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COTTON YIELD AND WEED DENSITY AND DIVERSITY IN RESPONSE TO PRE-EMERGENCE APPLICATION OF HERBICIDES IN COTTON FIELD

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Abstract

Weed density and diversity were measured at various periods of the growth of a cotton crop following pre-emergence application of 2 and 4 kg/ha prometryne and fluometuron. Application of 2 kg/ha prometryne resulted in decreased weed density but relatively higher weed species diversity and a significant improvement in cotton yield; however, application of prometryne at 4 kg/ha gave contrasting results. Fluometuron, despite reducing weed density and elevating weed diversity did not increase the crop yield over the controls presumably due to slower rate of dissipation and consequently higher residual activity in the cotton field.

Introduction

Weeds prevailing in cotton fields not only deteriorate the quality of cotton bolls but the reduction in yield may reach as high as 45 to 80 percent (Singh & Katti, 1970). In Pakistan the loss of cotton yield due to weeds is estimated to be about 8 per cent (Cramer, 1967). During the last 15 years, several selective herbicides have been available for weed control in cotton of which prometryne and fluometuron have generally given promising results in many parts of the world (Almieda, 1969a, b; Kafi *et al*, 1970; Singh & Katti, 1972). Odum (1971) pointed out that the effects of commonly used herbicides on ecosystem are scarcely understood. He conjectured that in the process of modifying community composition and structure (such as that of weed community) they indirectly affect other trophic levels. The population balance of phytophagus insects inhabiting crop fields may be particularly distrubed by herbicidal application to the disadvantage of the crop. Consequently the influence of herbicides on the diversity in addition to weed density is expected to play a key-role in determining the crop yield.

In view of these considerations, a study was undertaken to analyse the weed desntiy and diversity in relation to crop yield of cotton following the application of prometryne and fluometuron.

Materials and Methods

The trial was conducted during 15th June to 16th December, 1974 at a field situated in Karachi University Campus. The soil was sandy clay loam pH 8.1, maximum water holding capacity 44.3%, $CaCO_3$ 17.98% and total organic matter content of 2.4%. A 5 x 5 Latin square design was used, each plot being 2.25 m^2. The field was sown with delinted, chemically scarified seeds of *Gossypium hirsutum* L. var. BS1 (Bhatti, 1974). Nine evenly spaced plants were maintained in each plot. One day after sowing, prometryne and fluometuron (provided by Ciba-Geigy, Switzerland) were sprayed at a rate of 2 and 4 kg/ha on the respective plots with an air compressor type sprayer. Control plots received tap water. Weed composition and density was recorded 1, 2, 3 and 5 months after sowing. Complete picking of cotton (commercial cotton as well as prematurely abscised bolls) was carried out six months after sowing.

Weed species diversity, richness, equitability and dominance were measured for each treatment and controls. The diversity index used was the Shannon-Weaver information function (Shannon & Weaver, 1963). Equitability, being a measure of the allocation of individuals among species, was calculated following Pielou (1969). The species richness was calculated following Margalef (1958) while dominance was ascertained by the index proposed by Simpson (1949).

Results

a) *Effect of herbicide application on weed composition and density:*

Effect of herbicides on weed density at various time intervals appears in Table 1. Both prometryne and fluometuron used as pre-emergence herbicides gave a good weed control at both the rates of application (viz. 2 and 4 kg/ha). In general, dicot weeds were more susceptible to the herbicides than were moncots

Prometryne at both the doses was successful in controlling *Euphorbia hirta, Cynodon dactylon, Setaria verticillata, Cyperus bulbosus, Digitaria nodosa, Eragrostis pilosa, Euphorbia prostrata. Solanum surattense, Euphorbia granulata* and *Amaranthus viridis.* Two grass species, *Chloris barbata* and *Dactyloctinium scindicum* were effectively controlled by prometryne only at 4 kg/ha. *Cyperus rotundus* remained uncontrolled by prometryne. Although the density of *C. rotundus* declined with time, from 1 to 5 months, however, the density of *C. rotundus* in prometryne treated plots remained at a higher level in comparison to control plots.

Table 1. Effect of prometryne and flumeturon application on weed composition at various time interval after herbicide application.

	Species	Weed density (no. of individuals/m^2) Control	Prometryne 2 kg/ha	Prometryne 4 kg/ha	Fluometuron 2 kg/ha	Fluometuron 4 kg/ha
1	Months after sowing					
	Cyperus rotundus	52.00	89.95	121.06	125.33	29.77
	Euphorbia hirta	16.62	3.55	1.51	2.93	8.97
	Cynodon dactylon	4 62	2.31	2.40	1.86	8.62
	Setaria verticillata	6.48	0.17	0.62	1.60	0.88
	Cyperus bulbosus	3.11	1.24	0.35	1.68	6.57
	Digitaria nodosa	3.64	1.68	–	–	1.24
	Eragrostis pilosa	3.11	0.08	–	–	–
	Euphorbia prostrata	2.57	3.73	0.44	1.15	0.17
	Dactyloctinium scindicum	2.40	0.44	0.08	0.08	0.44
	Echinocloa colonum	2.40	0.26	–	–	–
	Solanum surattense	2.75	0.17	–	0.53	–
	Euphorbia granulata	2.22	0.88	0.53	–	–
	Amarnathus virdis	2.04	0.62	0.53	0.53	0.35
2	Months after sowing					
	Cyperus rotundus	32.26	78.84	91.64	86.93	14.48
	Euphorbia hirta	14.22	8.35	8.00	10.13	6.04
	Cynodon dactylon	6.48	4.08	4.53	4.80	10.13
	Setaria verticillata	3.64	0.53	0.26	1.06	0.35
	Cyperus bulbosus	3.64	0.97	0.26	1.06	3.45
	Digitaria nodosa	2.75	1.77	0.71	0.62	0.08
	Eragrostis pilosa	2.53	0.17	0.08	–	–
	Euphorbia prostrata	2.93	3.11	1.68	2.13	1.86
	Dactuloctinium sicindicum	0.26	0.35	0.08	–	0.17
	Echinocloa colonum	1.42	0.08	–	–	–
	Solanum surattense	1.51	0.97	0.08	0.53	0.08
	Euphorbia granulat	2.40	1.24	0.97	0.26	0.08
	Amaranthus viridis	1.77	0.71	0.53	0.71	0.26
	Chloris barbata	0.97	0.97	0.08	1.42	0.53

3 Months after sowing					
Cyperus rotundus	14.75	59.91	25.71	26.57	12.41
Euphorbia hirta	14.48	10.04	8.97	17.15	8.70
Cynodon dactylon	20.97	17.86	7.20	2.57	27.83
setaria verticillata	1.24	0.26	0.08	0.97	0.62
Cyperus bulbosus	0.71	0.44	0.17	1.24	1.77
Digitaria nodosa	2.57	0.88	0 44	0.26	0.97
Eragrostis pilosa	2.13	0.35	0.17	0.44	–
Euphorbia prostrata	32.80	3.64	2.48	2.04	2.75
Dactyloctinium scindicum	0.26	0.53	–	0.71	0.08
Echinocloa colonum	0.08	–	–	-	–
Solanum surattense	2.13	1.42	0.35	0.80	0.26
Euphorbia granulta	2.13	1.77	0.97	0.26	0.26
Amarnathus viridis	1.60	1.15	0.44	0.26	0.35
Chloris barbata	1.42	1.15	0.35	1.68	0.80
5 Months after sowing					
Cyperus rotundus	12.44	19.64	16.80	16.00	8.62
Euphorbia hirta	24.80	19.11	13.15	18.48	16.80
Cynodon dactylon	74.31	55.91	80.08	72.00	89.06
Setaria verticillata	0.88	0.08	–	0.26	–
Cyperus bulbosus	0.26	0.08	0.08	0.17	0.35
Digitaria nodosa	1.15	0.80	0.62	0.17	0.89
Eragrostis pilosa	0.62	0.08	0.17	0.08	–
Euphorbia prostrata	68.97	34.64	32.71	37.24	12.71
Dactyloctinium scindicum	0.71	0.62	–	0.26	0.08
Solanum surattense	1.77	0.71	1.15	0.44	0.08
Euphorbia granult	1.24	1.42	0.88	0.26	0.80
Amarnathus viridis	2.13	1.86	1.51	1.68	0.62
Chloris barbata	1.33	1.06	0.53	0.88	0.26

The weeds controlled effectively with the application of fluometuron were: *S. verticillata, D. nodosa, E. pilosa, E. prostrata, E. granulata, Echinocloa colonum,* and *S. surattense. E. hirta* was controlled by 4 kg/ha of fluometurn but with a dose of 2 kg/ha it was controlled only for the first two months. Similarly, *C. bulbosus* had lower density in 2 kg/ha fluometuron treatment for the first two months but subsequently its density increased over the controls. *D. scindicum* was controlled by fluometuron at 4 kg/ha but was only controlled initially with a dose of 2 kg/ha. Density of *C. rotundus* was lowered by fluometuron at 4 kg/ha in comparison to controls but at 2 kg/ha density levels remained higher than the controls at all periods of observation. *Cynodon dactylon* was controlled by 2 kg/ha fluometuron but not at 4 kg/ha of the herbicide.

Changes in cumulative density of dicot and monocot weeds and total density with time following herbicide application are given in Table 2. Generally, density of monocot weeds was higher than that of dicots at various time periods, the only exception being control where density of dicot weeds was higher at 3 and 5 months after sowing. In the 2 kg/ha prometryne treatment the density of dicot weeds remained at a substantially lower level than the controls but that of monocots was generally higher. Total density remained similar to that of controls but declined markedly over the controls at 5th month after sowing. A similar trend in exhibited by 4 kg/ha prometryne treatement, but the density level of dicot weeds was lower than that in 2 kg/ha prometryne treatment. The trend of weed desnity in 2 kg/ha fluometuron is similar to that of 4 kg/ha prometryne. Application of fluometruon @ 4 kg/ha generally decreased the monocot as well as dicot weed density at different periods, particularly in the initial period of crop growth.

b) *Effect of herbicide application on weed species diversity:*

Fig. 1 presents a comparison of species richness (variety), evenness (equitability), general diversity and dominance of the weed flora following pre-emergence herbicide application and that of controls during the crop season. Species richness and general diversity of controls remained at a substantially higher level than that of treatments at all sampling periods (fig. la, lc). Dominancea, however, followed an opposite trend and remained lower in the controls compared to the treat ments. General diversity, equitability and richness were remarkably low in prometryne 4 kg/ha and floumeturon 2 kg/ha upto two months after sowing but thereafter increased sharply at 3 months and then declined slightly. Initially dominance of weeds for these two treatments was very high but decreased rapidly at 3 months. Weed species richness in prometryne 2 kg/ha treatment remained intermediate between that of controls and all other treatments, but general diversity and equitability were higher than that in prometryne 4 kg/ha and fluometuron 2 kg/ha upto the second month after sowing, indicating that here the level of general diversity was greatly influenced by the equitability component. Dominance in prometryne 2 kg/ha showed values of general diversity and equitability intermediate between control and rest

Table 2. Effect of the application of prometryne and fluometuron on monocot, dicot and total weed density (no. of individuals/m^2)

Treatments	Months after Sowing											
	1			2			3			5		
	Dicot	Monocot	Total	Dicot	Monocot	Total	Dicot	Monocot	Total	Dicot	Monocot	Total
Control	31.45	80.08	111.53	27.55	56.35	83.90	59.40	46.66	106.06	103.38	93.77	197.15
Prometryne 2 kg/ha	12.69	97.23	109.92	17.36	89.12	106.48	21.95	82.93	104.88	69.87	79.81	149.68
Prometryne 4 kg/ha	3.72	124.53	128.25	13.06	97.95	111.01	16.00	34.60	50.60	54.66	98.75	153.41
Fluometuron 2 kg/ha	6.57	120.57	127.14	14.84	97.24	112.08	22.13	35.20	57.33	59.82	90.23	150.04
Fluometuron 4 kg/ha	12.26	47.99	60.25	9.59	30.41	40.00	13.95	45.42	59.37	33.24	98.84	132.08

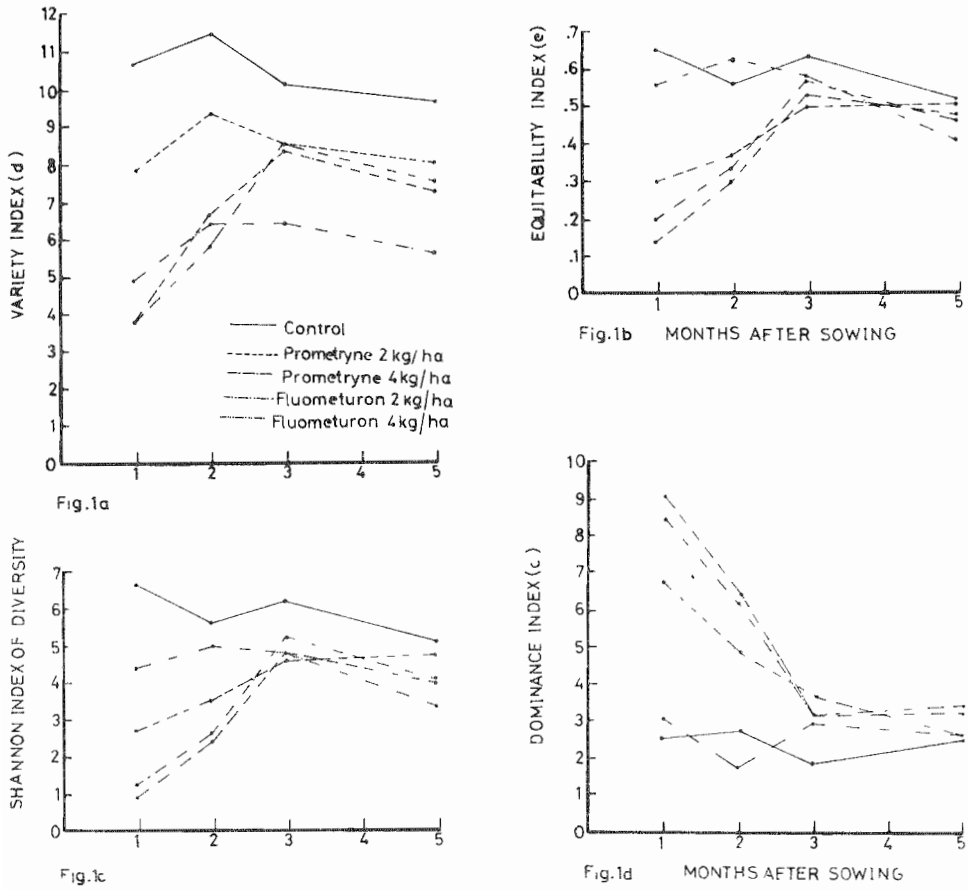

Fig. 1. Effects of the appliaction of prometryne and fluometuron in cotton field on weed species richness (Fig. 1a) equitability (Fig. 1b), general diversity (Fig. 1c) and weed dominance (Fig. 1d) at various stages of crop growth.

of the treatments. The richness component remained low throughout in this treatment and dominance remained similar to that of controls.

c) *Effect of herbicide application on cotton yield:*

Fig. 2 shows the effect of herbicides on cotton yield (dry weight of bolls and number of cotton bolls) in the control and treated plots. The application of 2 kg/ha of prometryne significantly increased the cotton yield over the controls ($p < 0.05$). Dry weight of bolls and the number of bolls/m^2 in prometryne 2 kg/ha treated plots were also significantly higher than that of control plots ($p < 0.05$). However, prometryne 4 kg/ha significantly reduced the yield as well as the number of cotton bolls in comparison with the controls ($p < 0.05$). Fluometuron at both the dosages had no significant influence on cotton yield.

Discussion

Prometryne successfully controlled a number of dicot and monocot weeds but failed to thwart the growth of *C. rotundus*, this is a universally troublesome weed, whose density even increased over the controls, apparently because of reduced competition resulting from the inimical influence of prometryne to other dicot weeds. Kasasian &

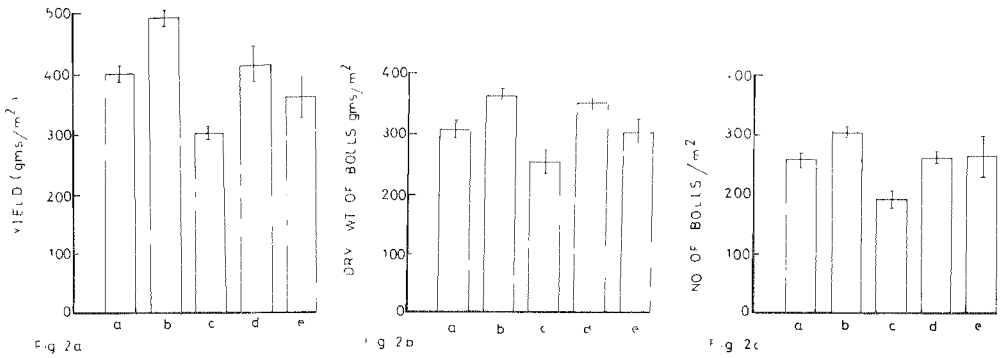

Fig. 2. Effects of the application of prometryne and fluometuron on cotton yield as determined by yield of commercial cotton (Fig. 2a), dry weight of bolls (Fig. 2b) and number of bolls (Fig. 2c).

a, Control
b, 2 kg/ha prometryne
c, 4 kg/ha prometryne
d, 2 kg/ha fluometuron
e, 4 kg/ha fluometuron

Phillips (1965) and Kasasian & Seeyave (1969) have reported that *C. rotundus* and *C. dactylon* are fairly tolerant to prometryne. The present study corroborates the notion that *C. rotundus* is resistant to prometryne but, contrary to previous findings, indicates that *C. dactylon* is susceptible to prometryne.

Fluometuron also effectively repressed the growth of a number of weeds particulary at the higher dosage (4 kg/ha). Fluometuron controlled remarkably at a dose of 4 kg/ha, but not at 2 kg/ha. This is in accordance with the results of Keeley *et al* (1971). Fluometuron was found to be more effective in controlling certain dicot weeds like

S. surattense, E. prostrata, E. granulata and *A. viridis* which corresponds with the results of Kafi *et al* (1970) and Singh & Katti (1972).

Initially the general diversity of weeds (at one month) was substantially higher in controls compared to treatments but as the crop approached maturity the diversity values of treated plots tended to be closer to the controls presumably due to the decreased residual activity of the herbicides (Anwar-ul-Haq, 1974). However, in general, weed species richness equitability and general diversity declined substantially at 5th month compared to first month after sowing and this was coupled with an increase in total weed density. This is, in part, attributable to the disappearance of certain annuals, like *C. rotundus* and *E. colonum* providing opportunity for perennial *C. dactylon* to increase its density because of reduced competitive pressure.

Although prometryne 2kg/ha decreased the weed species richness and diversity, total density remained similar to the controls until 5th month of crop growth when density declined substantially with respect to the controls, and gave rise to a higher yield compared to untreated lpots. This suggests that the crop is benefited by reduced weed density at maturation stages.

Despite marked reduction in weed species richness and diversity as well as decreased weed density in fluometuron 2 and 4 kg/ha and prometryne 4 kg/ha treatments, the yield of cotton remained unifluenced. One probable reason for this result appears to be the phytotoxic action of the herbicides not only to the weed flora but also to some extent to the crop. The bioassay for the residual activity of herbicides in various plots at different time periods during the trial disclosed that at 3 months after sowing the activity of prometryne 2 kg/ha was reduced to nill but that of fluometuron (2 and 4 kg/ha) and prometryne 4 kg/ha was atleast 15% that found at the time of herbicide application (Anwar-ul-Haq, 1974).

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