: 3. Influence of weed control treatment on weed dry weight and ginger rhizome yield at Umudike in 1995 and 1996

Weed control treatment	Rate (kg a.i./ha	Weed dry wt at 16 WAT3 (kg/ha) 1995	1996	Fresh rhizome yield (t/ha) 1995	1996
Primextra + Paraquat	2.0 +1.0	216.18d	230.07de	10.68a	9.32a
Primextra + Paraquat	4.0 + 1.0	122.34e	140.5e	9.64bc	8.44bc
Primextra	2.0	303.74cd	322.67cd	8.03efg	7.76def
Primextra	4.0	184.82e	246.67de	8.59ef	7.44ef
Alachlor + Fluometuron	2.0 + 1.0	246.90d	311.83d	9.48cd	8.96abc
Alachlor + Fluometuron	4.0 + 1.0	161.43e	173.33e	9.09d	8.20cde
Alachlor	2.0	333.35bc	403.17c	7.42fg	6.80ef
Alachlor	4.0	220.42d	269.10d	7.10g	6.76f
Manual weeding	4.8.12& 16 WAP[2]	120.20c	141.47e	8.81abc	8.80abc
Unweeded control	-	601.60a	688.33a	5.47h	4.38g
SE+		81.71	93. 7	0.89	0.98

1. Means in columns followed by similar letter are not significantly different at $P \leq 0.05$. DMRT.
2. WAP = weeks after planting
3. WAT = weeks after herbicide treatment

Primextra + paraquat at 2.0 + 1.0 kg a.i/ha supported the highest ginger stem tuber yield among the herbicide treatments, as well as the weeded and unweeded checks. However, this yield was no significantly different from that of hand weeded check in 1995 as well as those of hand weeded check, and alachlor + fluometuron at 2.0 + 1.0 kg a.i/ha in 1996. the high ginger stem tuber yields obtained with primextra + paraquat and alachlor + fluometuron could be attributed to effect of good weed control which lasted up to 16 WAP, which is the critical period for weed competition in ginger (Orkwor and Melifonwu, 1988). The unweeded control gave significantly lowest stem tuber yield.

Unchecked weed growth throughout the life cycle of ginger Cv. Maran depressed stem tuber yield by 56% and 50% in 1995 and 1996 respectively. Marginal benefit cost ratio and net returns were highest with primestra plus paraquat at 2.0 + 1.0 kg a.i/ha in the 2 years trial (Tables 4 and 5).

Table: 4. Costs and benefits of various weed control treatments in ginger at Umudike, 1995

Weed Control treatment	Rate (kg a.i./ha)	Total Cost of Production (N/ha)	Rhizome Yield (t/ha)	Total Revenue (N/ha)	Net Revenue (N/ha)	Marginal-benefit Cost ratio
Primextra + Paraquat	2.0 +1.0	114,000.00	10.68a	213,600.00	99,600.00	0.87
Primextra + Paraquat	4.0 + 1.0	116,400.00	9.64bcd	192,800.00	76,400.00	0.66
Primextra	2.0	110,700.00	8.03efg	160,600.00	49,900.00	0.45
Primextra	4.0	113,100.00	8.59ef	171,800.00	59,700.00	0.52
Alachlor + Fluometuron	2.0 + 1.0	113,196.00	9.48cd	189,600.00	76,404.00	0.67
Alachlor + Fluometuron	4.0 + 1.0	115,510.00	9.09d	181,800.00	66,290.00	0.57
Alachlor	2.0	110,446.00	7.42fg	148,400.00	37,954.00	0.34
Alachlor	4.0	112,760.00	7.10g	142,000.00	29,240.00	0.26
Manual weeding	4,8,12& 16 WAP[2]	119,150.00	9.81abc	196,200.00	77,050.00	0.65
Unweeded control	-	112,400.00	5.47h	109,400.00	-3,000.00	-0.03
SE+			0.89			

1. Cost of ginger production/ha includes cost of hand weeding 100 women – days @ N75.00/woman – day;

seed ginger @ N20.00/kg, cutting of setts 30 men – days; planting 120 m-d; cutting of mulch 140 m-d;

mulching 40 m-d, fertilizer 600kg/ha at N600.00/50kg bag; fertilizer application 2 m-d; primextra N580.00/it;

paraquat N550.00/it; Alachlor N500.it; herbicide application 3 m-d; harvesting 150 m-d; post harvest handing

80 m-d; knapsack (hired) N80.00; Fluometuron N580.00/it.

Table: 5. Costs and benefits of various weed control treatments in ginger at the experimental field at Umudike, 1996

Weed Control treatment	Rate (kg a.i./ha)	Total Cost of Production (N/ha)	Rhizome Yield (t/ha)	Total Revenue (N/ha)	Net Revenue (N/ha)	Marginal-benefit Cost ratio
Primextra + Paraquat	2.0 +1.0	118, 960.00	9.32	186,400.00	67,440.00	0.57
Primextra + Paraquat	4.0 + 1.0	121,820.00	8.44	168,800.00	46,980.00	0.39
Primextra	2.0	115,660.00	7.76	155,200.00	39,540.00	0.34
Primextra	4.0	118,520.00	7.44	148,800.00	30,280.00	0.25
Alachlor + Fluometuron	2.0 + 1.0	118,970.00	8.96	176,200.00	60,230.00	0.51
Alachlor + Fluometuron	4.0 + 1.0	121,590.00	8.20	164,000.00	42,410.00	0.35
Alachlor	2.0	115,320.00	6.80	136,000.00	20,680.00	0.18
Alachlor	4.0	117,940.00	6.76	135,200.00	17,260.00	0.15
Manual weeding	4,8,12& 16 WAP[2]	121,400.00	8.80	176,000.00	54,600.00	0.45
Unweeded control		112,400.00	4.38	87,600.00	-24,800.00	-0.22

Cost of ginger production/ha includes cost of hand weeding @ N100.00/man – day; @ N200.00/kg cutting of mulch 140 m-d; mulching 40 m-d, fertilizer 600kg/ha @ N8500.00/50kg bag; fertilizer application 2 m-d; primextra N730.00/it; paraquat N660.00/it; Alachlor N650.00/it; herbicide application 3 m-d; harvesting 150 m-d; post harvest handing 80 m-d; knapsack (hired) N80.00; Fluometuron N730.00/it.

In 1995, the MBCR with primextra + Paraquat at 2.0 +1.0 kg a.i. /ha;alachlor + fluometuron at 2.0 + 1.0 kg a.i./ha and handweeded check were 0.87, 0.67 and 0.65 respectively, while in 1996 it was 0.57, 0.51 and 0.45 respectively. The herbicide treatments eliminated the need for weeding up to 16 WAP, which is the critical period, handweeding was carried out four times. Under high weed pressure such as occurs in rainfed ginger herbicide application was the most profitable and physically efficient option, especially where cheap labour is not available.

Results from this experiment show that primextra + paraquat and alachlor + fluometuron at 2.0 + 1.0 kg a.i./ha can be used for the control of annual weeds in ginger. However, when herbicides are not available and affordable, the farmer can obtain optimum yields and high net revenue from hand weeding four times in ginger cultivar Maran.

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