EFFECTS OF HERBICIDES TOLERATED AND NOT TOLERATED BY SORGHUM (*SORGHUM BICOLOR*) ON PEARL MILLET (*PENNISETUM AMERICANUM*)

by

WILLIAM BATA NDAHI

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Approved by

Oliver G. Russ

(Major Professor)

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INTRODUCTION

Pearl millet [Pennisetum americanum (L) K. Schum] is a small grain cereal consumed by millions of people (17). Millet is sometimes referred to as poorman's cereal, because most people with a choice prefer other cereals such as wheat or rice.

There seems to be a renewed world wide interest in millet for several reasons. Millet often produces a greater quantity of grain than do other cereals under conditions of infertile soils, intense heat and scanty rainfall. It also matures in a shorter growing season. Another advantage of millet is that only a small amount of grain is required for seeding because the seeds are relatively small. This is important in such countries as China and India where the ratio of people to land is very high.

Large scale production of millet can be possible only if selective herbicides are used to control weeds. Herbicide research in pearl millet is very limited at the present time. Initial efforts to test herbicides for weed control in millet should focus on herbicides used in grain sorghum [Sorghum bicolor (L.) Moench]. Sorghum and millet have similar geographical distribution which in some cases may overlap, and the plants are also botanically similar (22).

The objectives of this research were 1) to determine if herbicides used in sorghum production are tolerated by pearl millet and 2) to determine if herbicides not tolerated by sorghum are also phytotoxic to pearl millet.

CHAPTER 1

REVIEW OF LITERATURE

Grain Sorghum and pearl millet have similar climatic requirements and are botanically similar (22). Factors affecting tolerance of pearl millet to herbicides may be similar to those affecting tolerance of grain sorghum.

Herbicides have been developed which can be safely and effectively used for weed control in sorghum. However use of these herbicides may result in injury under certain conditions. Wiese et al (29) found sorghum to be injured when atrazine [2-chloro-4-(tehylamino)-6-(isopropyl-amion)-s-triazine)] or propazine [(2-chloro-4,6-bis-(isopropyl-amino)-s-triazine)] was applied to clay loam soil and incorporated with a disc prior to bedding. The same investigators observed that propazine alone or propazine plus linuron [3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea] could be safely applied to beds and incorporated with a rotary cultivator up to twenty-four days prior to sorghum planting.

Williams et al (40) experimented with atrazine and propazine. Each of the herbicides was applied pre-plant and then incorporated. Two weeks after sorghum emergence, atrazine at various rates in oil-water mixtures was also applied to the sorghum seedlings. Results indicated that propazine applied preplant was safe for use in grain sorghum, but that crop injury and yield reduction did occur when atrazine was applied preplant or preemergence. Atrazine applied postemergence in oil-water mixtures either with or without a surfactant did not injure sorghum. The best result was obtained when atrazine was applied to sorghum 15 cm high.

Burnside et al (5) studied the effect of soil carryover of atrazine in a sorghum monoculture system by assessing sorghum yield factors. Atrazine applications of 3.4 kg/ha or more increased seed weight but decreased sorghum stand. Sorghum recovered from early atrazine injury and generally maintained yield. Rates up to 2.2 kg/ha did not reduce sorghum yield even with repeated annual applications. They concluded that there is no danger of reducing sorghum yield due to atrazine carryover in the soil from annual applications of atrazine.

Robinson et al (30) applied a mixture of CDAA (N,N-diallyl-2-chloroaetamide) and atrazine as pre-emergence on Waukegan silt loam and Webster silty clay loam. A mixture of CDAA at 2.2 kg/ha plus either atrazine or propazine at 2.2 kg/ha gave better weed control and higher yield than either CDAA or propazine alone.

Post emergence application of atrazine was evaluated by Burnside et al (6) on Sharpsburg silty clay loam soil. Combination of tillage, narrow spacings and pre-emergence atrazine treatments gave more dependable weed control than any one single treatment. It was also found that preemergence applications of atrazine as low as 1.12 kg/ha gave higher sorghum yield and better weed control than postemergence applications of atrazine at 2.2 to 4.5 kg/ha. They concluded that the rate of preemergence applications of atrazine should be reduced on lighter soils, since atrazine was more active in these soils.

Phillips (26) applied atrazine to a silty clay loam soil 3.7 kg/ha in wheat stubble shortly after harvest. Density, vigor, and grain yields of sorghum planted 11 months later were superior when compared to sorghum grown in cultivated check plots.

Wiese et al (39) examined tolerance of sorghum to preplant application of propazine and atrazine at rates ranging from 1.1 to 2.2 kg/ha on a Pullman clay loam soil. Sorghum grain yield was reduced the second year of this two year study. Their studies also showed that propazine plus linuron applied at 1.1 kg/ha plus 1.1 kg ai/ha and terbutryn applied at 4.4 kg/ha gave excellent weed control without any injury to sorghum.

Wiese et al (37) found atrazine and simazine [2-chloro-4,6-bis(ethylamino)-s-triazine] to be unsuitable for use in sorghum due to poor weed control and sorghum injury. Injury was most pronounced when heavy rains or flood irrigation occurred before sorghum emergence. They also found that propazine applied at 2.2 kg/ha resulted in stunting of sorghum.

Studies of the effect of atrazine and simazine and nitrogens, on crude protein in sorghum by Tweedy et al (36) showed simazine to increase grain yield and crude protein in sorghum when the plants were under nitrogen stress. But in the absence of nitrogen stress, neither simazine or atrazine increased grain yield or total crude protein in sorghum.

Ben et al (4) applied atrazine postemergence at 1.1 and 2.2 kg/ha with half liter of surfactant in 4 liters of water for control of pigweed in sorghum on fine and medium textured soils. On coarse textured soil rates higher than 1.1 kg/ha can be injurious to sorghum.

Yadav (41) in a four year experiment found atrazine applied at the rate of 1 kg/ha as preemergence reduced the dry weight of weeds by 67 percent and increased the grain yield of sorghum by 103 percent. Hand weeding and 0.5 kg/ha of atrazine were next best, giving increases in yield of 95 and 91 percent respectively.

Larry et al (21) found that atrazine is more toxic to sorghum in the southern states than in the northern states. Atrazine and norea [3-(hexahydro-4,7-methanoindan-5-yl)-1,1-dimethylurea] at 0.8 and 1.6 kg/ha respectively, and Linuron plus propazine at 1.1 kg/ha plus 1.1 kg/ha also gave satisfactory weed control and minimum crop injury.

These investigators also found propazine controlled broadleaf weeds with minimum injury to sorghum and also significantly reduced hoeing time. Linuron plus propazine at 1.1 kg/ha plus 1.1 kg/ha gave satisfactory weed control and minimal crop injury. Prometryn [2,4-(bis(isopropylamino)-6-(methylthio)-s-triazine] provided excellent control of both broadleaf weeds and grasses, but caused some sorghum injury.

In a similar experiment Larry et al (16) studied propazine incorporated at 40, 23 to 29, and 12 to 13 days before planting sorghum and also applied as preemergence treatment immediately after planting. Incorporation of the herbicide resulted in better control of grasses at the high rates than did preemergence applications. Incorporation of propazine up to 39 days before planting reduced the hoeing time significantly only when propazine was applied at the rate of 3.36 kg/ha. Injury to sorghum was found to be minimal.

Rea (29) applied propazine at the rate of 1.7 kg/ha as preemergence to sorghum on a Miller clay soil. There was 99 percent weed control and no injury to sorghum.

Cyanazine [2-[(4-chloro-6-(ethylamino)-s-triazine-2-yl] amino]-2-methylpropionitrile] has been shown to be effective in the control of weeds in sorghum. French, Santelmann, and Green (11) found that cyanazine was toxic to most grasses and broadleaf weeds without major injury to sorghum when applied either as preplant-incorporated or preemergence treatments at the rates up to 2.2 kg/ha. However, at rates greater than this there may be some injury to the crop. Cyanazine applied as postemergence treatment on sorghum may injure the crop at lower rates. They also found that cyanazine applications resulted in poor control of most annual grasses and broadleaf weeds when used as a postemergence application unless the weeds were treated when very small.

Abernathy et al applied terbutryn [2-(tert-butylamino)-4-(ethylamino)-6-(methylthio)-s-triazine] at the rates of 1.1 and 1.7 kg/ha as preemergence on a fine sandy clay loam soil. There was 60 to 100 percent weed control and 10 percent crop injury. They also applied 5.6 kg/ha as preemergence treatment on a loamy sandy soil. Sorghum was slightly injured, but there was 85% control of crabgrass (Digitaria sanguinalis (L) Scop).

Hill (16) conducted an experiment to determine the effectiveness of propachlor [2-chlor-N-isopropylacetanilide], bifenox [methyl 5-(2,4-dichlorophenoxy)-2-nitrobenzoate] and combinations of these herbicides as compared to proazine and terbutryn.

Propazine effectively controlled all the weed species, whereas terbutryn controlled all the broadleaf species but was less effective on barnyardgrass (Echinochloa crusgalli (L) Beauv). Propachlor provided satisfactory control of barnyardgrass, but was not effective on broadleaf weeds. Bifenox showed limited activity on barnyardgrass but controlled all the broadleaf species. The combination of bifenox and propachlor was as effective as triazine herbicides in controlling weed species. None of the herbicides significantly reduced the grain sorghum stand. Hill (16) also found propachlor applied at 4.8 kg/ha controlled grasses in two out of three years and caused only minimal injury to sorghum. Propachlor plus atrazine at 3.36 plus 1.68 kg/ha performed well in controlling grasses and broadleaf weeds without any injury to the crop.

Foy et al (10) applied propachlor plus propazine at 5.5 plus 2.2 kg/ha as preemergence on Othello fine sandy loam soil. Crop vigor was very good and both grasses and broadleaf weeds were controlled.

Heikes et al (14) found bifenox applied at 1.7 and 2.2 kg/ha to be promising for weed control in sorghum although it caused some stunting and delayed maturity. Bifenox plus propachlor at 1.1 plus 3.7 kg/ha resulted in excellent weed control without any adverse effect on sorghum. Bifenox plus cyanazine applied at 1.1 plus 0.8 kg/ha caused stunting and stand loss in sorghum. They also found that propazine at 1.34 kg/ha did not control foxtail (Festuca megalura Nutt.) or venice mallow (Hibiscus trionum 1), but there was no injury to crop. Terbutryn at the rates of 1.8, 2,3 and 2,7 kg/ha caused minor stunting at the highest rate, but the two lower rates were tolerated by sorghum. In post-emergence study they found that cyanazine at 0.9, 1.3 and 1.8 kg/ha caused stunting only in the highest rate.

Postemergence applications of Bifenox in small grain and sorghum (34) at recommended rate gave commercial control of most broadleaf weeds. Preemergence treatment in Canada at 0.84 to 1.1 kg/ha gave weed control superior to the postemergence treatments. Commercial weed control was obtained when bifenox was used at the recommended rates either alone or in combination with propachlor.

Effect of herbicides on several millet species has been investigated to a limited extent. Jain et al (17) found atrazine applied at 0.75 kg/ha to increase the yield of pearl millet. They also found that atrazine applied at 1.5 kg/ha and higher reduced both grain and stover yield. The reduction was greater in post-emergence treatments as compared to preplant incorporated or preemergence treatments. Atrazine, propazine and simazine were applied as preplant applications at 3.6, 2.2, and 2.2 kg/ha, respectively, to a black clay soil by Matveenko (24). Pearl millet was found to tolerate the herbicides. In Ethopia (18) injury was caused to pearl millet by preemergence application of atrazine and simazine, but their postemergence application appeared safe. Rao et al (28) presoaked seeds of pearl millet in distilled water for 12 hours and then treated with 1000 ppm aqueous solutions of atrazine, simazine and 2,4-D for 12 and 24 hours separately with an additional treatment of distilled water as a control.

Germination, seedling growth, mitotix index and pollen fertility were highly affected in all treatments in both 12 and 24 hour durations.

Robinson (30) observed that atrazine applied at 2.24 kg/ha preplant incorporated or preemergence did not appear to injure proso millet (Panicum miliaceum L). In USSR (18) preplant applications of atrazine and propazine have given good yields, and the most recent recommendation in that country includes the preplant and preemergence use of atrazine, propazine, prometryne, and simazine. Other studies (18) showed proso millet to be more sensitive to simazine than atrazine in both Germany and the USSR and that postemergence application of simazine is extremely injurious to millet.

Akobundu et al (2) studied the effect of atrazine and alachlor combination on various physiological processes in Japanese millet (Echinochloa crusgalli). Alachlor and atrazine combinations were found to reduce chloroplast protein synthesis.

Krisnamurthy (19) observed that simazine depressed grain and straw yield of finger millet (Elusine coracana). Kuzina found that simazine applied at 3 kg/ha reduced the yield of millet.

In a greenhouse test in Trinidad (18), preemergence application of linuron to bulrush millet (Pennisetum typhoides) was found to be promising.

METHODS AND MATERIALS

Tolerance of pearl millet to herbicides used in sorghum production was examined in field studies at Manhattan in 1977 and 1978 and at Minneola, Kansas in 1977. In 1977 the study at Manhattan was conducted on a Reading silt loam soil having 1.9 percent organic matter content and a pH of 6.6; whereas in 1978 Reading silt laom soil with 2.6 percent organic matter and a pH of 6.3 was used. The study at Minneola was conducted on a Harney silt loam soil having 1.2 percent organic matter content and a pH of 6.8. At both locations conventional methods were utilized for seedbed preparation.

Herbicides were applied by a tractor-mounted sprayer equipped with tapered flat fan nozzles with water applied as the carrier at a volume of 1.87 L/ha and at a pressure of 1.2 kg/cm^2. Treatments and rates are shown in Table 1. The plots consisted of four rows each measuring 9.1 meters long and 76.2 cm wide.

Treatments in 1977 at Manhattan and Minneola were applied as preemergence. However, a heavy infestation of chinch bugs (*Blissus leucopterus*) invaded the plot area at Manhattan and completely destroyed the millet seedlings fourteen days after planting. Consequently, plots were lightly harrowed and replanted. In 1978 treatments at Manhattan were applied and incorporated to a depth of 7.6 cm. Millet was planted immediately following herbicide application and incorporation. The insecticide carbofuran (2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate) was applied in the drill with the millet seed.

Each year the plots were kept weed free by occasional hand hoeing. Since the primary objective of the experiment was to observe millet tolerance to herbicides, weed control data was not taken. Data was not available at Minneola in 1978 due to a severe drought.

Data was collected from the center two rows of each plot and consisted of stand counts, visual injury ratings, and plant heights. Grain yields also were recorded after millet heads were harvested by hand, dried and threshed.

Data reported represent means of three replicates in a randomized complete block design.

RESULTS AND DISCUSSION

Percent lodged, mature head density, and yield of pearl millet were not significantly affected by herbicide treatments at Minneola in 1977 (Table 2). Low yields obtained at this location were attributed to chinch bug (*Blissus leucopterus*) infestation and drought during emergence. Herbicide treatments also did not significantly affect injury ratings, plant height, percent of plants flowering 50 days after treatment, mature head density, and yield at Manhattan in 1977 (Table 3). Lack of significant difference resulted because of chinch bugs injury. The first millet seedlings were completely destroyed and all of the plots had to be replanted. By the second planting all of the herbicides may have lost their phytotoxic effect.

Atrazine, terbutryn and bifenox application resulted in only slight seedling injury to millet at Manhattan in 1978. (Table 4). Seedling injury was slightly greater when propazine or cyanazine was applied.

Herbicide treatments containing propachlor, EPTC, and butylate severely injured millet seedlings. Plants either failed to emerge from treated soil or became severely twisted shortly after emergence. EPTC and butylate were included in the treatments to determine if they could control volunteer millet in subsequent crops.

Plate I shows typical plots that received terbutryn and Plate III shows a typical plot treated with bifenox. An untreated plot kept weed-free is shown in Plate IV.

Table 1. Treatments and rates of application for 1977 and 1978.

Treatments	Rates (Kg ai/ha)
Atrazine	2.42
Propazine	2.68
Terbutryn	2.68
Cyanazine	1.68
Bifenox	1.40
Propachlor	3.36
Propachlor + Atrazine	3.36 + 1.40
Propachlor + Linuron	3.30 + 1.12
Propachlor + Bifenox	3.36 + 1.40
EPTC + R-25788*	6.73 + 0.56
Butylate + R-25788*	6.72 + 0.28
Hand Weed	----

*Applied in 1978 only.

Table 2. Effect of herbicide treatments on lodging, head density, and yield at Minneola, 1977.

Treatment	Lodged plants	Mature Heads	Yield
	(%)	(number/hax10^3)	(kg/ha)
Atrazine	12	134	800
Propazine	10	133	884
Terbutryn	9	147	980
Cyanazine	7	150	635
Bifenox	9	141	1021
Propachlor	9	141	911
Propachlor + Atrazine	9	136	861
Propachlor + Linuron	9	138	993
Propachlor + Bifenox	10	145	910
Hand Weed	8	145	951
L.S.D. (.05)	NS	NS	NS

Table 3. Effect of herbicide treatment on vigor rating, plant height, percent flowering, mature head density, and yield of pearl millet at Manhattan, 1977.

Treatment	Vigor Rating[a]	Plant Height[b]	Plants flowering[b]	Mature heads[b]	Yield
		(cm)	(%)	(number/hax10^3)	(kg/ha)
Atrazine	9.0	115.2	63.3	318.0	2104
Propazine	8.7	85.3	63.3	296.5	1986
Terbutryn	8.7	67.4	40.0	274.1	1779
Cyanazine	9.3	84.0	53.3	308.2	2159
Bifenox	8.7	91.5	46.7	318.3	2029
Propachlor	7.7	52.7	30.0	273.7	1834
Propachlor + Atrazine	8.6	72.6	36.7	285.5	1671
Propachlor + Linuron	9.0	94.1	63.3	336.5	2116
Propachlor + Bifenox	8.0	105.8	36.7	333.9	2040
Hand Weed	9.7	92.1	66.7	292.0	1996
L.S.D. (.05)	NS	NS	NS	NS	NS

[a]Taken 21 days after planting; 0 = complete death, 10 = no injury.

[b]Height and percent flowering and maturity measurements taken 50 days after treatment.

Table 4. Effect of herbicide treatment on injury, plant height, maturity and, yield at Manhattan, 1978.

Treatments[a]	Injury Ratings[b] 7 DAT	Injury Ratings[b] 52 DAT	Plant Height	Maturity	Yield
			(cm)	%	(kg/ha)
Atrazine	1.0	3.0	113.3	30.0	857
Propazine	2.7	2.0	117.0	30.0	920
Terbutryn	1.3	2.0	130.0	30.0	1011
Cyanazine	2.0	1.7	125.0	35.0	1184
Bifenox	1.0	2.0	135.0	35.0	1661
Propachlor	10.0	5.0	83.0	0.0	705
Propachlor + atrazine	10.0	4.0	103.0	0.0	922
Propachlor + linuron	10.0	4.0	86.0	0.0	1000
Propachlor + bifenox	10.0	5.0	86.0	0.0	466
EPTC + R-25788	10.0	10.0	0.0	0.0	0
Butylate + R-25788	6.3	6.0	87.0	0.0	372
Hand weed					
L.S.D. (.05)	0.7	2.2	25.7	10.3	725

[a]Plots treated with propachlor, propachlor plus atrazine, propachlor plus bifenox, propachlor plus linuron and EPTC plus R-25788 were replanted 22 days after treatment (DAT).

[b]Rating scale: 0 = no injury, 10 = complete death.

[c]Maturity measurements taken 77 DAT

Millet was replanted 22 days later in plots that had been treated with herbicides which prevented emergence. Injury ratings taken 52 days after herbicide application revealed sufficient concentration of the herbicide remained to substantially injure the millet plants. Most severe injury occured on EPTC treated plots.

Plant height was not significantly affected by bifenox or triazine herbicides. Butylate applications did significantly reduce plant height. Also replanted millet from plots treated with propachlor or EPTC was significantly reduced in height.

Plots treated with bifenox, terbutryn, cyanazine and propazine gave yields that were comparable to the hand-weeded check. Atrazine application appeared to reduce yield. Atrazine has been reported by Jain et al (17) to cause injury in millet as high as 2.4 kg ai/ha and incorporated has been reported by Phillips (27) to be safe on sorghum. Lower rates of atrazine could possibly be tolerated by millet, but weed control at these lower rates may be inadequate. It is uncertain in our studies if the rate and/or the method of application caused the reduction of yield.

Butylate applications reduced yields of millet, but did not completely prevent seed production. Butylate in contrast to EPTC would appear not to provide control of volunteer pearl millet. Delay between application and planting allowed millet from propachlor treated plots to produce grain yields that were thirty to seventy percent of grain yield produced by millet from non-treated plots planted 22 days earlier. These yields occured even though the millet seedlings appeared to be substantially injured.

A late summer drought at Manhattan in 1978 contributed to overall grain yields being lower than in 1977.

SUMMARY

In 1977 millet tolerated all the treatments, and there was no significant difference among treatments on yield at both Manhattan and Minneola.

The experimental results at Manhattan in 1978 showed that millet can tolerate only the following herbicides when applied as preplant incorporated: Bifenox at 1.40 kg ai/ha, Cynanazine at 1.68 kg ai/ha, Terbutryn at 2.68 kg ai/ha, and Propazine at 2.68 kg ai/ha.

Atrazine, a common herbicide used in sorghum production, appeared to have depressed the grain yield of millet when applied at the rate of 2.42 kg ai/ha.

Propachlor alone or in combination with bifenox, linuron or atrazine did not allow millet to emerge at first planting, but some plants emerged when the plots were replanted 22 days after treatment (DAT). Plate VI shows a typical plot treated with propachlor or propachlor in combination with other herbicides. Plate V shows that sorghum can tolerate propachlor at the rate that prevented emergence of millet.

EPTC plus R-25788 did not allow any seedling establishment even when millet was replanted 22 days after treatment. EPTC plus R-25788 will therefore effectively control volunteer millet when it is used in other crops such as corn.

Both butylate plus R-25788 and EPTC plus R-25788 are used for the control of shattercane, (a close relative) of cultivated sorghum. Cultivated sorghum like millet will therefore not tolerate the two herbicides.

With propachlor allowing millet germination 22 days after treatment, its use in a layby application appears possible. Since sorghum tolerates propachlor, in the event of a natural disaster in a sorghum field in which propachlor has been applied, millet can be planted.

Not only will the millet be able to withstand the herbicide, but its relatively shorter growing season will enable it to reach maturity.

EXPLANATION OF PLATE II

Butylate + R-25788 applied at the rate of 6.7 kg ai/ha did not prevent germination of millet, but millet seedling shoots were twisted and yield was very low.

EXPLANATION OF PLATE I

Terbutryn applied at the rate of 2.68 kg ai/ha was well tolerated by millet. Millet vigor was high and yield high.

Plate I

Plate II

EXPLANATION OF PLATE IV

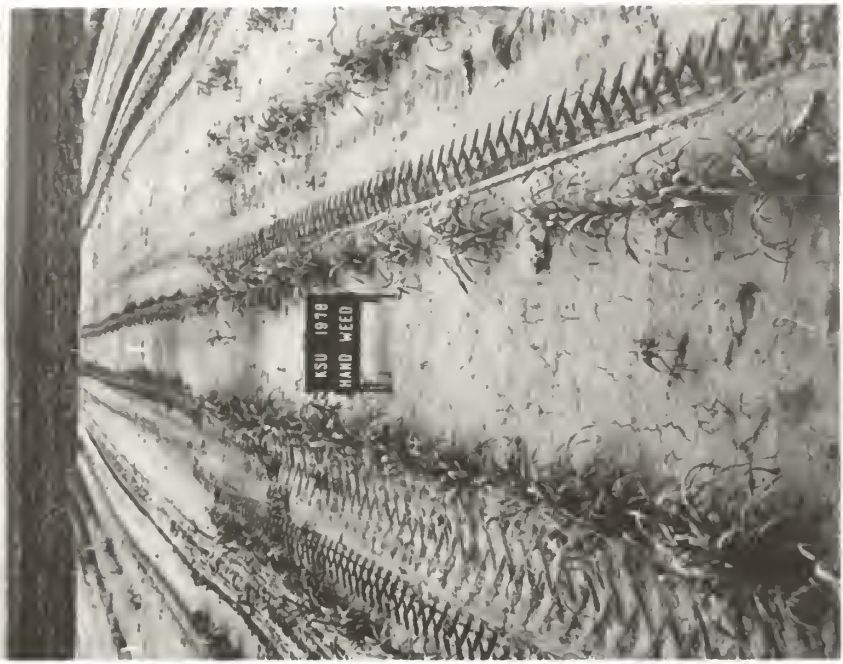
The plate shows a hand weeded treatment.

EXPLANATION OF PLATE III

Bifenox applied at the rate of 1.4 kg ai/ha was tolerated by millet giving yield comparable to the hand weeded check.

Plate III

Plate IV



EXPLANATION OF PLATE VI

Propachlor plus linuron applied at the rate of 3.36 and 1.12 kg ai/ha prevented germination in millet. The same treatment was well tolerated by sorghum as shown below.

EXPLANATION OF PLATE V

Propachlor plus linuron applied at the rate of 3.36 and 1.12 kg ai/ha was tolerated by sorghum. The same treatment prevented germination in millet as shown in Plate VI.

Plate V

Plate VI

EXPLANATION OF PLATE VIII

Linuron plus propachlor applied at the rate of 1.12 and 3.36 kg ai/ha two weeks before millet was planted did not affect millet emergence and vigor in 1977. The same treatment prevented millet germination in 1978 when millet was planted the same day as the treatment was applied.

EXPLANATION OF PLATE VII

The plate shows a hand weeded treatment.

Plate VIII

Plate VII

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APPENDIX

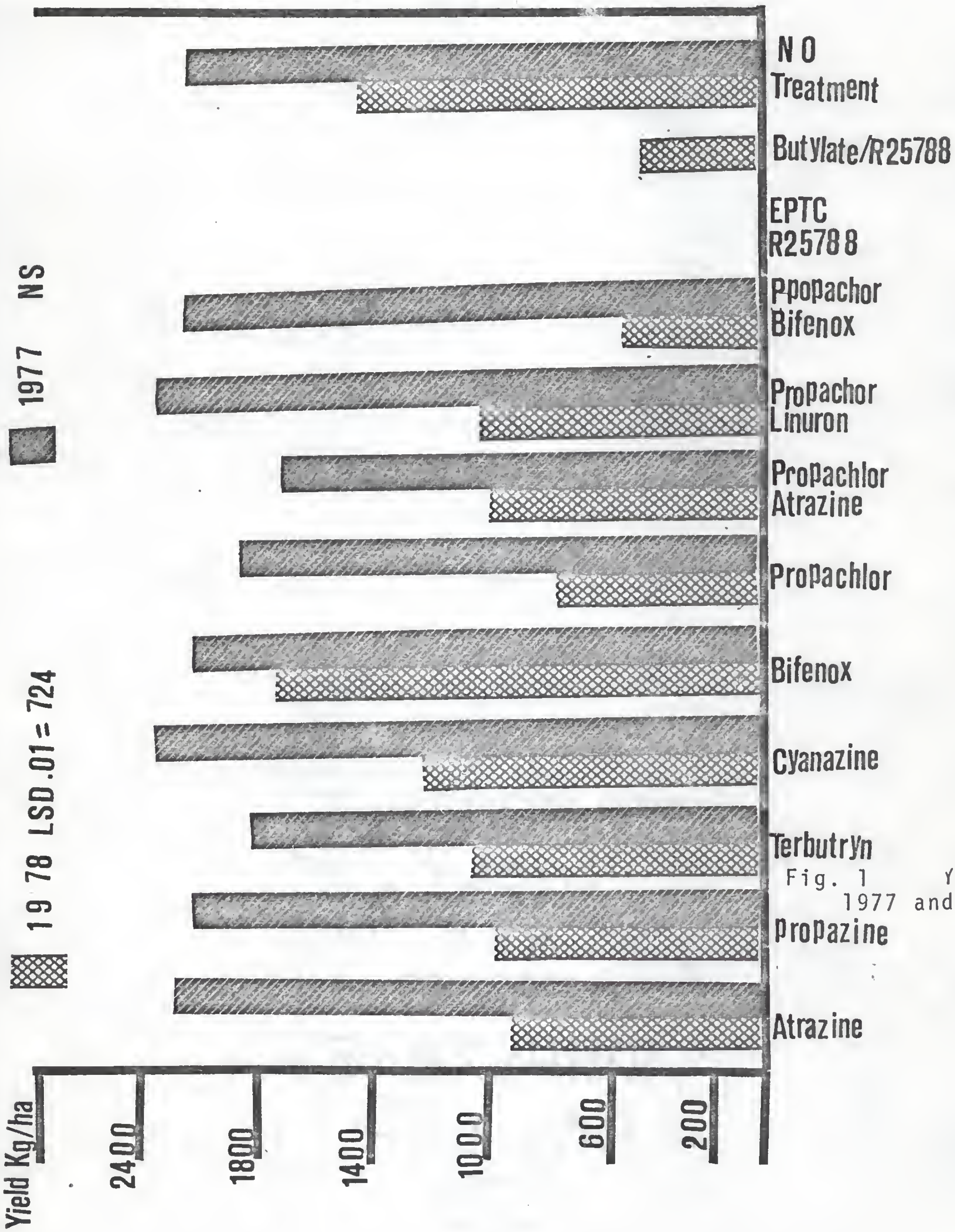

Fig. 1 Yield 1977 and 1978

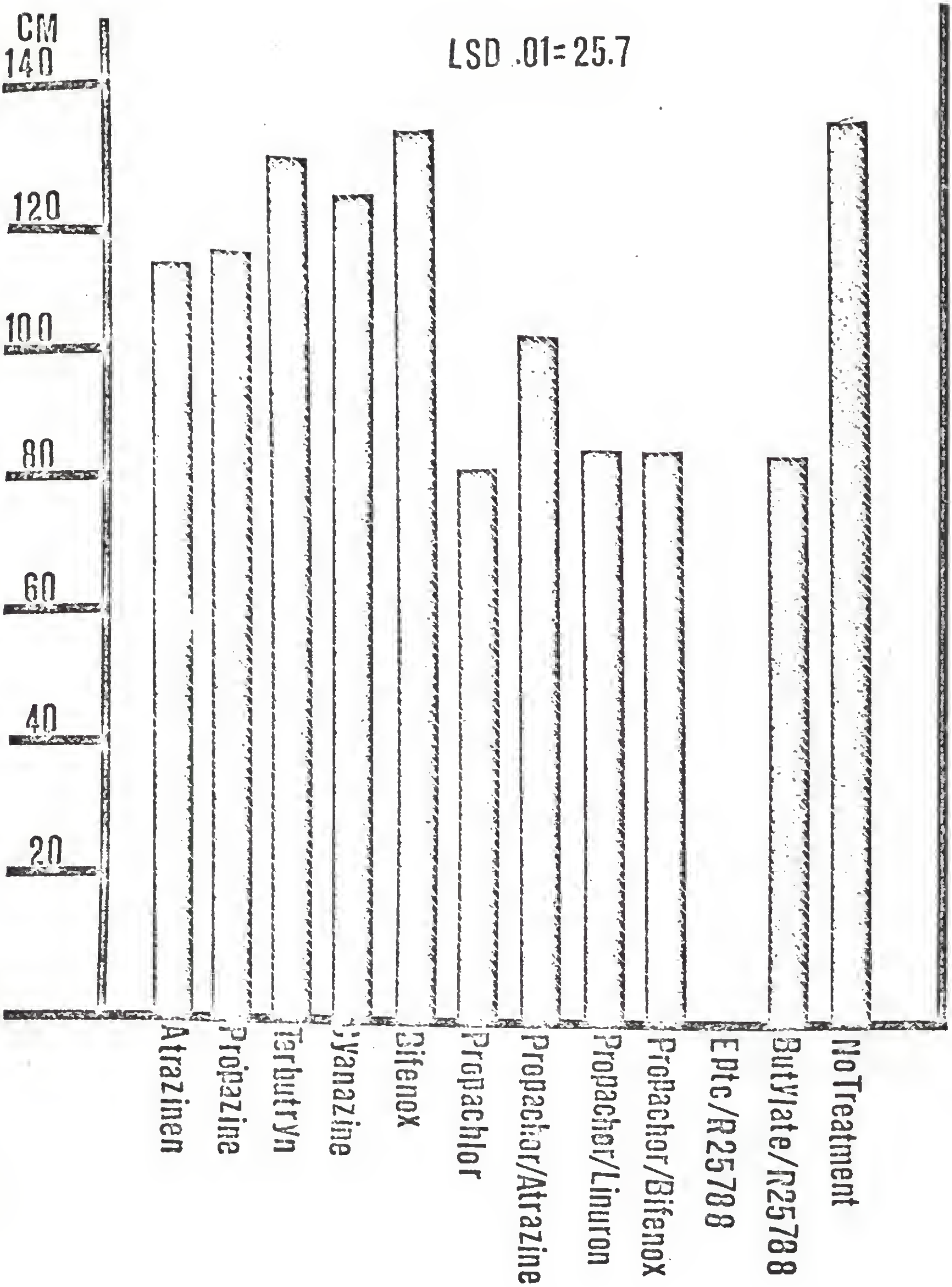

Fig. 2. Plant height in cm. 78 days after planting.

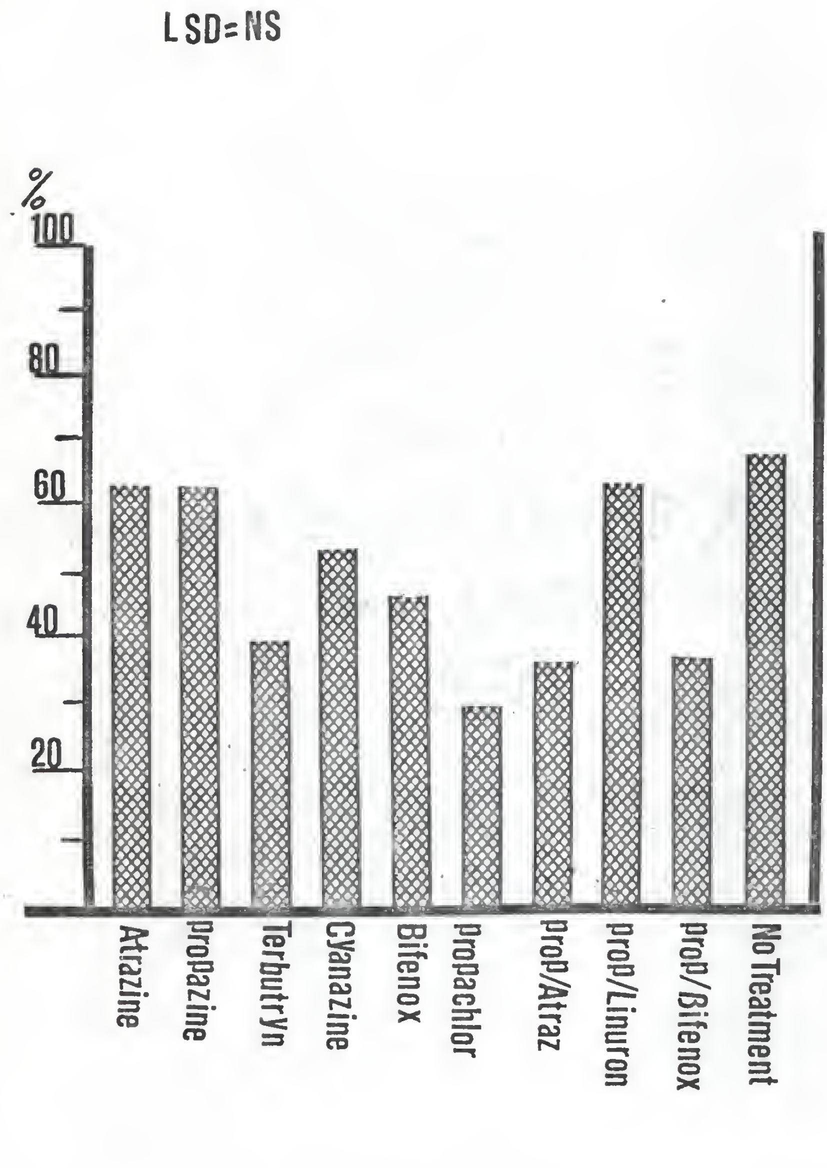

Fig. 3. Percent flowering 52 days after planting 1977.

Analysis of variance for Manhattan, 1978

Source	df	Mean Square		
		emergence score	July injury score	August injury score
Rep.	2	.19444	0.08333	6.02778
Trmt.	11	54.226*	51.75*	18.573*
Error	22	0.1614	0.386	1.633

*Significant at the .05 level.

Analysis of variance for Manhattan, 1978

Source	df	Percent Maturity	Plant height	Yield
Rep.	2	279.8611	225.6944	147042.9
Trmt.	11	855.8*	4205.239*	623345.6*
Error	22	36.67929	230.2399	182835.1

*Significant at the .05 level.

Analyses of variance for Manhattan, 1977.

Source	df	Mean Square Yield	mature head/ha	% Flowering	emergence score
Rep.	2	26488.0	1562	390.0	.0333
Trmt.	9	76279.1	1924	562.9	1.0222
Error	18	35643.6	2103	352.9	0.833

Anaylsis of variance for Minneola, 1977

Source	df	Percent lodged	Yield	Number of head/sample
Rep.	2	36.7	-----	41.2
Trmt.	9	5.4	-----	104.7
Error	18	15.1	29098	123.2

FIELD OPERATION AND DATES

1977

Date	Operation
14th June	Millet planted
14th June	Herbicides applied
20th June	Millet emerged
28th June	Millet replanted
4th July	Second planting emerged
5th July	Surrounding area sprayed against chinch bugs
18th July	Plants sprayed against chinch bugs
10th October	Millet harvested

1978

Date	Operation
5th June	Herbicide applied and incorporated
5th June	Millet planted
11th June	Millet emerged
23rd June	All plots sprayed for chinch bugs
27th June	Five plots in each replication were replanted
1st July	Millet in replanted plots emerged
28th September	Millet harvested

EFFECTS OF HERBICIDES TOLERATED AND NOT TOLERATED BY SORGHUM (*SORGHUM BICOLOR*) ON PEARL MILLET (*PENNISETUM AMERICANUM*)

by

WILLIAM BATA NDAHI

BSC. Ahmadu Bello University, Nigeria, 1973

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1979

Tolerance of pearl millet (Pennisetum americanum (L) K. Schum) to selected herbicides was evaluated at two locations in Kansas in 1977 and at one location in 1978. There was no significant differences among treatments at both locations in 1977. Tolerance of pearl millet to herbicides was difficult to assest due to chinch bug (Blissus leucopterus) infestations at Manhattan and drought at Minneola.

Pearl millet in 1978 exhibited excellent tolerance to bifenox [Methyls-(2,4-dichlorophenoxy)-2-nitrobenzoate], terbutryn [2-tert-butylamino)-4-(ethylamino)-6-(methylthio)-s-triazine], atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine], propazine [2-chloro-4,6-bis(isopropylamino)-s-triazine], and cyanazine [2-L[4-chloro-6-ethylamino)-s-triazine-2-yl]amino]-2-methylpropionitrile]. Propachlor [2-chloro-N-isopropylacetanilide] alone or in combination with atrazine, bifenox and linuron [3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea] prior to planting prevented emergence. Pearl millet however did emerge when the plots were replanted 22 days after treatments were applied.

Butylate [5-ethyl diisobutylthiocarbamate] plus R25788 [N,N-diallyl-2,2-dichloroacetamide] allowed millet to emerge when planted immediately after treatments, but seedlings became twisted and yield was severely reduced. EPTC [S-ethyl dipropylthiocarbamate] plus R25788 prevented emergence even when planting occured three weeks after application.