Weed Management Studies in Pigeonpea (Cajanus Cajan L.) based intercropping

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ABSTRACT

The paper summarizes the results obtained through various field trials on different pigeonpea (*Cajanus cajan* L.)-based intercropping systems for two years at the International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, India. It was observed that intercropping pigeonpea with various other crops reduced weed growth to an extent of 75%. The crop-weed balance in intercrop system was influenced by many factors like crop species and variety, plant population, crop geometry, soil types and herbicides. Among the various intercrops maize (*Zea mays* L.), cowpea (*Vigna cylindrica* Skeels) and pearl millet (*Pennisetum typhoides*) showed initial weed-smothering effect while groundnut (*Arachis hypogaea* L.) was effective at later stages of the crop growth. Weed growth in compact type of pigeonpea (HY3A) was substantially higher than that observed in spreading type (ST1). Within the intercrop system row arrangement pattern did not influence the weed infestation but the increase in population pressure resulted in considerable decrease in weed dry matter weights. Among the different herbicides evaluated in various systems, alachlor [2-chloro-2', 6'-diethyl-*N*-(methoxymethyl) acetanilide] at 1 kg/ha in maize + pigeonpea system caused initial toxicity to pigeonpea while prometryn [2,4-bis(isopropylamino)-6-(methylthio)-s-triazine],terbutryn[2-(*tert*-butylamino)-4-(ethylamino)-6-(methylthio)-s-triazine), and ametryn [2-(ethylamino)-4-(isopropylamino)-6-(methylthio)-s-trazine]proved promising in sorghum + pigeonpea system. Further studies with these herbicides are underway. The studies on intercropping revealed that the biological and cultural factors like suitable crop species, crop varieties, plant population, nature of crop in the system and supplemental use of suitable herbicides should form the major part of the integrated weed management system.

INTRODUCTION

Mixed cropping[2] or intercropping[3] are an age-old traditional practice of many farmers in the semi-arid tropics (SAT). In view of the complexities of problems involved in dealing with crop mixtures in both mixed cropping and intercropping, research on crop mixtures has been minimal when compared to sole-cropping research. However, a greater insight in under-

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2 Mixed cropping — two or more crops are grown simultaneously in the same area with no row arrangement.

3 Intercropping — two or more crops are grown simultaneously in the same area in alternate rows or in other geometrical patterns.

standing of the technical, socio-economic, and physical factors associated with crop mixtures (Norman 1974), has revealed that under the prevailing conditions of low resource base, less capital investment, and aberrant weather situation in SAT, intercropping or mixed cropping have greater yield potential, stability in production and advantages in pest-, disease-, and weed-management aspects (Aiyer 1949, Andrews 1972, Rao and Shetty 1977). Intercropping has shown a yield advantage up to 60% over sole crops (Bantilan and Harwood 1973, Munro 1960 and Norman 1970), not only in low levels of technology but also (contrary to the belief of many) at high levels of inputs like improved varieties, fertilizers, and management (Andrews 1972, IRRI Annual Reports 1972, 1973, 1974; Krantz *et al.* 1976). Pigeonpea, one of the important crops in SAT areas, is characterized by slow growth for about 8 to 10 weeks and rapid growth thereafter, to cover as much as 1 to 1.5. m row width. This is especially true in the case of mid to late maturing and spreading varieties which require 180 to 220 days for maturity. This situation provides an excellent opportunity to grow one or two short-duration cereals or pulses between the wide rows of pigeonpea without affecting the growth of the other (Saxena 1973, Rao *et al* 1977). Unless such intensive cropping is practiced with pigeonpea, not only are resources wasted, but the vacant interrow space creates more weed problems.

In the sphere of weed management, little is known about many crops grown individually, let alone intercropping involving these crops. An attempt at ICRISAT Center to determine the effect of some biological factors such as crop species, crop variety and plant density, on the incidence of weeds and crop-weed balance has been reported by Rao and Shetty (1977). A major objective was the determination of how different intercropping systems, using pigeonpea as the main crop, affect the incidence of weeds, and to identify principles which will lead to better management of weeds. Studies were also initiated to assess yield losses due to weeds in established intercropping systems and to determine the critical period of crop-weed competition. Yield trials were also conducted to screen effectiveness of herbicides in selected intercropping systems.

MATERIALS AND METHODS

A series of field experiments on intercropping were conducted at ICRISAT Center during the 1975 – 1976 and the 1976 – 1977 seasons. Observations of weed infestation in many other agronomic field trials involving intercropping were recorded. A description of the ICRISAT Center trials is given below.

Influence of some pigeonpea-based intercropping systems on weed infestation. Two field trials were conducted (during 1975 and 1976) to study the influence of various intercropping systems on the incidence of weeds and the trends in weed infestation.

The experiments were conducted in Randomised Block Design (RBD) with three and four replications. Optimum agronomic inputs were provided for all crops involved in the systems (pigeonpea, sorghum, maize, millet, mungbean, cowpea, and groundnut).

Weed observations (counts and dry weights) were taken frequently to determine the trends in weed infestation.

Evaluation of pigeonpea genotypes with and without intercrop (1975). In this trial, the performance of four pigeonpea genotypes — two of long duration (ICRISAT 7065 and ICRISAT 7086) and two of medium duration (STI and HY3A); in each group one spreading (STI and ICRISAT 7065) and the other compact (HY3A and ICRISAT 7086) — were evaluated in sole form and with sorghum as an intercrop. In intercropping, the planting pattern of pigeonpea to sorghum was 1 : 1 at 75 cm and 1 : 3 at 150 cm row spacing of pigeonpeas (thus all rows were spaced at 37.5 cm). The pigeonpea population growing alone and intercropped was 30,000 plants/ha, while that of sorghum was 100,000/ha. The trial was conducted in factorial RBD replicated four times. Weed observations were taken.

The influence of population pressure in intercropping (1976). In this trial, response of contrasting pigeonpea varieties (compact HY3A and spreading ICRISAT-1) to population pressure (30, 60 and 90 thousand plant units/ha) in sole planting and with sorghum as intercrop at different relative proportions (100 P, 50 : 50, 33 : 66, 25 : 75, and 100 S) was studied. The experiment was conducted in split-plot design with combinations of varieties and densities in main plots and relative proportions in sub-plots repeated four times. Basic row width was 45 cm. In intercropping, three plants of sorghum replaced one plant of pigeonpea in different proportions, the equality being based on the optimum plant population for these crops in sole form. Weed observation were taken.

Critical period of crop-weed competition in sorghum + pigeonpea intercrop system (1975). The objectives of the trial were (i) to determine the nature and extent of weed problems in sorghum + pigeonpea intercrop, and (ii) to determine the most critical period of crop-weed competition in the system. The crops were kept weedfree for certain periods of time by repeated hand weeding, and then compared with the crop (i) that was kept weed free till harvest, (ii) weedy check, and (iii) that which received hand weedings at 4 and 8 weeks after sowing. The trial was condcuted in RBD replicated four times. The intercrop was planted in alternate rows in 50S:50P proportions.

Chemical weed control in intercropping systems. Based on observations of the preliminary herbicide screening trials (Shetty 1977), large-scale replicated field trials were conducted to evaluate the efficacy of some selected herbicides on intercropping systems in an effort to select suitable herbicides safe to the system as a whole. Initial emphasis was on sorghum + pigeonpea and maize + pigeonpea systems.

Two replicated field trials were conducted (1975 – 1976 and 1976 – 1977) to evaluate the effective chemicals on sorghum + pigeonpea system (50S:50P proportion). Only pre-emergence herbicides were included, and the application was made with a high-volume knap-sack sprayer.

A large-scale operational trial was also conducted to determine the efficacy of alachlor (1 kg/ha) in maize and pigeonpea system. Observations were mainly confined to pigeonpea growth.

RESULTS AND DISCUSSION

The most critical period of crop-weed competition is during the early part (4 to 6 weeks) of crop growth (Kasasian and Seeyave, 1969). The crop should be protected from weed competition during this initial stage. Recent work (Bantilan *et al.* 1974) has indicated that crop-weed balance[4] can be manipulated through intercropping. Intercropping of quick-growing short-duration crops with long-duration slow-growing crops may offer such protection. Pigeonpea, a long-duration crop that grows very slowly at first, is a very poor competitor with weeds.

Intercropping of pigeonpea with sorghum reduced weed growth (Table 1). In pure pigeonpea, weed growth was high (200.5 g/m^2) when compared to the intercropped combination (41.0 g/m^2). Also, while the pure pigeonpea required a third weeding, the intercrop treatments did not require further weeding. Data (Tables 1, 2, 3, 4, 5) illustrate that 50 to 75% reduction in weed infestation was achieved through intercropping pigeonpea with crops like sorghum, millet, cowpea, mungbean, and groundnuts. It was noticed that in all intercropping systems the competitive character of the system was derived mostly from the various intercrops, and very little was contributed by pigeonpea.

In intercropping, the total canopy at any times is higher than in sole cropping and ground cover is obtained quickly due to simultaneous growing of two or more crops. Weed growth is influenced by the crop canopy and the amount of light intensity reaching the ground. The larger canopy obtained through intercropping intercepts much of the incident light (reducing downward transmission of light) and competes more effectively for other inputs, creating an environment unfavourable for weed growth.

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[4] Crop-weed balance: The result of crop-weed competition which is the realization of crop yield as well as yield of the species comprising the weed community (Bantilan *et al.* 1974).

The spreading type of crop species, due to their high initial leaf area index, intercept more light than do the compact types, thus possessing more weed suppressing ability. The enchanced competitive ability of intercropping is also due to high plant population pressure provided by the component species together. Crops like pigeonpea, which require 80 to 90 days to develop reasonable spread, benefit from intercropping with short and fast

Table 1. Effect of compact vs spreading pigeonpea genotypes growing on vertisols with and without sorghum intercrop upon weed infestation at 60-day stage one initial hand weeding, ICRISAT center 1975.

Row spacing	Pigeonpea type				Mean
	Spreading		Compact		
	Sole	Intercrop	Sole	Intercrop	
	Dry weight of weeds (g/m^2)				
75 cm	156	40	228	36	115.0
150 cm	178	40	240	48	126.5
Mean	167	40	234	42	
Sole vs intercrop	200.5	41			
Spreading vs compact	103		138		

Weed dry-weights are means of two varieties for each plant type and two replicates; data not analyzed statistically.

Table 2. Effect of intercropping of pigeonpea (HY2) growing on vertisols with cereals and legumes on the growth of weeds 6 weeks following planting ICRISAT center 1975.

S. No.	Crop Combination	Dry weight of weeds (g/m^2)
1	Pigeonpea + Sorghum (CSH5)	92
2	Pigeonpea + Pearlmillet (HB3)	97
3	Pigeonpea + Cowpea (C152)	60
4	Pigeonpea + Field bean	87
5	Pigeonpea + Sorghum (Mixture)	93
6	Pigeonpea sole	196
7	Sorghum sole	96

Table 3. Relative weed-suppressing ability (in percentage) of crops in pure stands

Crop	Day after planting 44	68
Setaria	73	73
Pearl millet	82	88
Maize	76	92
Sorghum	69	81
Castor	57	51
Pigeonpea	23	54
Cowpea	78	88
Groundnut	74	62

Weed-suppressing ability :

$$\frac{\text{Dry wt. of weeds from fallow} - \text{Dry wt. weeds from cropped plot}}{\text{Dry wt. of weeds from fallow}} \times 100$$

developing crops which tend to shift the balance of crop-weed competition to the advantage of crop during the early critical period of competition. The wider row spacings (1 to 1.5 m) required for pigeonpea cultivars, if not intercropped, provide ideal conditions for weeds to grow and multiply. The productive advantages of intercropping systems (Willey and Osiru, 1972, Rao 1974, Bantilan and Harwood 1973[5], Krantz *et al.* 1976, Rao and Shetty 1977) in conjunction with their utility as an inexpensive weed management system make them highly renumerative over sole crops.

Bantilan *et al.* (1974) described various physical, biological, and cultural factors affecting crop-weed balance in a crop season. Rao and Shetty (1977) further demonstrated that within an intercropping system the crop-weed balance is again dependent upon various factors such as crop type, genotype, and plant density. A further discussion on some of these factors which can be manipulated in such a way as to minimize weed problems is presented below:

Effect of different crop combinations. Weed dry matter weights as influenced by various pigeonpea-based intercropping systems, along with

[5] Bantilan, R.T. and R.R. Harwood 1973. Weed management in intensive cropping systems. Paper presented at IRRI, Saturday seminar, July 28, 1973.

Table 4. Influence of different intercrops growing on alfisols on weed growth after an initial hand weeding (25 days), ICRISAT center 1976 – 1977.

	Intercrop Yield		Pigeonpea Yield		Total return	Weed dry matter		
						At hand weeding (25 days)	After inter crop harvest (90 days)	At pigeonpea harvest (150 days)
	(q/ha)	(Rs/ha)	(q/ha)	(Rs/ha)	(Rs)	(q/ha)	(q/ha)	(q/ha)
Pigeonpea + Groundnut	10.7	2140	4.5	450	2590	3.5	5.0	6.1
Pigeonpea + Maize	27.8	2224	3.9	390	2614	3.8	3.4	3.8
Pigeonpea + Sorghum	27.5	2063	4.0	400	2463	3.1	2.9	2.8
Pigeonpea + Millet	4.8	360	4.2	420	780	2.8	6.3	6.2
Pigeonpea + Cowpea	10.6	1590	5.4	540	2130	2.5	4.9	6.8
Pigeonpea + Mungbean	5.7	855	4.5	450	1305	2.0	4.5	8.9
Pigeonpea alone	—	—	6.2	620	620	6.1	6.6	17.6

1 q (quintal) = 100 kg.

Table 5. Influence of different intercrops growing on vertisols on weed growth after an initial handweeding (25 days). ICRISAT center 1976 – 1977.

Treatments	Intercrop yield		Pigeonpea yield		Total return	At hand weeding (25 days)	After inter crop harvest (90 days)	At pigeonpea harvest (180 days)
	(q/ha)	(Rs/ha)	(q/ha)	(Rs/ha)	(Rs)	(q/ha)	(q/ha)	(q/ha)
Pigeonpea + Groundnut	11.9	2380	1.4	140	2520	5.2	5.4	16.9
Pigeonpea + Maize	27.4	2192	1.4	140	2332	5.4	5.1	17.9
Pigeonpea + Sorghum	32.5	2438	1.2	120	2558	4.7	5.5	12.5
Pigeonpea + Millet	15.6	1170	1.1	110	1280	4.3	7.4	22.7
Pigeonpea + Cowpea	6.2	930	1.6	160	1090	3.2	4.5	11.9
Pigeonpea + Mungbean	2.3	345	1.4	140	485	2.9	5.6	20.5
Pigeonpea alone	—	—	1.9	190	190	8.2	9.7	23.2

Table 6. Grain yield of sorghum (CSH-5) intercropped with pigeonpea (T-21) on vertisols affected by different weed-management treatments, ICRISAT center 1975.

Treatments	Sorghum yield (q/ha)	Pigeonpea yield (q/ha)	Grain yield of sorghum (as % of weed-free sorghum)	Weed counts/m² (one week before sorghum harvest)	Weed dry-matter at sorghum harvest (q/ha)
1. Weed-free up to 2 weeks after sowing	21.3	2.8	74	20	11.3
2. Weed-free up to 4 WAS	22.3	3.1	78	18	4.3
3. Weed-free up to 6 WAS	25.1	2.2	88	10	1.0
4. Weed-free up to 8 WAS	27.2	3.0	95	12	0.98
5. Two hand weedings 4,8 WAS	22.9	1.1	80	10	1.2
6. Weed-free	27.8	2.1	100	0	0.0
7. Weedy check	10.4	2.1	35	31	15.4
L.S.D. at 5%	2.75	N.S.			

Table 7. Efficacy of different pre-emergence herbicides in sorghum (CSH-5) and pigeonpea (HY3A) intercropped on alfisols, ICRISAT center 1976 — 1977.

Treatments	Rate (kg/ha)	Sorghum yield (q/ha)	Grain yield of sorghum (% of weed-free)	P. pea yield (q/ha)	P. pea (% of weed-free)	Sorghum + p. pea (Rs/ha)	Weed dry matter	
							At sorghum harvest (q/ha)	At p. pea harvest (q/ha)
dinitramine	0.5	14.0	39	2.9	85	1340	14.5	8.4
devrinol	1.0	18.7	52	2.7	79	1672.50	13.5	13.1
prometryn	1.5	27.9	78	3.2	94	2412.50	5.1	5.1
terbutryn	1.5	29.1	81	2.7	79	2452.50	5.7	11.4
ametryn	1.5	30.9	86	3.1	91	2627.50	6.9	7.2
destun	1.5	8.1	23	1.9	56	792.50	23.2	17.9
fluochloralin	1.5	10.0	28	3.6	106	1110	17.1	11.4
atrazine	1.5	25.0	70	—	—	1875	27.2	11.6
alachlor	2.0	18.6	52	1.8	53	1575	11.2	12.7
Weed-free	—	35.9	100	3.4	100	3032.50	—	—
Weedy check	—	11.9	33	1.6	47	1052.50	36.5	22.0
L.S.D. 0.05.		6.6		1.4				

Table 8. Efficacy of different pre-emergence herbicides in sorghum (CSH-5) and pigeonpea (HY3A) intercropped on vertisols, ICRISAT center 1976 — 1977.

Treatments	Rate (kg/ha)	Sorghum yield (q/ha)	Grain yield (% of weed-free)	P. pea yield (q/ha)	P. pea (% of weed-free)	Sorghum + p. pea (Rs/ha)	Weed dry matter	
							At sorghum harvest (q/ha)	At p. pea harvest (q/ha)
dinitramine	0.5	14.0	84	0.7	140	1120	12.7	9.3
devrinol	1.0	11.3	68	0.5	100	897.50	12.4	13.4
prometryn	1.5	3.9	24	0.6	120	352.50	4.2	0.5
terbutryn	1.5	13.2	80	0.5	100	1040	2.9	14.3
ametryn	1.5	3.7	22	0.4	80	317.50	5.4	6.3
destun	1.5	4.3	26	0.4	80	322.90	22.5	19.7
fluochloralin	1.5	15.1	91	0.4	80	1172.50	10.8	27.6
atrazine	1.5	4.3	26	—	—	322.50	6.1	15.0
alachlor	2.0	9.6	58	0.7	140	790	19.0	22.2
Weed-free	—	16.6	100	0.5	100	1295	—	—
Weedy check	—	4.3	26	0.6	120	382.50	39.9	29.9

yields and gross returns, are presented in Table 2, 3, 4 and 5. Weed infestation was about the same in the early part of the season, but late season weeds yielded 2.4 times more weed weights in the vertisols (black soils) when compared to alfisols (red soils) (Table 4, 5). Even by the first general hand weeding at 25 days, the effect of intercrop systems on weed growth, in contrast to sole pigeonpea, was perceptible in that weed weight was about 2 to 5 q/ha in intercrops, whereas it was 6 to 8 q/ha in sole pigeonpea. By the time of intercrop harvest, the differential effects of various systems on weed was quite evident on either soil type. Intercropping of cowpea and maize with pigeonpea suppressed weed growth to a greater extent, (followed by mung, sorghum, and groundnut) than sole pigeonpeas. However, intercrop systems differed in their weed-smothering effect in that some of them showed low weed intensity throughout the growing period, whereas in others weeds reappeared after the intercrop harvest. Pearl millet growth was poor due to downy mildew and the data for it do not truly represent the system. Though cowpea efficiently suppressed weeds due to its quick growth and ground cover in early stages, weeds reappeared after the early harvest and produced by the end of the season one-third the growth measured in the sole-crop system. A similar trend was also noticed in mung and pearl millet systems. Groundnut, though associated with pigeonpea for a longer time (90 days), could not prevent weed growth in later periods. This may perhaps be due to initial slow growth of the crop, favoring early establishment of weeds. Systems with maize and sorghum as intercrops, on the other hand, recorded less weed growth, not only up to intercrop harvest, but also until the final harvest of pigeonpea. Similar observations were noted in other trials as reported by Rao and Shetty (1977).

Crops differ in their relative growth rates, spreading habit, height, canopy structure, and duration. They accordingly vary in their weed-smothering ability. Quick growing and fast-covering cowpea and tall and fast-developing maize smothered weeds more efficiently than did other crops. Pearl millet, by its tillering and vigorous growth, had a similar weed suppressing effect. Sorghum increased its competitive effect progressively and from flag-leaf stage (50 days) onwards kept down weeds for the rest of the season, as did maize. Mung was equally good on vertisols when there was no moisture stress. In systems where intercrops (millet, mung, cowpea) were harvested early, there was considerable time before closure of the pigeonpea canopy in the rows, and a fresh crop of weeds resulted. On the other hand, tall and vigorous crops (maize and sorghum) suppressed the weeds up to their harvest time. Subsequent weed growth was less. However, because of better moisture conditions in vertisols, specific weeds such as *Phyllanthus niruri* L., *Phyllanthus maderaspatensis* L., *Corchorus sp.*, and *Hibiscus panduriformis* Burm. F. came up after intercrop harvest to record high weed growth during the later part of the season. In low-growing crops like groundnut and mung, tall and hardy weeds like *Celosia argentea* L., *Digitaria sanguinalis* Back., and *Acanthospermum hispidum* L. overtook the crops at later stages.

Yields of pigeonpea on either soil type was not significantly different among various intercrop systems and sole pigeonpea. A slight depression in yields in intercropping situation was apparent, especially in alfisols. Intercrop systems with maize and sorghum, because of their high yields, and groundnut (due to its high premium value) recorded the maximum return on either soil. The gross return from the former three systems on vertisols was 11 to 12 times and those on alfisols 4 times the return from pigeonpea growing alone. To what extent the reduction in weed growth obtained by various intercrop systems reduced the expenditure necessary for weed control could not be ascertained from the current data. Reduction in weed growth alone was not the only cause for the advantages of intercropping observed in all systems. However, if reduced weed growth can be considered a criteria of an efficient system, it can be said that intercropping pigeonpea with any other suitable species is an improved practice of weed management, as well as efficient utilization of available resources.

The cost of the high weed population observed in sole pigeonpea must be considered to be overlapping into subsequent seasons because of the quantities of seeds coming from such populations.

Dry weights of weeds from various intercrop systems on vertisols in 1975 are presented in Table 2. Weed growth in sole pigeonpea was two to three times that observed in intercrop systems and sole sorghum. Again the data suggest that the reduced weed growth in the intercropping systems was primarily due to the presence of fast and spreading intercrops like cowpea or vigorous and competitive intercrops like sorghum and pearl millet.

Effect of plant density. Increase in plant-population pressure produced a significant reduction in weed infestation (Figure 1). This was true in sole as well as the intercropping system. There was a linear decrease in weed dry weights up to 90,000 plants/ha in pigeonpea growing alone and pigeonpea intercropped with sorghum. When the population density was increased from 30 to 60 thousand plants/ha in sole pigeonpea, the reduction in weed growth was 36%. An increase to 90,000 plants/ha achieved 61% weed control. In case of sole sorghum, higher levels than the lowest population level of 90,000/ha (equivalent to 30,000 P/ha) did not produce an additional advantage in suppressed weed growth. Sorghum being very competitive, its presence in the pigeonpea intercropping system helped to reduce weeds by 73%. The three different relative proportions of pigeonpea to sorghum in intercropping (50:50, 33:66 and 25:75) did not result in significantly differing weed infestation problems.

High plant density would enable the crop to cover ground quickly and consequently inhibit the growth of weeds. However, increasing plant

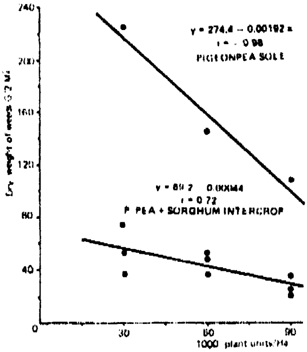

Figure 1. Effect of population pressure on weed growth.

density beyond a certain level may not be of additional advantage, as the total canopy would lével off at some value because of interplant competition and death of most of the lower branches. It is important to consider to what extent high populations that suppressed weed growth are necessary for yields. Yield data from the present experiment for pigeonpea indicated that the optimum stand would be anything within 30 to 60 thousand plants/ha when growing alone and no less than 60,000 in an intercrop situation. Earlier work (Anon 1976) has shown that in pigeonpea, being an indeterminate and spreading type, yield remains fairly uniform over a great population range, and 40,000 plants/ha could be the minimum required for high yields. Hence, in such crops as pigeonpea, to help the crop encounter the interference of weeds better and shift the balance of crop-weed competition early in the season to favor the crop, it would be advantageous to use higher levels of population than the minimum required for optimum yields. Especially in intercrop systems, high total populations are required for better intercropping advantages which would also help to check weeds efficiently.

Effect of genotypes. Weed growth in the compact genotype of pigeonpea (HY3A) was 37% higher than in the spreading variety (ST1) in the 1975 trial (Table 1). However, in the 1976 trial the advantage of spreading genotype was not apparent, primarily due to the use of a different variety (ICRISAT-1). ICRISAT-1 had not spread much by the time of weed observation. Moreover, growing conditions in 1975 were much better than those in 1976, which experienced a prolonged dry spell from early September onwards. Just like any fast-spreading crop species, genotypes which close the canopy rapidly are more successful in competing against weeds.

Weed management in intercropping. Even though intercropping can be a potential biological tool for the suppression of weeds, the system by itself does not completely avoid weeds. It is evident that the smothering effect of the intercrop system did not increase in additive proportion of the individual sole-crop abilities, mainly due to interspecies competition and also due to poor contribution by the main crop, pigeonpea. Intercropping may greatly help in interrow weed suppression, but little in intrarow weed suppression. Therefore, research should continue to evaluate direct methods of weed control, even in intercropping. This has special significance in that the crops involved in a system differ significantly in growth characteristics.

Critical period of crop-weed competition. In the experiment conducted to determine the critical period of crop-weed competition in sorghum + pigeonpea, pigeonpea (due to excess rain late in the season) was completely damaged. A meaningful pigeonpea yield could not be obtained. However, initially there was an excellent plant stand of both sorghum and pigeonpea and a fairly good yield of sorghum was obtained (Table 6). The preliminary observations indicated that the critical period of crop-weed competition in sorghum + pigeonpea intercrop (alternate rows) falls around 4 to 7 weeks after sowing. The yield loss due to weeds in the intercrop was only 32% indicating the minimum weed infestation in the experimental field. There was a gradual increase in grain yields of sorghum as the duration of the weed-free environment lengthened. Weed dry-matter weighed during sorghum harvest indicates the trend of lesser weed dry-matter values for the better weed-management treatments.

The critical period of crop-weed competition in sole sorghum is the initial 4 to 5 weeks of crop growth (Shetty 1976). But in sorghum + pigeonpea intercropping, the period tends to be extended further, indicating that the system should be kept weed-free for at least 7 weeks after sowing to obtain higher yields. This is understandable in that slow-growing and poorly competitive pigeonpea plants occupy about 50% of the plot area (which otherwise would have been occupied by sorghum in sole cropping) in intercropping, giving a niche favorable for better weed growth. Therefore, though total weed growth is less in intercropping, the weeding operations may have to be extended in order to obtain optimum yields of the crops involved.

Chemical weed control. Hitherto, herbicide-oriented weed research was mainly confined to sole cropping. The selectivity of herbicides is more critical when used on an intercrop system involving two or more crop. For example, sorghum + pigeonpea is a popular intercropping system in many areas. Herbicides for this system should not be injurious to either sorghum (a monocot) or pigeonpea (a dicot). Two herbicidal trial are reported in Tables 7 and 8. In general, triazine herbicides appeared to be more promising than the other herbicides tested. It is known that triazines perform well on sorghum, but atrazine was severely phytotoxic on pigeonpea. However, ametryn appeared very safe on both the crops, as did terbutryn and prometryn. In red soils prometryn, ametryn and terbutryn were the most effective chemicals on sorghum + pigeonpea intercrop system. Further testing of these triazines is underway. Among other herbicides, performance of the fluochloralin (1) [*N*-(2-chloroethyl)-2,6-dinitro-N-propyl-4-trifluoromethyl analine] (2 kg/ha) was excellent with pigeonpea, but was slightly toxic to sorghum. The efficacy of fluchloralin at lower rates need to be further tested, especially on sorghum.

Alachlor was known to be a potential herbicide for both maize and pigeonpea (Kasasian 1971). Suprisingly enough, it was observed that alachlor caused initial stunting of pigeonpea. The retarded growth of pigeonpea continued up to 4 months after treatment (Figure 2). However, the crop recovered later in the season and the growth was almost equal to that of the untreated crop. Alachlor gave excellent control of weeds intially, but its initial effect on pigeonpea needs further investigation. Perhaps a

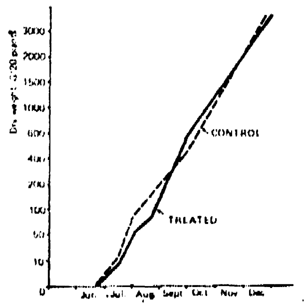

Figure 2. Pigeon pea growth as influenced by alachlor, ICRISAT-1976-1977.

change in the depth of planting of pigeonpea may help avoid the toxic effect of alachlor.

The studies revealed that intercropping systems involving pigeonpea and other crop species, when compared with pigeonpea growing alone, reduced weed growth to varying degres up to 75%. Crop-weed balance was influenced by many factors, including species, variety, population, crop geometry, soil type and herbicides. Maize, cowpea and pearl millet produced weed-smothering effects early in growth and groundnut was effective at later stages. Compact pigeonpea was less effective in suppressing weed growth than was spreading pigeonpea. Initial toxicity of alachlor to pigeonpea disappeared as the plant matured. Prometryn, terbutryn, and ametryn were effective herbicides for sorghum pigeonpea system.

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