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Weed-management Studies in Sorghum/ Pigeonpea and Pearl Millet/Groundnut Intercrop Systems — Some Observations

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Abstract

*Studies were initiated at ICRISAT Center to examine the competition between weeds and intercrop systems and the increased weed suppression by the inclusion of additional crops. In this paper, some preliminary observations on sorghum (*Sorghum bicolor *L.)/pigeonpea (*Cajanus cajan *L.) and pearl millet (*Pennisetum typhoides *L.)/groundnut (*Arachis hypogaea *L.) intercrop systems are highlighted, with particular reference to weed growth as affected by a few selected biophysical factors. With increase in density of a sorghum/pigeonpea system, there was rapid decrease in weed dry weights. The inclusion of additional "smother" crops like cowpea (*Vigna unguiculata *L.) and mung bean (*Vigna radiata *L.) minimized weed infestation. These crops could replace one hand weeding without affecting the main crop yields. Cowpea was more efficient than mung in its weed-suppressing ability later in the season. In the pearl millet/groundnut system, the row arrangement of one pearl millet with three groundnuts resulted in optimum weed suppression and maximum intercrop advantage. With the increase in groundnut rows, there was a rapid increase in total weed dry-matter weights. *Digitaria *and *Celosia *were found in increased density and biomass as the groundnut rows were increased. The relative composition of *Cyperus*, however, tended to decrease in groundnut systems.*

In this paper, some of these initial trends in weed growth, as affected by different factors operating in the complex plant mixtures, are discussed in the broader perspective of intercropping weed research in general.

From the available literature, it is evident that crop/weed competition in intercrop systems depends on various physical, biological and cultural factors (Moody and Shetty 1978). Research should be directed, therefore, toward manipulating these factors to minimize weed problems. At ICRISAT, weed research in intercropping is mainly aimed toward both examining the competition between weeds and crops and developing principles for management systems to minimize weed competition. Earlier results at ICRISAT (Rao and Shetty 1976, Shetty and Rao 1977) revealed that many biological and cultural factors — such as suitable crop species, crop varieties, plant population, and supplemental use of herbicides — should form the major components of integrated weed-management systems for a sorghum/pigeonpea intercrop system. Recently, it has been considered that more permanent and economically feasible weed-management technology can be developed by orienting the intercropping weed research more toward ecophysiological studies (Moody and Shetty 1978). At ICRISAT, two systems selected for detailed weed-related studies were sorghum/pigeonpea on Vertisols and pearl millet/groundnut on Alfisols. The main objectives of the studies were:

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a. To understand the competition between weeds and the crops involved, and the trends (both intensity and composition) in weed growth in sole vs intercrops; and
b. To examine the increased weed suppression by the inclusion of additional "smother" crops with a view to increasing the competitive ability of the crops.

In this paper, some preliminary observations from the results of 1977 and 1978 crop seasons are highlighted with reference to the above two objectives.

Methods

A series of field experiments on sorghum/pigeonpea and pearl millet/groundnut intercropping were conducted at ICRISAT Center. A brief description of the trials is given below.

Sorghum/Pigeonpea

Population Effect

A trial was conducted on deep Vertisols primarily to examine the effect of population of sorghum/pigeonpea intercrops on the incidence of weeds. The treatments included the proportional increase of relative plant populations of these two component crops. The normal populations considered were 180 000 plants/ha for sorghum and 40 000 plants/ha for pigeonpea. Only one initial hand weeding (3 weeks after planting) was given to all the treatments to keep weeds from dominating and suppressing crop growth. Crop- and weed-growth observations were taken to examine the relationships between crop density and weed growth.

"Smother" Cropping Effect

Two field trials were conducted during the 1977 and 1978 crop seasons to observe the influence of sole cropping, intercropping, and the inclusion of an additional low-growing legume "smother" crop on the intensity of weed infestation. The treatments also included varying levels of hand weedings mainly to examine whether the inclusion of additional "smother" crops could replace hand weeding(s). The cropping systems tested were sole cropping of sorghum and pigeonpea, and a sorghum/pigeonpea intercrop with or without the inclusion of a "smother" crop and with two, one, or no hand weedings. The smother crop was planted between the normal crop rows and removed at physiological maturity.

Pearl Millet/Groundnut

To examine the weed-competitive ability of a pearl millet/groundnut intercrop, trials were conducted on Alfisols during the 1977 and 1978 monsoon seasons. Treatments included different row proportions of pearl millet and groundnut (1:1 to 1:6) in the intercrop situations to observe the trends in weed infestation as affected by different row arrangements of component crops. Again, only one initial hand weeding (3 weeks after planting) was given uniformly to all the treatments to keep the weeds from dominating the crop.

In addition to observations on crop growth, phytosociological observations on weeds were recorded to detect and compare variation and change in weed community as affected by the above-modified environments. In addition to the study of the contribution of each species to the total biomass (total dry weight of weeds), a quantitative measure of density (number of weeds per unit area) was also employed. The relative density of each weed was calculated as follows:

$$\text{Relative density} = \frac{\text{density of the species}}{\text{total density of all the species}}$$

Density, relative density, and biomass were used as measures of detecting the trends in weed infestation as affected by various treatments.

Results and Discussion

Sorghum/Pigeonpea

Crop Density Effect

Earlier results at ICRISAT (Rao and Shetty 1976, Shetty and Rao 1977) indicated that higher plant populations necessary for a greater advantage in intercropping were also effective in suppressing weed growth. In the present experiment, there is a clear trend in the relationships between plant population and weed growth (Fig. 1). The contribution to weed suppression is more evident with increased population of sorghum than of pigeonpea. There was a rapid decrease in weed biomass as the sorghum population was increased from normal to two times normal; however, there was no substantial increase in crop yields (Table 1). The same trend

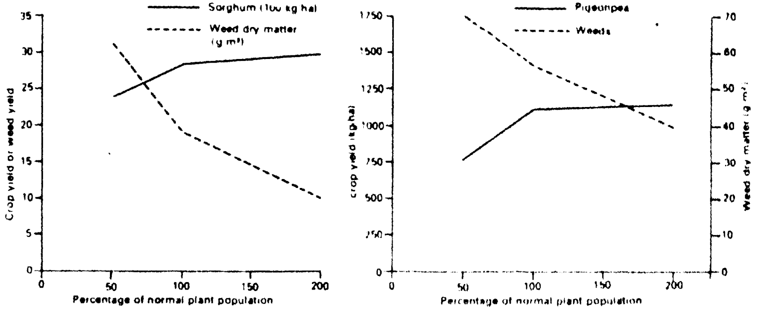

Figure 1. Influence of crop density on crop and weed yields in sorghum/pigeonpea intercrop on Vertisols at ICRISAT Center, 1977.

Table 1. The influence of crop density of sorghum/pigeonpea intercrop on weed growth, Vertisols, 1977–78.

Treatment[a]	Yield (kg/ha) Sorghum	Yield (kg/ha) Pigeonpea	LER	Weed counts/m of sorghum row	Weed dry matter (g/m²) at harvest Sorghum	Weed dry matter (g/m²) at harvest Pigeonpea
N-sorghum	4043	—	—	22	30	57
N-pigeonpea	—	1704	—	—	169	142
0.5N-sorghum + 0.5N-pigeonpea	2108	809	1.0	21	36	118
0.5N-sorghum + N-pigeonpea	2438	970	1.2	15	32	95
0.5N-sorghum + 2N-pigeonpea	2540	1002	1.2	17	25	43
N-sorghum + 0.5N-pigeonpea	2895	804	1.2	21	23	52
N-sorghum + N-pigeonpea	2615	1062	1.2	17	15	51
N-sorghum + 2N-pigeonpea	2913	1375	1.5	12	18	46
2N-sorghum + 0.5N-pigeonpea	2675	661	1.0	15	10	45
2N-sorghum + N-pigeonpea	3168	1295	1.6	16	10	26
2N-sorghum + 2N-pigeonpea	3118	1071	1.4	12	9	31
LSD (0.05)	902	517	—	—	39	15

a. N-sorghum = "Normal" sorghum population of 180 000 plants/ha; N-pigeonpea = "Normal" pigeonpea population of 40 000 plants/ha; 0.5N = ½ the normal; 2N = twice the normal.

of decrease in weed dry-matter weights was observed when the pigeonpea population was increased from half normal to two times normal. Further, the number of weeds per row of sorghum at sorghum harvest indicated that the increase in population tends to favor less weed survival in the crop row. This aspect needs further investigation.

The data further indicate that the maximum intercropping advantage was obtained with the combination of greater-than-normal sole populations of component crops. There also exists a trend of decreasing weed dry-matter weights as the intercropping advantage (LER) is increased due to the suppressing effect of higher plant population upon weeds.

Since plant population is an important agronomic aspect of intercropping research, there is a need to examine the smothering effect of high crop density upon weeds. Increasing plant density beyond a certain level may not be practical because of interplant competition. It is important to consider, however, to what extent increasing plant population suppresses weed growth without a detrimental effect on individual crop yields.

Effect of "Smother" Crops

The results of 2-year studies (Figs. 2, 3) indicate that, in both years, the inclusion of the additional cowpea and mung crops showed promise in minimizing weed infestation and virtually replaced one hand weeding without significantly affecting the yields of main crops. There were no significant differences between sorghum yields in sole- and "smother"-cropping systems; therefore, the advantage of the "smother" crop is the additional yield of the "smother" crop and the elimination of one hand weeding. The same conclusion can be drawn in the pigeonpea system (Shetty and Rao 1977). However, in the sorghum/pigeonpea intercrop, both the pigeonpea and sorghum yields were affected when the additional crop was included. In the one-hand weeding treatment, there were indications of deleterious competitive effects on the main crops both by the "smother" crops and by the increased weed growth. The decline in main crop yield was noticed even during 1978 when the row spacing adopted was 60 cm instead of 45 cm. Therefore, there does not seem to be any additional gain by replacing hand weedings completely and including additional "smother" crops in the sorghum/pigeonpea intercrop.

The weed dry-matter weights indicate the weed-competitive ability of different cropping systems. The inclusion of additional crops, cowpea and mung bean, resulted in less weed growth (Fig. 4) after one hand weeding. The weed suppression due to these additional crops was about the same as obtained with two hand weedings. After the harvest of "smother" crops, a new flush of weeds again emerged, resulting in higher weed growth. However, these late-season weeds were not competitive with the main crop of sorghum as the crop was already well established. The yield data support this observation. Among the "smother" crops, mung is a quick grower and was more efficient in suppressing weed growth initially; later in the season, however, cowpea performed better, mainly because of its good canopy structure. There was a distinct difference in weed growth after the "smother" crop harvest. While there was a marked increase in total weed dry matter after mung harvest, the weed dry matter did not differ much in cowpea plots before and after cowpea harvest. The same observation was noticed earlier (Shetty and Rao 1977) when the residual effect of cowpea seemed to have a detrimental effect on further weed seed germination later in the season.

Pearl Millet/Groundnut

Earlier results (ICRISAT 1978) indicated that the row arrangement in pearl millet/groundnut intercropping influences the weed infestation. The data shown in Figure 5 further support this claim. When compared with respective sole croppings, groundnut suffered more because of competition by both pearl millet and weeds. As the groundnut rows were increased by replacing pearl millet rows, there was an increase in groundnut yields, whereas there was no significant change in pearl millet yields. This is perhaps due to the compensatory ability of the dominant pearl millet in the system. The row arrangement of 1:3 looked optimum as far as total advantage of the pearl millet/groundnut system was concerned. Further increase in groundnut rows did not help in increasing groundnut yields. The possibility of any increase in groundnut yields due to more

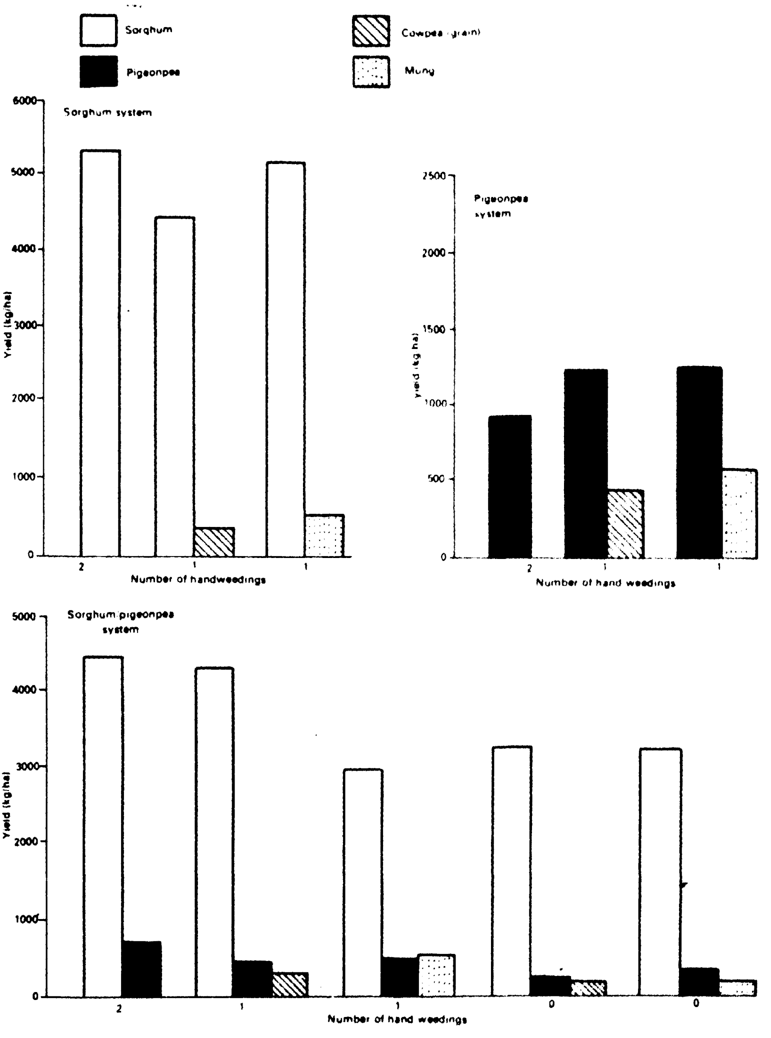

Figure 2. Influence of "smother" crops and number of hand weedings on crop yields on Vertisols at ICRISAT Center, 1977.

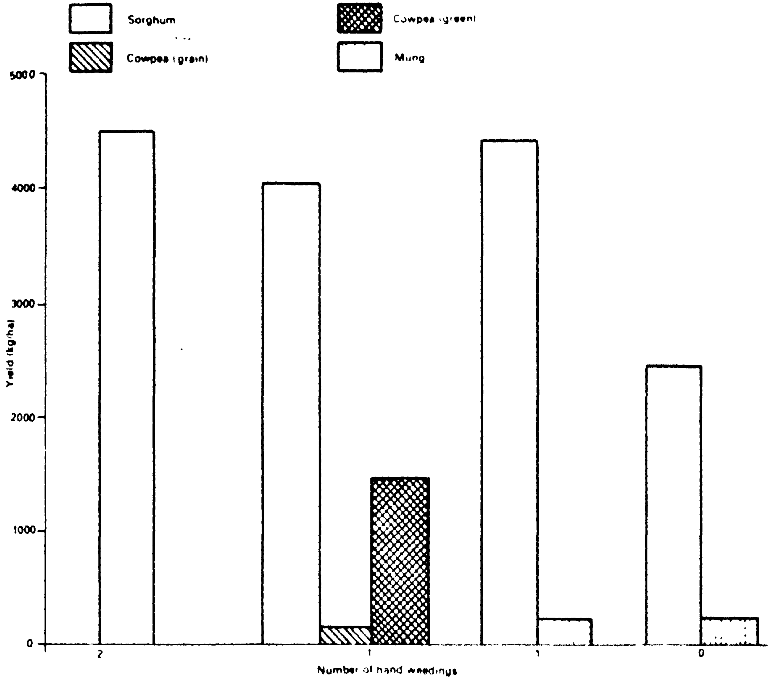

Figure 3. Influence of "smother" crops and number of hand weedings on crop yields on Vertisols at ICRISAT Center, 1978.

groundnut rows was nullified by increasing weed competition. The LER data indicate that a maximum of 15% advantage was obtained with a 1 pearl millet : 3 groundnut row arrangement. Further increase in groundnut rows resulted in lower LER values.

The weed dry matter taken during pearl millet harvest showed the least weed growth in the sole pearl millet. The sole groundnut and the 1 pearl millet : 6 groundnut intercrop showed the highest weed dry-matter values. The highest weed-competitive ability of pearl millet was visible until the 1:3 row arrangement, and thereafter there was a rapid increase in weed dry-matter weights, mainly because of the introduction of more groundnut, which is a poor weed competitor.

The seriousness of weed growth, in groundnut systems was evident not only in the quantity of weed growth but also in the composition of weed flora (Fig 6). The relative composition of weed flora in different treatments indicates that the dominant weeds in the pearl millet/groundnut intercrops were *Digitaria*, *Celosia*, and *Cyperus*. In sole pearl millet, the flora was a mixture of many weeds, including

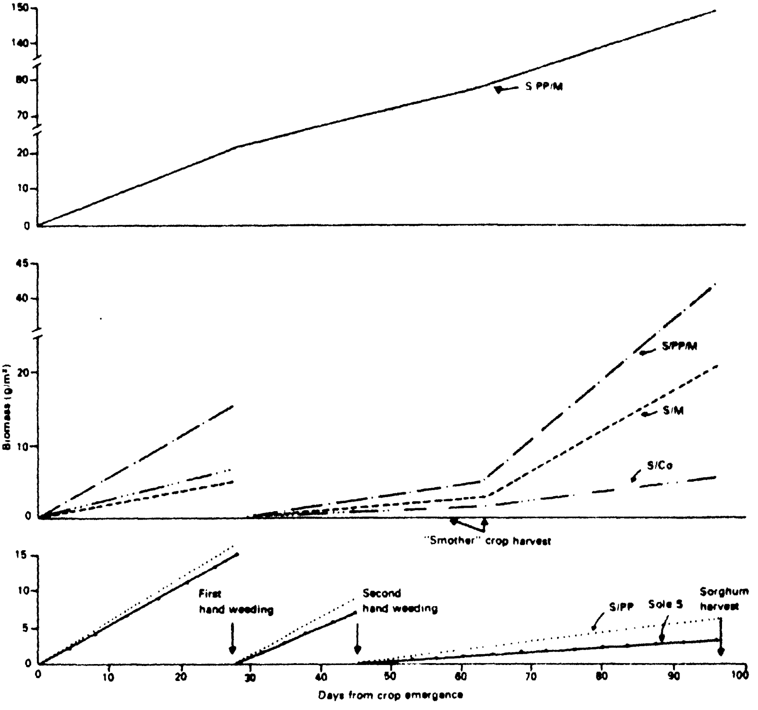

Figure 4. Biomass of weeds at different stages of crop growth as affected by different cropping systems on Vertisols at ICRISAT Center, 1978 (S = sorghum, PP = pigeonpea; M = mung; Co = Cowpea).

Digitaria, Cyperus, Celosia, Tridax, Phyllanthus, Eragrostis, and *Brachiaria*, whereas in sole groundnut, the predominant weeds were only *Celosia, Digitaria*, and *Cyperus*. As more rows of groundnuts were introduced in place of pearl millet rows, the relative proportion of *Digitaria* increased to a certain extent and then remained constant, while that of *Cyperus* went on decreasing. But the most striking observation was the build-up of more competitive and tall-growing *Celosia* in the groundnut-predominant systems. There appeared to be a shift in weed flora toward this particular weed as the groundnut rows were increased. These results have some practical significance in that a better weed-management practice, more suited to managing *Celosia* and *Digitaria*, should be a part of improved management technology for a pearl millet/groundnut intercropping system.

The data on relative density of different

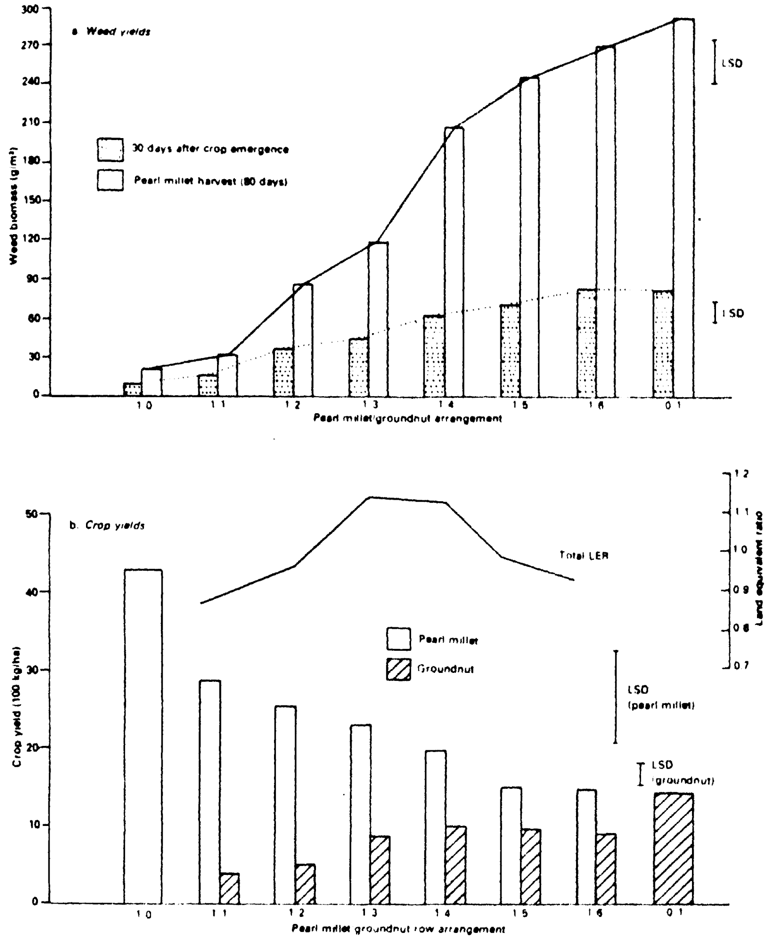

Figure 5. Effect of row arrangement in a pearl millet/groundnut intercrop on weed and crop yields on Alfisols at ICRISAT Center, 1978.

weeds in different treatments follow the same trend as that of weed dry-matter weights, except in the case of *Cyperus*. There was not much change in the density of *Cyperus* as the groundnut rows were increased, but the dry-matter weights decreased, as indicated earlier.

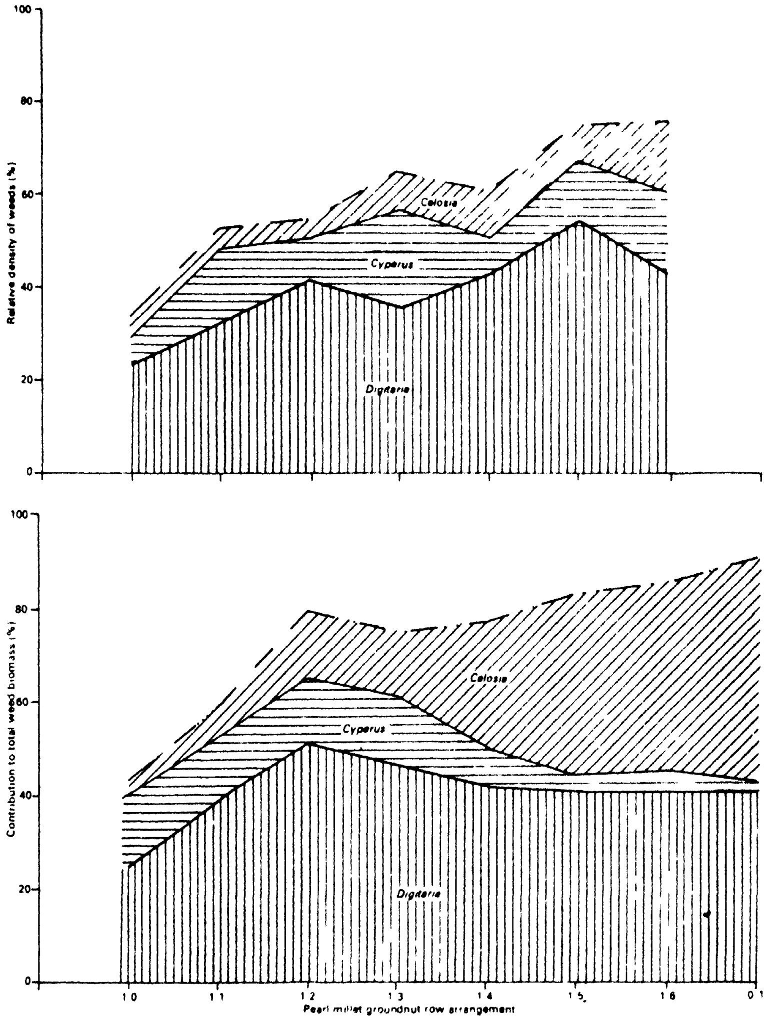

Figure 6. Percentage contribution of Celosia, Cyperus, Digitaria, *and other weed species to the total biomass and density of weeds at the time of pearl millet harvest on Alfisols at ICRISAT Center, 1978*

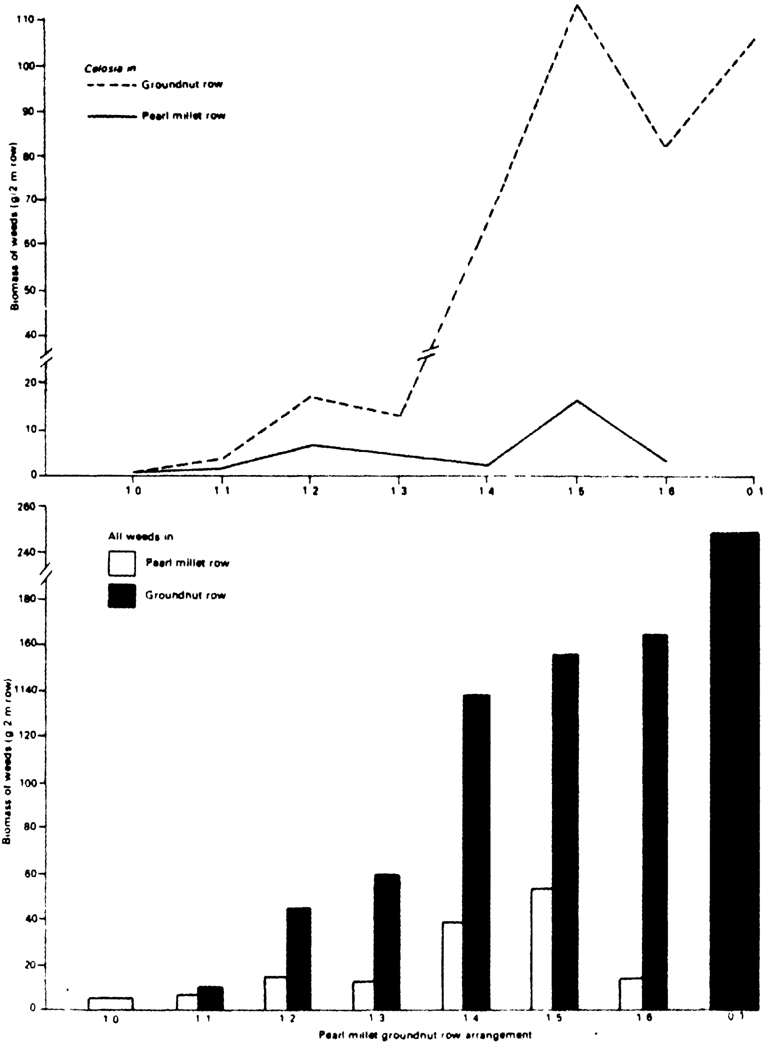

Figure 7 Effect of row arrangement in pearl millet/groundnut intercrops on weed growth in the crop rows on Alfisols at ICRISAT Center, 1978

This can be attributed to the shade sensitivity of *Cyperus*. As the groundnut rows were increased, the crop canopy provided a higher level of shading to *Cyperus* (which grows under the canopy), resulting in poor growth of *Cyperus*. However, *Digitaria* and *Celosia*, which are tall and usually grow above the groundnut canopy, did not suffer and hence had greater dry weights.

The data on number of weeds in the crop row (Fig. 7) further indicate that, as the intercrop system contains more groundnuts, the number of weeds in the crop rows tends to increase. As the ecosystem was changed due to the presence of groundnuts in place of pearl millet, there appeared to be a change in the environment more favorable to weeds. Likewise, as the groundnut rows were replaced by pearl millet rows, the number of weeds in the groundnut rows tended to decrease. Among the individual weeds, *Celosia* was found to be more associated with groundnut rows, whereas it was found in negligible numbers in and around pearl millet rows.

These studies indicate that intercropping can be a method of weed management if suitable component crops are grown with proper agronomic manipulation. Although all intercropping systems are not favorable for weed suppression, some systems can be manipulated to obtain better weed management. As the growth pattern of weeds changes due to a change in the environment, studies to identify suitable combinations of component crops and the resultant change in trends in weed growth need to be intensified. As the main factor operating in many systems is light, it is also essential to determine the response of different weeds to different levels of shading offered by different crop canopies.

These studies clearly underline the need for more ecophysiological studies in the field of intercropping weed management. As intercropping research is a fairly new discipline, simultaneous studies should be carried out to determine the implications of different intercropping systems on weeds. As brought out by the results of pearl millet/groundnut intercropping systems, weeds respond differently to different cropping systems. Ecological studies should be conducted mainly to answer questions like:

1. Which species of weeds contributes more?
2. At what stage?
3. How do different weeds behave with changes in the system?
4. What fluctuations in density occur in different weeds?

Answers to these questions should help in designing proper weed-management techniques.

Also, efforts should be oriented to manipulate intercropping systems to obtain better weed management; as the results of sorghum/pigeonpea/cowpea or mung intercrop systems reveal, additional crops can be grown mainly to obtain more weed suppression without offering serious competition to the main crops. Intercropping can thus be utilized as a method of weed management. Further studies are necessary to examine the weed-competitive ability of different crops/systems to design and develop systems which show increased weed suppression along with higher productivity. These studies would also help in predicting the seriousness of weed problems due to a change in the farming system.