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Some Biological Aspects of Intercropping Systems on Crop-Weed Balance[1]

M. R. RAO and S. V. R. SHETTY[2]

ABSTRACT

Many physical, biological and cultural management factors determine the crop-weed balance which in turn influences the crop and weed reproductive yields. Intercropping of pigeonpea (*Cajanus cajan* L. Millsp.) with sorghum (*Sorghum vulgare* Pers.) reduced weed growth to an extent of 50 to 75%. The competitive ability of intercropping was enhanced by high plant population pressure provided by the component species together. Within an intercrop system row arrangement patterns did not significantly influence the weed infestation. With the increase in the population pressure there was considerable decrease in weed dry matter weight. Weed growth in compact pigeonpea genotype (HY3A) was 37% higher than that observed in spreading type (ST1). Pearlmillet (*Pennisetum typhoides* S. and H.) and maize (*Zea mays* L.) showed high initial weed smothering ability followed by cowpea (*Vigna sinensis* Savi.) and groundnut (*Archis hypogaea* L.). Sorghum progressively increased its competitive ability with time. Hardy and tall weeds like *Celosia argentea* L., *Acanthospermum hispidum* DC., and *Digitaria sanguinalis* (L.) Scop. were predominant in groundnut system. Pigeonpea and castor (*Ricinus communis* L.) were poor competitors with weeds. A quantitative description of the effects of some biological factors like crop species, crop variety, plant population, crop geometry, relative proportions of the crops in the mixture and cropping pattern on the crop-weed balance indicated that these factors should be taken into account while evolving integrated weed management systems.

INTRODUCTION

The battle against weeds is often the costliest agronomic input for successful crop production. Favourable temperature and light regimes, especially under semi-arid tropical conditions, not only provide scope for multiple cropping but also favour rapid multiplication of weeds which compete with man's crops all through the year. For the small tropical farmer operating with low capital

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[1]Contribution of Farming System Research Program, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), 1.11.256, Begumpet, Hyderabad-500016, A.P., India.

[2]Agronomists, Cropping Systems and Weed Science, respectively. Farming System Research Program, ICRISAT.

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

investment, low technological skills, and traditional mixed cropping practices, weeds and their management often pose more problems than to his counterparts in the temperate climate where sole cropping, fossil energy and herbicide usage are more common.

Weed researchers associated with cropping systems work in recent years have recognised the importance of integrated weed management approaches, which take cognisance of ecological and biological aspects of crops and weeds rather than looking mainly at specific weed control methods (Bantilan and Harwood, 1973a)[3].

Whether the weeds take over the crop or the crop smothers the weeds depends upon the farmer's managerial ability of crop-weed balance. An understanding of the ecology and biology of weeds associated with any cropping pattern is of utmost importance so as to create an altered environment by manipulating the crop that is no longer favourable to weeds. Some of the biological aspects of crop management that have strong bearing in shifting the crop-weed balance to the advantage of crop are crop species, variety, plant population and, in case of intercropping nature of crops used, relative proportion of crops in the mixture and geometry of planting. The interaction of the above aspects of crop competition with weeds is little understood and it is imperative to quantify their effects on weeds for developing alternative weed management strategies. Since these are non-monetary in nature, they are more relevant to small farmers who have limited capital resources.

It has been observed that intensive cropping systems like intercropping and relay cropping can increase the competitive ability of crops to reduce the pressure of weeds (Bantilan and Harwood, 1973a and 1973b). However, certain weeds associated with these specific inter or relay cropping systems may in fact be favoured by their constant practice (Plucknett *et al.*, 1976.) The influence of factors such as crops, variety, density, and planting patterns upon weed growth is discussed in this paper.

MATERIALS AND METHODS

A brief description of the trials at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) which provided weed growth observation is given below :

Evaluation of pigeonpea genotypes with and without intercrop (1975). Four pigeonpea genotypes, two of long duration (ICRISAT 7065 and ICRISAT 7086), and two medium duration (STI and HY3A), in each group and spreading (STI and ICRISAT 7065) and the other compact (HY3A and ICRISAT 7086), were evaluated for their performance with and without sorghum intercrop (CSH 5) at 75 and 150 cm rows. In intercropping, the planting pattern of pigeonpea to sorghum was 1 : 1 at 75 cm and 1 : 3 at 150 cm row spacing (thus, all the rows were at 37.5 cm spacing). The trial was conducted in factorial RBD replicated four times and carried out on black and red soils. The population of pigeonpea in sole form and in intercropping was 30,000 plants per ha while that of sorghum was 1,00,000 per ha.

Effect of some intercropping systems of pigeonpea on the behaviour of major pests of pigeonpea (1975). The trial was conducted in RBD replicated four times in black soils. Spacing between rows in intercropping was to suit the normal ridge and furrow system (75 cm) where pigeonpea (P) and intercrop (I) rows were grouped to 25 cm apart on one ridge and the distance between two such groups was 50 cm. The planting pattern and row width details are shown below :

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                         75 cm
P    P    P    P    P<——>P
                      50   25 cm
P   I P  I P  I P  I P↑  I↑ P  I
    I    I    I    I     I <——> I
                            75 cm
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Population of pigeonpea (P) was at the rate of 30,000 plants per ha and that of intercrops (I) sorghum, pearlmillet and field beans (*Dolichos lablab* L.) 90,000 per ha. Cowpea was unthinned (approximately 2,00,000 per ha.)

Intercropping of pigeonpea with sorghum (1976)

The response to population pressure (30, 60 and 90 thousand plant units/ha) of contrasting pigeonpea (P) varieties (compact, HY3A and spreading, ICRISAT-1) in sole planting and with sorghum (S) intercrop at different relative proportions of the crops P : S (100 P, 50 : 50, 33 : 66, 25 : 75, and 100 S) was studied. The experiment was conducted in split-plot with combinations of varieties and densities in main plots and relative proportions in sub-plots repeated four times. The 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 number of plant population for these crops in sole form.

Effect of competition from sorghum and pigeonpea on various intercrops (1976)

The effect of continuous competition for light, moisture and nutrients from sorghum and the late competition from pigeonpea on the performance of six intercrops—pearl milet, setaria (*Setaria italica* Beauv.) maize, groundnut, castor and cowpea in comparison to no competition from these base crops (*i.e.*, sole crops of intercrops) was studied. Optimum agronomic inputs were provided for all the crops involved in the trial in sole form whereas in intercropping the base crop, either sorghum or pigeonpea, was additive. The trial was conducted in split-plot design replicated four times with three systems of cropping : (i) pigeonpea (P) + various intercrops (I), (ii) sorghum + various intercrops and (iii) sole crops of each intercrop as main plots and six intercrops (I) + one no intercrop treatmentas sub-plot treatments.

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                                   75 cm
P        P        P        P       P<-->P
P   I    P   I    P   I    P   I ↑ P  I  P
                                37.5 cm
    I        I        I        I<-->I
                                75 cm
I   I    I   I    I   I    I   I   I  I  I (In case of groundnut and
                                             setaria)
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Dry weight of weeds was recorded at 44 and 68 days after planting, after an initial hand weeding 20 days after planting, when weed growth was considerably less.

RESULTS AND DISCUSSION

Effect of intercropping on crop-weed balance. Intercropping of pigeonpea with sorghum reduced weed growth considerably. This was true whether the intercropping system contained the component crops in additive proportions (Tables 1 and 2) or in differcnt relative proportions of a replacement series (Table 3). In pure pigeonpea weed growth was high giving a dry matter of 200.5 g/sq m compared to 41 g/sq m noted under the intercropping system (Table 1). Another observation made in the same trial on red soil after two initial hand weedings, revealed that while the pure pigeonpea required a third weeding and allowed on an average 260 g/sq m of weed dry matter, the intercrop treatments did not necessitate any further weeding. Data from experiments 2 and 3 (Table 2 and 3) illustrate that nearly 50 to 75% reduction in weed infestation could be achieved through inter-cropping pigeonpea with crops like sorghum, millet, cowpea and field beans. Similarly, various intercropping systems based on pigeonpea in 1976 (Table 4a and b) were found to be significantly effective in suppressing the weeds compared to sole pigeonpea.

Sorghum based intercropping systems kept down the weed growth on

Table 1. Effect of compact vs spreading pigeonpea genotypes with and without sorghum intercrop upon weed infestation (g/sq m) at 60 days after one initial hand weeding (Black soil, 1975)[a]

Row spacing	Pigeonpea type				Mean
	Spreading		Compact		
	Sole	Intercrop	Sole	Intercrop	
75 cm	156	40	228	39	115.0
150 cm	178	40	240	48	126.5
Mean	167	40	234	42	
Spreading vs compact	103		138		
Sole vs intercrop	200.5	41			

[a] Weed dry weights are means of two varieties for each plant type and two replicates ; data not analysed statistically.

Table 2. Effect of intercropping of pigeonpea (HY2) with cereals and legumes on the growth of weeds 45 days after planting (Black soil 1975)

Sl. No.	Crop Combination	Weed dry weights g/sq m
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

an average 25% more efficiently than the sole crop system (Table 4a). The competitive ability of the sorghum intercrop systems increased 20% more latter in the season (Table 4b). On the other hand the pigeonpea based intercropping systems did not show any improved competitive ability over the respective sole crops of intercrops mainly due to poor contribution of pigeonpea to the system. It was also evident that the smothering effect of intercrop system did not increase in additive proportion of the individual sole crop abililities perhaps due to inter

Table 3. Effect of three population levels in sole cropping vs intercropping of pigeonpea and sorghum on weed growth (g/2 sq m) at 70 days after two early hand weedings (Black soil, 1976)

Population Units/ha	Sole Cropping				Intercropping	Mean
	Pigeon varieties					
	IC-1	HY3A	Mean (100 P)	Sorghum (100 S)	Pigeonpea+Sorghum[a]	
30,000	233.3	215.0	224.1	27.9	54.6	83.2
60,000	129.8	159.6	144.7	18.1	45.5	60.0
90,000	128.5	89.5	109.0	21.5	28.2	43.1
Mean	163.9	154.7	159.3	22.6	42.7	—
L.S.D. (.05)						24.1

Mean of varieties : IC-1=64.5 ; HY3A=59.7 'F' test not significant.

L.S.D. (.05) relative proportions=25.9.

L.S.D. (.05) for comparing two relative proportions at the same level of a population=44.8

L.S.D. (.05) for comparison of two levels of populations at the same relative proportion=46.7

[a] Mean over three relative proportions of P : S (50 : 50, 33 : 66 and 25 : 75) and two varieties.

species competition. Intercropping could thus be a potential biological tool to manage weeds, but by itself would not completely avoid weeds.

In intercropping the total canopy at any time is higher than in sole cropping and the ground cover is obtained quickly due to the simultaneous growing of two or more crops. The larger canopy thus obtained intercepts much of the incident light and competes better for other inputs creating an environment unfavourable for weed growth. The enhanced competitive ability of intercropping is due primarily to high plant population pressure provided by the component species together. The slow and long growing crops like pigeonpea which require 80 to 90 days to develop reasonable spread are highly benefited by intercropping with short and fast developing crops such as cereals or pulses which tend to shift the balance of crop-weed competition to the advantage of crop at an early stage itself. The wider row spacing of 1 to 1.5 m required for medium and spreading pigeonpea varieties, if not intercropped, would provide an ideal condition for weeds to multiply rapidly. The productive advantages of intercropping systems (Willey and Osiru, 1972 ; Andrews, 1972 ; Baker, 1974 ; Bantilan and

Table 4a. Dry weight of weeds (g/sq m) 44 days after planting in different pigeonpea and sorghum based intercropping systems and sole crops in red soil, 1976

Intercrops	Intercropping with		Sole crop	Mean
	Pigeonpea	Sorghum		
Setaria (H1)	45.9	49.7	45.6	47.1
Pearlmillet (HB3)	34.8	18.7	30.3	27.9
Maize (SB23)	34.4	21.4	42.1	32.7
Castor (157B)	70.9	41.7	73.9	62.2
Groundnut (TMV2)	62.2	41.4	44.8	49.5
Cowpea (1152)	69.3	34.1	37.7	47.1
Mean	52.9	34.4	45.7	—
No Intercrop	132.2	53.3	174.1[a]	120.2
Mean	64.4	37.2	64.2	—

LSD (.05) for comparison of means within groups=43.5
LSD (.05) for comparison of means of different groups=44.5
LSD (.05) for comparison of cropping systems=25.7
LSD (.05) for comparison of various intercrops=25.1

[a] Fallow plot without any crop.

Harwood, 1973b, and Krantz *et al.*, 1976) in conjunction with their utility as weed management practices make them highly remunerative over sole crops.

Within intercrop system the two row arrangement patterns (1 : 1 in 75 cm and 1 : 3 in 150 cm rows) did not seem to influence the weed growth (Table 1). Even in pure crop of pigeonpea, widening the row width to 150 cm resulted in only slightly higher weed growth than in 75 cm rows mainly because of better growth and spread of pigeonpea under no moisture stress in the 1975 season. Likewise, the three relative proportions of sorghum to pigeonpea (50 : 50, 66 : 33, and 75 : 25) in intercropping trial of 1976 did not result in significantly differing weed infestation problems. Sorghum being the dominant component component in the system, its presence even at 50 : 50 proportion, seemed to have reduced weed growth sufficiently to compare favourably with any other proportions of sorghum to pigenopea (66 : 33 and 75 : 25).

Table 4b. Dry weight of weeds (g/sq m) 68 days after planting in different pigeonpea and sorghum based intercropping systems and sole crops in red soil, 1976

Intercrops	Intercropping with		Sole crop	Mean
	Pigeonpea	Sorghum		
Setaria	25.3	14.1	23.6	21.1
Pearlmillet	9.2	7.9	10.6	9.2
Maize	6.8	11.0	7.5	8.4
Castor	36.9	15.7	43.7	32.1
Groundnut	45.7	11.0	34.0	30.3
Cowpea	15.9	9.5	10.4	11.9
Mean	23.3	11.6	21.6	—
No intercrop	41.2	16.9	89.4[a]	49.2
Mean	25.9	12.3	31.3	—

LSD (.05) for comparison of Means within groups=24.7
LSD (.05) for comparison of Means of different groups=23.5
LSD (.05) for comparison of cropping systems=6.8
LSD (.05) for comparisons of various intercrops=14.3

[a] Same follow plot as in Table 4a.

Table 4c. Relative weed suppressing ability of various crops in pure stands (red soil, 1976)[a]

Crop	Days after planting	
	44	68
Setaria	73	73
Pearlmilet	88	88
Maize	92	92
Sorghum	81	81
Castor	57	51
Pigeonpea	23	54
Cowpea	78	88
Groundnut	74	62

[a] Weed suppressing ability= $\frac{\text{Dry wt of weeds from fallow} - \text{Dry wt of weeds from cropped plot}}{\text{Dry wt of weeds from fallow}} \times 100$

Effect of plant density on crop-weed balance. With increase in population pressure there was considerable decrease in weed dry matter weight (Table 3). This was true in sole as well as in intercropping system. For each increase of 30,000 plant units/ha the reduction achieved in weed growth was to an extent of 28%. There was considerable variation in the data from intercropping treatments primarily due to non-uniformity in weed infestation throughout the experimental area and due to shootfly (*Atherigona soccata*) incidence on sorghum depriving perfect stands. However, the magnitude of differences among mean data clearly showed the trends of treatment effects. Weed weights in intercropping system at three populations were the average of the three relative porportions and varieties. The effect of increasing population to suppress weeds was more apparant in sole crop of pigeonpea than in sorghum as a sole crop. When the population pressure was increased from 30 to 60 thousand plants per ha in sole pigeonpea the reduction in weed growth was 36% and with further raise of population to 90,000 per ha 61% weed control was obtained. The importance of high density may perhaps be felt more in case of a compact variety which exposes more soil surface than of a spreading one at any given population. About 45% reduction in weed growth was achieved upon raising the population of spreading variety from 30 to 60 thousands per ha. However, in case of compact one for obtaining the same amount of weed growth reduction, the population had to be increased up to 75,000 plants per ha. A high density would enable the crop to cover the ground quickly in the season and consequently reduce weed infestation. However, increasing the population pressure beyond a certain level may not be advantageous from the point of view of weed control also because the total canopy would level-off at some value due to interplant competition and death of most of the lower branches.

Now the question is to know to what extent populations high enough to suppress weeds are desirable for yields. The yield data from the present experiment indicated that the optimum stand for the above genotypes would be within 30 to 60 thousand plants per ha in sole form and no less than 60,000 per ha in intercrop situation. Past work (Anon, 1976) has also shown that a minimum stand of 40,000 plants/ha was required for high yields of medium maturing and spreading varieties and the yields were unaffected over a greater range of populations. However, although higher than the optimum stand may not benefit yield, growing few thousand plants extra at negligible cost may be beneficial to smother weeds especially in the initial stages and reduce weed control expenditure. For crops like pigeonpea, castor, and sonflower whose pselds remain constant over a large range of population pressure (Fig. 1) efficient weed management it is

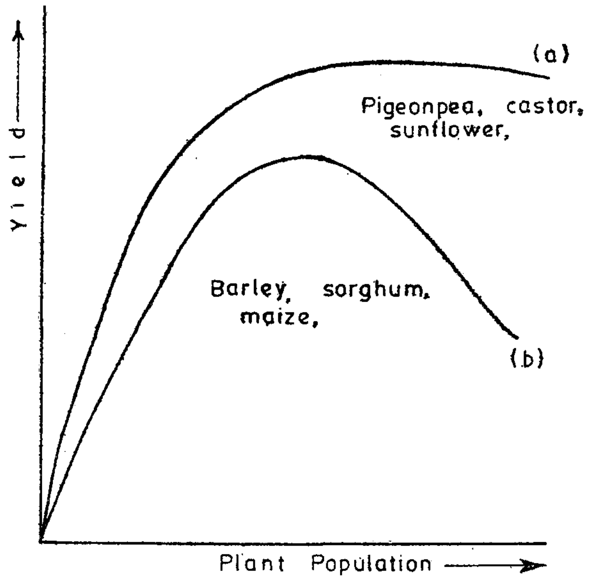

Fig. 1. Effect of plant populations on yield pattern of various crops

reasonable to have higher level than the minimum required for optimum yields. Increase in population pressure for weed growth reduction especially in intercropping is in consonance with the suggestion that the greatest intercropping benefit may come from the system that contains considerably higher stand than either on the component monocrop optimum (Willey *et al.*, 1977).[4] However, as the yield population response curve approaches to parabolic type, the scope for growing population higher than that required for optimum yields for the sake of lessening weeds gets reduced. Where interculturing with bullock drawn blade harrows is widely practised for some of the sole crops (castor, cotton, chillies, etc.), the choice of the density level, in order to achieve cheap but effective weed control should be such that it permits planting in as wide a square as possible for running harrows cross-wise. Perhaps it is more realistic to think of optimum population from the stand point of yield as well as weed management aspects rather than that of yield alone. Realising that most crop plants suffer maximum from competition of weeds in the early stage, it is desirable to have sufficient crop community to

[4]Willley, R.W., M.R. Rao, and L. Oyen, 1977. Suggested research priorities in cropping systems. Memeo, Farming System Research Program, ICRISAT.

shift early the crop-weed balance in favour of the crop. Since weed growth is highly negatively correlated with crop population (eg. r=-0.98, Table 3) whereas crop yield at sub-optimal populations is positively correlated, under no circumstances can one think of less than optimum stand.

Effect of genotype on weed growth. Weed growth in the compact genotype of pigeonpea (HY3A) was 37% higher than in the spreading variety (STI) in 1975 (Table 1). However, in the 1976 trial the advantage of a spreading genotype was not apparent, primarily due to a change of the variety (ICRISAT—1) which had not spread much by the time of weed observation. Moreover, the growing conditions in 1976 were much better than in 1976 which had a prolonged dry spell from early September onwards. Just as with any fast spreading crop species, genotypes which close the canopy rapidly are better competitors for suppressing the weeds.

Effect of crop type on weed growth. Crops differ in their relative growth rates, spreading habit, height, canopy structure, and inherent competitive character and accordingly differ in their weed suppressing ability. Pearlmillet and maize by virtue of their fast growing habit, especially under no moisture stress conditions as in the early kharif of 1976, showed high weed smothering ability over other crops from the early stages. Pearlmillet by its tillering habit and maize by its high leaf canopy development further increased competitive ability with weeds as the season progressed (Table 4a, 4b and 4c). Following them were cowpea and groundnut with their close canopies and quick ground cover. However, groundnut being low growing crop, tall and hardy weeds like *Celosia*, *Digitaria*, and *Acanthospermum* overtook the crop in latter stages. Sorghum progressively increased its competitive ability with time and its introduction into a pigeonpea sole system reduced weed growth by about 75%. Pigeonpea and castor were poor competitors with weeds for most of the growing season and could not control more than 50% of the fallow weed situation. The result suggests that intercropping presents an alternatixe method of increasing the ability of crops to compete with weeds.

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