Pakistan J. Sci. Ind. Res., Vol. 30, No. 12, December 1987

FIELD EVALUATION OF DIFFERENT WEEDICIDES AGAINST WEEDS OF WHEAT CROP

Mahar Sujawal Khan and Muhammad Iqbal Makhdum*

Adaptive Research Farm, Sargodha

(Received October 21, 1986; revised November 22, 1987)

Field investigations were carried out to study cultural and herbicidal effects on weed control in wheat crop under irrigated conditions. The results showed that Chlortoluron, Isoproturon, Methabenzthiazuron, Bromoxynil + MCPA and Metaxuron (post-emergence herbicides) significantly decreased the weed population of *Chenopodium album, Melilotus alba, Anagallis arvensis, Cronopus didymus* and *Phalaris minor.* Benzoylpropyl ethyl was least effective in controlling *Melilotus alba* and *Phalaris minor.* The weed plots yielded 16% more than the weed control plots. This compares with yield increase of 35% from Methabenzthiazuron and 21% from Isoproturon.

Key words: Wheat, Weed control, Herbicides, Weeding losses, Economic return, Pakistan.

INTRODUCTION

The national average yield of wheat at 1510 kg per hectare in Pakistan is still lower in the world [1]. One of the major contributing factors for this low yield is the increasing weed population in the wheat crop[2]. Therefore, weed control is a pre-requisite for making agriculture a profitable business.

A varieties of broad and narrow leaved weeds infest wheat fields, which an average lowered the yields by 10-25% [3, 4, 5, 6]. In very weedy fields, the yield reduction may be as high as 67-69% [7, 8]. The chemical weed control in wheat gave significant increase (30-90%) in grain yield and its components over no weeding [9, 10, 11, 12, 13, 14, 15] and in less weedy fields, manual or chemical weeding did not enhance the yield significantly. The application of post-emergence herbicides, viz Chlorotoluron, 2-Methyl-4-Chlorophenoxy acetic acid, Bromoxynil + MCPA, Isoproturon, Metoxuron and Methabenzthiazuron effectively eradicated most of rabi weeds within 6-7 days after application and increased the yield from 23 to 37% over check [5, 17, 18, 19, 20, 21]. Chaudhry and Aslam [22] observed that the application of Simazine @ 0.56 kg a.i/ha all nitrogen levels, decreased the weed population and caused a significant increase in 1,000 grain weight and grain yield.

The present study is aimed at evaluating the effectiveness of promising herbicides to control rabi weeds in wheat crop under irrigated conditions.

*Central Cotton Research Institute, Multan.

MATERIALS AND METHODS

Field investigations were carried out at the adaptive Research Farm, Vehari, during the rabi seasons 1982-83 and 1983-84 to assess the effectiveness of eight post-emergence herbicides (Table 1) compared with manual weeding. The herbisilt loam of the Rustam series (Typic ustifluvents) with pH 8.4 and 0.73% organic matter (Table 2). The particle size distribution was determined by the hydrometer method [23] and textural class according to USDA system. The soil series has been described by Akram [24] and soil units have been classified by Schroeder [25]. Other chemical determinations were done according to methods described by Black [26]. All herbicides (Table 4 and 6) were sprayed on the experimental crop at the 4-6 leaf stage (1-2 tillers) of wheat after first irrigation when the field was still sufficiently wet. The herbicides were applied with a hand pumped sprayer CP-3 Knapsack sprayer with a boom of 1.5 m in height fitted with T-jet nozzles adjusted at a distance of 30 cm for uniform spray. The sprayer was operated at 4 km/hr and 275K Pa pressure to deliver 400 litres water per hectare.

The experiment was laid out in randomized complete block design and replicated thrice [27] in a 6 m x 9 m plot size. In the hand weeding treatment, the weeds were removed by hoeing at 30 and 50 days after sowing with a supplimental hand-weeding. A check plot was left unweeded. The experimental fields were sown on December 24 each year. The wheat cultivar Punjab-81 was grown under recommended management The weeds under study were naturally occurring and were not seeded. The data on weed prevalence (Table 3) were recorded prior to three

Table 1. The common and chemical names of herbicides studied in the experiments, 1982-84.

Common name	Chemical name	Brand (S) registered & dose used	Holders of registration certificate
Chlortoluron	N'(3-Chloro-4-methyl- N' N-dimethylurea	Dicuran NA-60 (2.5 kg/ha)	Ciba Geigy (Pak) Ltd.
Isoproturon	N'4(4-isopropylphenyl)-N' N-dimethyl urea	Arelon 75 WP (2.5 kg/ha Tolkan 75 WP 2.0 kg/ha)	Hoechest (Pak) Ltd.
Methabenzthiazuron	N-(2-Benzothiazoyl N-methyl-N' methyl urea	Tribunil 70 WP 2.0 kg/ha	Bapco Ltd.
Dicamba	3,6-dichloro-0-anisic acid	Banvel 40.6 EC (1.0 l/ha)	Velsicol Chemical Corp
Benzoylpropethyl	Ethyl(4')-2-2-(3,4-dichlorophenyl) benzamido propionate	Suffix 25 EX (3.5 l/ha)	Shell International Co
Metoxuron	N'-(3,Chloro-4-methoxyphenyl)-N,N-dimethyl urea	Dosanex 80 WP (1.75 kg/ha)	Sandox (Pak) Ltd.
Bromoxynil + MCPA	3,5-dibromo-4-hydroxy-benzonitrite	Buctril-M 40 EC (1.25 l/ha)	ICI (Pak) Ltd.

Table 2. Physico-chemical characteristics of the investigated site, 0-30 cm depth (average of two years).

1. pH	8.4
2. ECeX 10^3	2.3
3. Organic matter %	0.73
4. Available NO_3-N(ppm)	10.00
5. Available-P(ppm)	8.90
6. Available-K(ppm)	225.00
7. Textural class	Silt loam
8. Soil series	Rustam
9. FAO Soil Units	Clacaric Fluvisols
10. USDA comprehensive soil classification system, 7th approximation (sub-group)	Typic Ustic-fluvents
11. Field capacity (%)	27.6
12. Wilting points (%) (15 atm)	5.6
13. Available water (m^3)	427
14. Bulk density (g/m^3)	1.49
15. Pore space (%)	43.9

Table 3. Important weeds studied in the experimental fields, 1982-84.

Family	Botanical name	Vernacular name
A. **Broad-leaved**		
Papilionaceae	*Melilotus alba* L.	Saniji
	Vicia Sativa L	Revori
	Medicagodenticalata W.	Maina
Primulaceae	*Anagallis arvensis* L.	Billi booti
Brassicaceae	*Cronopus didymus* L.	Jangli haloon
Chenopodiaceae	*Chenopodium album* L.	Bathu
Fumariaceae	*Fumaria indica* W.	Shahtra
Polygonaceae	*Rumex acutus* L.	Jangli palak
Convolvulaceae	*Convolulus arvensis* L.	Lehli
B. **Narrow leaved**		
Poaceae	*Phalaris minor* Retz	Dumbi-grass
	Avena fatua L.	Jai

and six weeks after the spray of herbicides and near to harvest of the crop by the counting the weeds from two randomly selected $1m^2$ areas in each treatment. The weeds were harvested near the soil surface, bagged separately and were oven dried at 90^o for 24 hr till at constant weight. The biomass production was determined on gram per square meter area.

The wheat harvesting was done from three randomly selected $1m^2$ spot in each treatment. Three samples of wheat were pooled and threshed manually. The yield data were averaged and analyzed statistically [28]. The economic analysis of data was done using the partial budget method. The cost benefit ratios were calculated by dividing the extra benefits attained from the enhanced yield the extra costs incurred for each treatment. The cost included labour charges @ Rs. 20/- per man day (24.7 mandays for two hoeings and a hand weeding/ha), herbicide price = Chlorotoluron (Dicuron MA-60 WP) Isoproturon (Arelon 75 WP) (Tolkan 75 WP), Methabenzthiazuron (Tribunil 70 WP) Metoxuron (Dosanex 80 WP), Benzoylpropethyl (Suffix 25 EC), Dicamba (Banvel 40.6 EC), Bromoxynil + MCPA (Buctril-N 40 EC) @ Rs. 149/-, 150, 148/-, 212/- 150/kg and 139, 134 and 147 per litre, respectively, labour for herbicide applications (Rs. 37 per hectare) and extra charges for the threshing of additional yield (Rs. 7.50/40 kg) of wheat.

RESULTS AND DISCUSSION

The common weeds found in both years were mostly broad-leaved weeds and grasses (Table 4) and grouped after Steel, *et al.*, [28] and Holm [29]

The statistically analyzed data in Table 4 indicate that Chlortoluron, Isoproturon and Methabenzthiazuron proved effective in controlling annual broad leaved weeds and grasses (*C. album, M. alba, A. arvensis, C. didymus* and *P. minor*). The herbicides offered above 97% control (Table 5) of all weeds (broad-leaved and grasses) with Chlortoluron, Isoproturon, and Methabenzthiazuron. The effective weed control by 95% with these chemicals was also noted by previous workers [11, 12, 8, 7, 13]. Dicamba and Benzoylpropethyl was least effective against *M. alba, A. arvensis* and *P. minor* and offered 46% weed control over check. Chlortoluron suppressed *C. arvensis,* but did not kill it. No herbicide gave effective control of *Convolvulus* spp. Hand weeding was also an effective means of weeding and proved 74% weed control over unweeding. Hand weeding (generally 2 hoeings and one hand weeding) found better with at least commercial herbicides [14, 16, 13]. However, Gill and Brar [11] and Gill, *et al.*, [7] have begated the above conclusions.

The wheat grain yield differed significantly due to herbicidal and cultural treatment (Table 4). Maximum

Table 4. Comparison of hand weeding and six herbicides on weed count before and after spraying and wheat grain yield 1982-83.

Herbicides treatments	Dose a.i./ha	*C. album*		*M. alba*		*A. arvensis*		*C. didymus*		*P. Minor*		Other		Grain yield (kg/ha)
		Pre-spray	Post-spray	Pre-spray	Post-spray	Pre-spray	Post-spray	Pre-spray	Post-spray	Pre-spray	Post-spray	Pre-spray	Post-spray	
Chlortoluron	1.50	29	0	28	16	17	3	6	2	30	13	12	4	4977 bc.
Isoproturon (Arelon)	1.88	8	0	22	2	6	2	1	0	28	6	6	0	5013 b.
Methabenzthiazuron	1.40	22	1	27	11	16	0	2	0	33	3	6	2	5624 a.
Dicamba	0.41	36	19	48	1	23	13	9	3	26	26	12	10	3913 dc.
Benzoylprop (ethyl))	0.88	59	31	66	66	28	32	11	8	31	31	21	13	3627 c.
Isoproturon (Tolkan)	1.00	34	0	30	3	13	0	9	1	25	1	12	1	5054 b.
Two hoeings	–	19	12	33	4	22	7	9	4	28	7	0	2	4809 c.
Unweeded (check)	–	72	68	79	93	83	86	33	36	32	32	7	9	4157 d.
Stat. Sig.	–	H.S.	H.S.	N.S.	H.S.	N.S.	H.S.	H.S.	H.S.	N.S.	H.S.	H.S.	H.S.	
LSD(P=0.05)	–	3.85	2.45	–	2.39	–	3.59	1.84	1.70	–	2.43	1.95	1.02	
C.V. %	–	2.50	9.94	5.8	6.64	5.9	13.46	12.54	16.50	4.7	11.10	13.74	13.31	

Table 5. Effect of six herbicides on weed biomass at various times after treatment 1982-83.

Herbicides treatments	Dose a.i./ha	Weeds before application	2 weeks after application		6 weeks after application		Near to harvest		Weeds control over check (%)
			Treated	Untreated	Treated	Untreated	Treated	Untreated	
Unweeded	Check	51.00	54.00	–	53.00	–	52.3	–	–
Chlortoluron	1.50	53,7	1.3	16.3	1.3	16.3	1.2	16.3	98
Isoproturon	1.88	44.2	1.7	16.0	1.5	16.1	1.3	16.2	97
Methabenzthiazuron	1.40	49.3	1.2	16.3	1.3	16.2	1.0	16.3	98
Dicamba	0.41	42.3	12.0	11.9	12.3	11.8	12.0	11.9	77
Benzoylpropethyl	0.88	36.0	32.2	2.7	30.0	2.8	28.2	3.6	46
Isoproturon	1.00	37.2	1.0	16.0	1.0	16.2	0.8	16.3	98
Two hoeings	–	51.8	14.3	12.1	14.7	12.0	13.8	12.2	74
Stat Sig.	–	H.S.	H.S.	H.S.	H.S.	H.S.	H.S.	H.S.	
LSD(P=0.05)	–	2.17	2.54	1.55	2.19	1.26	2.13	2.59	
C.V. %	–	3.23	11.91	9.00	10.32	7.49	10.46	15.02	

grain yield of 5624 kg/ha was achieved by the application of Methabenzthiazuron followed by 5054,4977 and 4809 kg grain yield/ha given by Isoproturon, Chloroturon and manual weeding respectively. The herbicides Arelon 75 WP and Tolkan 75 WP belonging to Isoproturon group produced significantly lower yields compared to others, as these herbicides proved little effective against controlling broad-leaved weeds and grasses (Table 4). These results substantial to earlier findings [10, 11, 14, 9, 16, 7, 20, 17, 15, 21].

The statistically analyzed data in (Table 6) indicates that Methabenzthiazuron, Isoproturon, chlortuluron and metozuron enhanced grain yield significantly by producing 4992,4594,4535 and 4478 kg/ha respectively compared to 3695 kg/ha in check treatment. The increase in yield was attributed due to significant reduction in weed population and biomass reduction (Table 7) The results confirm earlier findings [18, 20, 31, 32].

Methabenzthiazuron (Tribunil 70 WP) produced maximum grain yield during both seasons, which proved

Table 6. Comparison of hand weeding and six herbicides on seed count before and after spraying and wheat grain yield 1983-84.

Plant count (No./m^2)

Herbicides treatments	Dose a.i./ha	*C. album*		*M. alba*		*A. arvensis*		*C. didymus*		*P. Minor*		Other		Grain yield (kg/ha)
		Pre-spray	Post-spray	Pre-spray	Post-spray	Pre-spray	Post-spray	Pre-spray	Post-spray	Pre-spray	Post-spray	Pre-spray	Post-spray	
Chlortoluron	1.50	62	5	9	–	10	1	17	1	40	13	16	5	4535 bc.
Isoproturon	1.88	81	6	5	1	9	3	13	3	29	6	14	7	4594 b.
Methabenzthiazuron	1.40	69	7	6	1	10	4	28	–	44	4	8	0	4992 a.
Dicamba	0.41	67	11	6	1	4	2	18	–	33	31	8	3	3453 d.
Metoxuron	1.40	88	22	4	4	6	1	18	2	14	1	25	5	4478 b.
Bromoxynil + MCPA	0.50	89	14	8	6	3	1	20	4	20	15	15	1	3972 d.
Two hoeings	–	83	39	6	3	4	–	14	4	39	6	10	3	4350 a.
Unweeded (Check)	–	82	84	4	4	5	5	7	8	25	25	9	10	3695 a.
Stat. Sig.	–	N.S.	H.S.	H.S.	H.S.	H.S.	H.S.	H.S.	H.S.	H.S.	H.S.	H.S.	H.S.	
LSD(P=0.05)	–	–	2.41	0.91	1.06	1.67	0.72	1.80	1.00	0.70	1.77	2.71	1.16	
C.V. %	–	7.91	6.96	10.29	27.57	17.79	11.69	7.29	22.71	1.56	9.46	14.03	15.74	

Table 7. Effect of six herbicides on weed biomass at various times after treatment 1983-84.

Weed biomass (g/m^2)

Herbicides treatments	Dose a.i./ha	Weeds before application	2 weeks after application		6 weeks after application		Near to harvest		Weeds control over check (%)
			Treated	Untreated	Treated	Untreated	Treated	Untreated	
Unweeded	Check	16.5	16.8	–	16.1	–	16.0	–	–
Chlortoluron	1.50	19.3	3.1	10.9	3.1	10.9	2.9	11.0	82
Isoproturon	1.88	18.9	3.3	10.4	3.1	10.4	3.0	10.5	81
Methabenzthiazuron	1.40	20.6	2.0	11.3	2.0	11.3	1.9	11.4	88
Dicamba	0.41	17.0	6.0	8.1	6.1	8.0	6.0	8.1	62
Metoxuron	1.40	19.4	4.4	9.7	4.4	9.7	4.3	9.8	73
Bromoxynil + MCPA	0.50	19.4	5.1	9.2	5.4	9.0	5.1	9.2	68
Two hoeings	–	19.0	6.9	8.1	7.3	7.9	6.5	8.3	58
Stat Sig.	–	H.S.	H.S.	H.S.	H.S.	H.S.	H.S.	H.S.	
LSD(P=0.05)	–	3.53	1.31	1.86	0.84	1.58	1.12	0.85	
C.V. %	–	12.74	14.82	5.51	9.58	12.61	13.37	6.67	

Table 8. Economic analysis of weeding by cultural and herbicidal application.

Herbicides	Grain yield (kg/ha)	Increase/decrease in yield over control (kg/ha)	Benefits (Rs./ha)	Variable cost (Rs./ha)	Benefit cost ratio
Check	3926	–	–	–	–
Chlortoluron	4756	830	1660	566	2.90:1
Isoproturon	4929	1030	2006	600	3.30:1
Methabenzthiazuron	5308	1382	2764	720	3.80:1
Dicamba	3683	243(–)	–	171	–
Metoxuron	4478	552	1104	628	1.75:1
Bromoxynil + MCPA	3972	46	98	305	–
Hand weeding	4580	654	1308	344	3.80:1

*Averaged over two years, and grouped together according to their common name (Arelon 75 WP and Tolkan 75 WP).

effective in controlling weeds. Jalis *et al.*, [19], Jalis and Muhammad [15] and Rizk *et al.*, [33] observed that enhancement in grain yield was mainly attributable to the removal of weeds which compete with the crop plants for nutrients moisture, light and space.

The economic analysis of herbicidal use show that all weeding treatments were economical (Table 8). In this case, by spending one rupee on weeding with Methabenzthiazuron, Chlortoluron, Isoproturon and hand weeding, one can get Rs. 3.80, 3.30 and 3.80 respectively as returns. Bhardwaj [16] also found similar economic returns among different herbicides and hand weeding.

The cost benefit ratio due to hand weeding was similar to chemical methods. The choice for weed control of the farmer would further depend on the availability of equipment, labour, herbicides and knowledge to apply the chemicals properly. Because of the morphological similarly of grassy weeds with wheat plants, the manual method of control has not been very effective in reducing the infestations of such weeds. In such circumstances chemical weedicides can effectively, economically and safely be used in wheat. This conclusion in supported by the findings of Tosh and Misra [14].

REFERENCES

1. Anonymous, "Pakistan Statistical Year Book", Fed. Bur. Statistics, Statistics Div., Government of Pakistan, p. 120 (1985).
2. M.Y. Chaudhry, The weeds a constraint to productivity, progr. Farming, **7**, (1): 6-9 (1987).
3. H.H. Crammer, Plant Protection and World Crop Production, Pflanzenchutz Nechrichten "Bayer" **20**: 524 (1967).
4. Anonymous, Smaller farm land can yield more, Agr. Handbook, F.A.O. Rome, p. 31 (1969).
5. H.S. Gill and U.S. Walia, Herbicides control of *Phalaris minor* Retz in wheat *(Triticum aestivum)*, Proc. 7th Asian Pacific Weed Sci. Soc. Conf. Suppl., **30**: 59-62 (1979).
6. H.M. Hepworth, *Pakistan's weed problem,* Proc. National Sem. on Wheat Res. Prod., PARC, Islamabad, Pakistan. (1979).
7. H.S. Gill, U.S. Walia and L.S. Brar, Control of *Phalaris minor* and wild oats in what with new herbicides, Punjab Agr. Univ. Ludhiana (1979).
8. A. Misra and G.C. Tosh, Chemical weed control studies on dwarf wheat, 17th All India Wheat Res. Workers' Workshop, Hyderabad, (1978).
9. V.M. Bhan, K.C. Sharma, P.S. Negi and D.S. Anad, Effect of weed control treatment on grain yield of wheat, Univ. Agr. and Tech. Pantnagar, 17th All India Wheat Res. Workers' Workshop, Hybderabad, pp. 1-3 (1978).
10. H.S. Gill and L.S. Brar, Menance of *Phalaris minor* and wild oats in wheat and their control, ICAR, 15th All India Wheat Workshop, Kalyani (West Bengal), **II** (2): 1-10 (1975).
11. H.S. Gill and L.S. Brar, Chemical Control of *Phalaris minor* and *Avena ludoviciana* in wheat , PANS **23** (3): 293-296 (1977).
12. H.S. Gill and U.S. Walia, Some board spectrum weedicides and the efficacy, of weed control in wheat, 17th All India Wheat Res. Workers' Workshop, Hyderabad, pp. 1-11 (1978).
13. A. Majeed, M.R. Hussain and M.A. Akhtar, Studies on chemical weed control in wheat, J. Agr. Res., **21** (4): 167-171 (1983).
14. G.C. Tosh and M. Misra, Studies on the effect of herbicides on weed control and yield of wheat in irrigated conditions, Pesticides **11** (7): 31-35 (1977).
15. A. Jalis and G. Muhammad, Post-emergence weedicidal trial on wheat, Ann. Abridged Res. Rep. Plant Physiol. Sect., Ayub Agr. Res. Inst., Faisalabad, pp. 15-16

(1980).
16. R.B.L. Bhardwaj, Chemical control of grass weeds in wheat, All India Co-ord. Wheat Project, Indian Counc. Agr. Res. Rep. Co-ord. Experiments on wheat agronomy, 1977-78 (1978).
17. M.C. Phillips, Timing of weed control in winter cereals, Arabic Farming, **6** (10): 61-63 (1978).
18. M.A. Hamid, Weedicide trials against weeds in wheat, Ann. Res. Rep. Univ. Agr., Faisalabad, pp. 24 (1977).
19. A. Jalis, M.L. Shah and M. Ramzan, Post-emergence weedicidal trial on wheat, Ann. Rep. Plant Physiology Section, Ayub Agr. Res. Inst., Faisalabad, pp. 44-45 (1977).
20. L.A. Boyall, G.H. Ingram and D.J. William, Isoproturon, a selective herbicide for post-emergence grass weed control in Australia and Indian cereal crops, Proc. 17th Asian Pacific Weed Sci. Soc. Conf., pp. 55-58 (1979).
21. N.N. Angirass and S.C. Modgal, Control of grassy weeds in wheat (*Triticum aestivum*) through promising herbicides under hill conditions, Proc. 8th Asian-Pacific Weed Sci. Soc. Conf., pp. 45-49 (1981).
22. M.A. Chaudhry and M.Aslam, Response of wheat to simazine herbicide on various levels of nitrogen, Pakistan J. Agr. Sci., **9** (1-4): 62-65 (1972).
23. C.D. Moodie, H.E. Smith and R.A. McCreery, "Laboratory Manual for Soil Fertility", State College of Washington, Pullman, Washington, Mimeograph, pp. 13-39 (1959).
24. M. Akram, Reconnaisance soils survey of Multan North, Directorate of Soil Survey of Pakistan, Lahore, pp. 130, 210 (1969).
25. D. Schroeder, "Soils-Facts and Concepts", International Polash Institute, Berne, Switzerland (1984).
26. C.A. Black, "Methods of Soil Analysis, Part II, Chemical and Mineorological Properties", Agronomy Series 9, Ann. Soc. Agron. Inc., Madison, Wisconsin, USA (1965).
27. K.A. Gomez and A.A. Gomez, "Statistical Procedures for Agricultural Research", 2nd ed.. p. 574, John Wiley & Sons, New York, USA (1984).
28. R.G.D. Steel and J.H. Torrie, "Principles and Procedures of Statistics, 2nd ed., McGraw Hill Book Company Inc., New York (1980).
29. L. Holm, J.V. Bancho, J.P. Herberger and D.L. Plucknett, "A Geographical Atlas of World Weeds, John Wiley & Sons, New York, pp. 1-391 (1979).
30. S. Behrendt and M. Hanf, "Grass Weeds in World Agriculture", BASF Aktiengesallschaft, D-6700 Ludwigshafen BRD (1979).
31. J. Asghar and M.L. Shah, Effect of different herbicides on the yield of wheat, Abridged Report of Plant Physiology Sec. Punjab Agr. Res. Inst., Faisalabad, pp. 25-26 (1982).
32. J. Pandey, Chemical control of *Phalaris minor* Retz in timely and late sown wheat in sandy loam calcareous soils of North Bihar Pesticides, **15** (11): 20-21 (1981).
33. T.V. Rizk, M.T. Fayal, and E.F. Hussain, A comparative study on the use of some new herbicides in seeded rice, Mesopotamua J. Agr., **14** (1): 109-119 (1979).