research article | International Journal of Plant Sciences, (July to December, 2009) Vol. 4 Issue 2 : 454-459

Weed flora and the management strategy in intercorpping cultivation

G. KUMARAVELU

Accepted : April, 2009

SUMMARY

Weed populations in a sugarcane crop field mixed with groundnut, greengram and cowpea as intercrops were monitored till the harvest of mixed crops. Changes in the weed flora were recorded in three phases. Hand weeding/hoeing was carried out at 20, 40 and 60 DAS of mixed crops. A total of 32 weed species belonging to 28 genera and 17 families were associated with these crops. Among the monocot weeds, grasses like *Cynodon, Cyperus, Dactylotaenium* and *Eragrostis* were dominant. Among the dicots, the predominant ones were *Phyllanthus, Amaranthus* and *Acalypha*. Weed species like *Ammania baccifera, Prosopis spicigera, Ricinus communis* and *Croton bonplandianus* disappeared completely after hand weeding. At the time of harvest of the mixed crops, the entire field was rich in grass weed species but they were less in number and so did not affect the crop much. In the present study, it was noted that burning the soil debris at the time of ratooning the sugarcane, removed most of the plant pathogens and weeds. Moreover, after the sowing of mixed crop seeds, hand weeding/hoeing at three stages resulted in the reduction of the total number of individual weeds. The total number of weeds got reduced from 794 in the beginning to 114 at the time of harvest. Hand weeding/hoeing was the most effective weed control strategy in the study area.

Key words : Weed flora, Intercropping, Weed management

Weed science involves the study and control of the most aggressive, troublesome, and unwanted plants of the world's vegetation. Moore (1954) has defined a weed as "a plant which interferes with man's utilization of land for a specific purpose". A plant classed as a weed in one region eg. cultivated land may actually be cultivated in a different region for its medicinal uses. Some of the weeds help in improving the mineral richness of the soil and also provide a protective cover against soil erosion.

An important feature of weed growth particularly in competition with crop plants is the rapidity of growth, resistance to diseases and early maturity. Most of the annual weeds in the cultivated crop fields are destroyed before seed production. The spread of weeds in an agricultural land is largely due to the dispersal of seeds through manure, seeds already present in the soil as well as by the grazing animal. Pulse crops like cowpea, greengram and groundnut are grown for mixed cropping cultivation because of their low water requirements and deeper root system and they can easily be grown in many areas along with the main crop without any supplemental irrigation. Advantages of intercropping cultivation have been reported by many workers (Nair *et al*., 1979; Ramdoss *et al*., 1980; Rai, 1986; Sharma *et al*., 1986; Patil and Mahendra, 1988 and Shah *et al*., 1991).

The objectives of the present work are to find out the type of weed communities that invades the crop field and to study the weed management techniques adopted by the farmers to improve the yield of mixed crops.

Correspondence to:
G. KUAMARAVELU, Department of Botany, Kanchi Mamunivar Centre for Post Graduate Studies, Lawspet, PUDUCHERRY (U.T.) INDIA

MATERIALS AND METHODS

A brief survey of the literature showed that several works on the weed association with the main crop and mixed crops were undertaken in different parts of India. To get information about weed plants, it is necessary to make a survey of the fields in different areas. Hence, an attempt has been made to study the crop-weed association in the sugarcane field with mixed cropping cultivation. The present investigation was carried out at Vinayagampet village of Puducherry, India. In this area, sugarcane is the chief crop as this place is very near to a sugar mill.

To identify the weed communities, three surveys were conducted between Mid-December 2006 and Mid-March 2007. Weed counts (number/m^2) were recorded at three stages, *viz.*, 20, 40 and 60 DAS of pulse crops. The distribution of weeds was studied by quadrat method. The quadrats were taken at random, the size of the quadrat being kept 100 × 100 sq.cm. Ten quadrats were laid randomly in the field area of 60 × 20 sq.m. The number of dicot and monocot species present in each quadrat was recorded. To avoid the "edge effects", distorting the data, peripheral areas adjoining the bunds 50 cm from the margin of the bunds were excluded from the analysis.

The weed flora species were identified by using the Flora of Presidency of Madras (Gamble and Fischer, 1915 – 1938), Illustrations on the flora of the Tamil Nadu Carnatic (Matthew, 1982), Further illustrations on the Flora

of Tamil Nadu Carnatic (Matthew, 1988), An excursion flora of central Tamil Nadu, India (Matthew, 1991). Weeds were collected, pressed, dried and the mounted herbarium sheets were deposited at the Herbarium of Kanchi Mamunivar centre for P.G. Studies, Puducherry.

The following parameters – Abundance, Density, Relative density, Frequency, Relative frequency were analyzed by the methods and formulae of Cottam and Curtis (1956). Importance Value Index (IVI) for the species was worked out by adding the figures of the relative density and relative frequency.

RESULTS AND DISCUSSION

Weed populations in a sugarcane crop field mixed with pulse crops as intercrops were monitored till the harvest of the mixed crops. Diversity and weed community composition were examined in sugarcane-pulse cropping system. In the experimental field, after the harvest of the sugarcane, the seeds were left for ratooning. The pulse seeds, chiefly groundnut, greengram and cowpea were sown in rows between the sugarcane ratoons. The weed seedling density increased over a period of 14 days. Changes in the weed flora composition at the time of intercropping cultivation were recorded in three phases. Hand weeding / hoeing was done at 20, 40, and 60 DAS. Hoeing resulted in decreased number of weeds.

At stage I (20 DAS), a total of 31 weed species belonging to 28 genera and 17 families were associated during the first stage prior to hand weeding/hoeing (Table 1 and 4). Of these, 26 plants were of dicot species and others were monocots. Among the monocots, grasses were dominant. Four different grasses were recorded *viz.*, *Cynodon dactylon, Cyperus rotundus, Dactylotaenium aegyptium* and *Eragrostis plumosa*. Among the different weeds found in the experimental field, the predominant ones were *Phyllanthus amarus, Commelina benghalensis, Cynodon dactylon, Cyperus rotundus* and *Acalypha indica*. In general broad-leaved weeds were most dominant. The dominant weeds on the basis of frequency and IVI included *Cyperus rotundus, Cynodon dactylon, Dactylotaenium aegyptium, Commelina benghalensis, Abutilon indicum* and *Trianthema portulacastrum* (Table 1).

At stage II (40 DAS), a total of 30 species belonging to 27 genera and 18 families were associated with this phase (Tables 2 and 4). Of these, 25 plants were of dicot species and others were monocots. Among the monocots, only the grasses were dominant. All the five monocots which were found during phase I appeared again even after hand weeding during the second phase. Among the different weeds found in the experimental field, the predominant ones were *Amaranthus viridis, Phyllanthus amarus, Commelina benghalensis, Acalypha indica* and *Ageratum conyzoides*. The less dominant species were *Cynodon dactylon, Oldenlandia umbellata, Cyperus rotundus* and *Eclipta prostrata*. During this phase also, the broad – leaved weeds were dominant. After the first hand weeding/hoeing, weeds like *Prosopis spicigera* and *Ricinus communis* failed to appear during the second phase.

At stage III, a total of 26 species belonging to 23 genera and 14 families were associated with this stage (Tables 3 and 4). Of these, 21 plants were dicot species and others were monocots. Among the monocots, all the five species continued to invade the field in spite of the two hand weeding /hoeing. Compared to the first stage, the number of monocot species was greatly decreased, the maximum number being 9 for *Dactylotaenium aegyptium* (Table 3). The total number of all the individuals of the species was 114 (Table 4). The predominant weeds in stage III were *Dactylotaenium aegyptium, Cyperus rotundus, Commelina benghalensis, Amaranthus viridis* and *Phyllanthus amarus*. The broad-leaved weeds like *Ageratum conyzoides, Ricinus communis* and *Croton bonplandianus* did not reappear after the second weeding process. *Ammania baccifera* and *Prosopis spicigera* were also not seen among the weed flora.

During the three months study, in all 28 genera and 32 species were recorded during pulse crop growth. The most frequent weeds were *Cynodon dactylon, Cyperus rotundus, Dactylotaenium aegyptium* and *Eragrostis plumosa* of grasses. Among other weeds, the predominant ones were *Phyllanthus amarus, Commelina benghalensis, Acalypha indica* and *Trianthema portulacastrum*. At the time of first hand weeding, maximum number of individuals was seen as *Commelina benghalensis* and *Phyllanthus amarus*. In general, broad-leaved weeds were most dominant during stage I. This was also confirmed in the earlier reports by Bana (1987).

Singh and Singh (1978) reported nearly 22 major types of weeds in a sugarcane field. Since the soil composition, seasons and cropping patterns of sugarcane play an important role, the types of weeds that crop up in a sugarcane field also differ in different localities. Srivastava *et al*. (1988), while studying the weed flora of sugarcane and its mixed crops in Muzaffarnagar, India, reported the occurrence of common weeds like *Bracharia, Cyperus, Digitaria, Eclipta, Eragrostis, Erigeron, Euphorbia, Malvastrum, Melilotus, Polypogon, Rumex* and *Vandelia*. In our study area, weed species like *Cyperus, Eclipta, Eragrostis* and *Euphorbia*

Table 1 : Weed flora encountered before the first hand weeding in the study plot

Sr. No.	Name	No. of individual	Density	Relative density	Frequency	Relative freq.	Abundance	IVI
1.	*Abutilon indicum* (L) G. Don	34	0.04	4.28	0.8	80	4.25	84.28
2.	*Acalypha indica* L.	37	0.05	4.66	0.7	70	5.28	74.66
3.	*Achyranthes aspera* L.	25	0.03	3.15	0.6	60	4.16	62.15
4.	*Ageratum conyzoides* L.	35	0.04	4.41	0.6	60	5.83	64.41
5.	*Amaranthus viridis* L.	25	0.03	3.15	0.7	70	3.57	73.15
6.	*Boerhavia diffusa* L.	30	0.04	3.78	0.7	70	4.28	73.78
7.	*Cleome viscosa* L.	27	0.03	3.40	0.6	60	4.50	63.40
8.	*Commelina benghalensis* L.	41	0.05	5.16	0.8	80	5.12	85.16
9.	*Croton bonplandianus* Bailion.	20	0.02	2.52	0.6	60	3.33	62.52
10.	*Cynodon dactylon* (L.) Pers.	38	0.05	4.78	0.9	90	4.22	94.78
11.	*Cyperus rotundus* L.	38	0.05	4.78	1.0	100	3.8	104.78
12.	*Dactylotaenium aegyptium* Willd.	31	0.04	3.90	0.9	90	3.44	93.90
13.	*Digera muricata* (L.) C. Martius	20	0.02	2.52	0.6	60	3.33	62.52
14.	*Eclipta prostrata* L.	28	0.03	3.53	0.7	70	4	73.53
15.	*Eragrostis plumosa*, Link.	12	0.01	1.51	0.5	50	2.4	51.51
16.	*Euphorbia hirta* L.	22	0.03	2.77	0.6	60	3.66	62.77
17.	*Euphorbia prostrata* Ait.	17	0.02	2.14	0.6	60	2.83	62.14
18.	*Glinus pentaphylla* Linn.	15	0.02	1.89	0.4	40	3.75	41.89
19.	*Gynandropsis pentaphylla* DC.	23	0.03	2.89	0.5	50	4.6	52.89
20	*Leucas aspera* (Willd.) Link.	26	0.03	3.27	0.7	70	3.71	73.27
21	*Oldenlandia umbellata* L.	30	0.04	3.78	0.6	60	5	63.78
22	*Phyllanthus amarus* Schum & Thonn.	42	0.05	5.29	0.7	70	6	75.29
23	*Physalis minima* Linn.	19	0.02	2.39	0.5	50	3.8	52.39
24	*Portulaca oleraceae* L.	16	0.02	2.01	0.7	70	2.28	72.01
25.	*Portulaca quadrifida* L.	18	0.02	2.27	0.7	70	2.57	72.27
26	*Prosopis spicigera* L.	16	0.02	2.01	0.5	50	3.2	52.01
27.	*Ricinus communis* L.	15	0.02	1.89	0.5	50	3	51.89
28	*Ruellia tuberosa* L.	21	0.03	2.64	0.6	60	3.5	62.64
29	*Trianthema portulacastrum*, Link.	24	0.03	3.02	0.7	70	3.43	73.02
30.	*Tridax procumbens* L.	28	0.03	3.53	0.9	90	3.11	93.53
31.	*Triumfetta annua* L.	21	0.03	2.64	0.6	60	3.5	62.64

were present. Apart from this, other types of weeds which were not reported in Mazaffarnagar sugarcane field were also present. Among them were *Cynodon, Dactylotaenium, Phyllanthus, Commelina, Acalypha, Abutilon, Trianthema* etc. The presence of new weed species in this sugarcane – pulse crop field suggests that different field conditions determine the type of weed flora in a crop field. And in intercrops, crop-weed-crop interaction, crop-weed exudates, fertilizers, irrigation and overall climate and soil conditions are well known factors to effect weed flora (Crafts and Robbins, 1973).

As regards the total number of weed species, it decreased with increased number of hand weeding / hoeing. Predominance of grasses like *Cynodon, Cyperus* and *Dactylotaenium* was observed in all the three stages. At stage I, the maximum value for IVI was observed for *Cyperus rotundus* (104.78) whereas at stage II, the maximum IVI value was for *Acalypha indica* (94.92). At stage III, *Dactylotaenium aegyptium* (77.81) showed the highest value of IVI. The IVI values showed a decreasing trend from stage I to III, because of frequent hand weeding. Similarly, decreased values were observed in density and abundance of various species at stage III. Analysis of the ratios of dicot : monocot families, dicot : monocot species and dicot genus : species in various stages showed an increasing trend in the number of monocot family and species. This clearly showed that monocot weed plants survived the weed control treatments rather than dicots. The ratio of dicot genus : species was slightly higher at stage III. The study also showed the presence of prostrate weed species, like *Euphorbia prostrata, Trianthema portulacastrum,*

Table 2 : A list of weed flora encountered before the second hand weeding in the study plot

Sr. No.	Name	No. of individual	Density	Relative density	Frequency	Relative freq.	Abundance	IVI
1.	*Abutilon indicum* (L.) G. Don.	11	0.02	2.46	0.6	60	1.83	62.46
2.	*Acalypha indica* L.	22	0.05	4.92	0.9	90	2.44	94.92
3.	*Achyranthes aspera* L.	15	0.03	3.35	0.6	60	2.5	63.35
4.	*Ageratum conyzoides* L.	23	0.05	5.14	0.6	60	3.83	65.14
5.	*Amaranthus viridis* L.	26	0.06	5.81	0.7	70	3.71	75.81
6.	*Ammania baccifera* L.	9	0.02	2.01	0.6	70	1.5	72.01
7.	*Boerhavia diffusa* L.	17	0.04	3.80	0.8	80	2.12	83.80
8.	*Cleome viscosa* L.	15	0.03	3.35	0.6	60	2.5	63.35
9.	*Commelina benghalensis* L.	24	0.05	5.37	0.7	70	3.43	75.37
10.	*Croton bonplandianus* Bailion.	12	0.02	2.68	0.7	70	1.71	72.68
11.	*Cynodon dactylon* (L.) Pers.	21	0.04	4.69	0.7	70	3.00	74.69
12.	*Cyperus rotundus* L.	20	0.04	4.47	0.7	70	2.85	74.47
13.	*Dactylotaenium aegyptium* Willd.	17	0.04	3.80	0.8	80	1.66	83.80
14.	*Digera muricata* (L.)C. Martius	10	0.02	2.23	0.6	60	2.72	62.23
15.	*Eclipta prostrata* L.	19	0.04	4.25	0.7	70	2.71	74.25
16.	*Eragrostis plumosa* Link.	8	0.01	1.79	0.5	50	1.6	51.79
17.	*Euphorbia hirta* L.	12	0.02	2.68	0.6	60	2.0	62.68
18.	*Euphorbia prostrata* Ait,	11	0.02	2.46	0.6	60	1.83	62.46
19.	*Glinus pentaphylla* L.	5	0.01	1.11	0.4	40	1.25	41.11
20.	*Gynandropsis pentaphylla* DC.	12	0.02	2.68	0.5	50	2.4	52.68
21	*Leucas aspera (Willd)* Link.	16	0.03	3.58	0.7	70	2.28	73.58
22	*Oldenlandia umbellata* L.	21	0.04	4.69	0.6	60	3.5	64.69
23	*Phyllanthus amarus* Schum and Thonn.	24	0.05	5.37	0.5	50	4.8	53.37
24	*Physalis minima* L.	14	0.03	3.13	0.6	60	2.33	63.13
25	*Portulaca oleraceae* L.	9	0.02	2.01	0.6	60	1.5	62.01
26.	*Portulaca quadrifida* L.	8	0.01	1.79	0.5	50	1.6	51.79
27.	*Ruellia tuberosa* L.	10	0.02	2.24	0.6	60	1.66	62.24
28.	*Trianthema portulacastrum* Link	8	0.01	1.79	0.6	60	1.33	61.79
29.	*Tridax procumbens* L.	15	0.03	3.35	0.7	70	2.14	73.35
30.	*Triumfetta annua* L.	13	0.03	2.91	0.7	70	1.86	72.91

Glinus pentaphylla etc. These weeds help in protecting the soil moisture by preventing evaporation from soil. Because of frequent hand weeding/hoeing, the crop and some of the dominant weeds avoided overlapping of their ontogenetic events and thereby the crop proved to be a beneficiary one on account of less competition from the weeds so far resource utilization from the soil was concerned. This is in conformity with the findings of Ojha (1983).

The fluctuations in the value of IVI, abundance and frequency of the weed flora in the three stages were due to mortality of some weeds and emergence of some new ones as seen in the second and third stage (Tables 2 and 3). *Ammania baccifera* appeared in the second stage *i.e.* between 20 and 40 DAS. Species like *Prosopis spicigera* and *Ricinus communis* disappeared from the field during the second stage of observation. After the eradication of these weeds by physical means, it failed to invade into the study area. Similar observation was also made by Rai and Tripathi (1984). The lowest weed population was recorded at 60 DAS, *i.e.* after two hand weedings at 20 and 40 DAS. Weed population was significantly decreased by hand weeding alone. This greatly reduced the total number of weeds from 794 to 114 in 60 × 20 sq.m. plot (Table 4).

Crop management:

In the study area, most of the beneficiaries were marginal farmers and so they were not using any type of herbicide for the fear of contamination of soil. An

Table 3 : A list of weed flora encountered before the third hand weeding in the study plot

Sr. No	Name	No. of individual	Density	Relative density	Frequency	Relative freq.	Abundance	IVI
1.	*Abutilon indicum* (L.) G. Don.	1	0.01	0.87	0.1	10	1.0	10.87
2.	*Acalypha indica* L.	4	0.03	3.51	0.3	30	1.33	33.51
3.	*Achyranthes aspera* L.	3	0.02	2.63	0.2	20	1.5	23.63
4.	*Amaranthus viridis* L.	6	0.05	5.26	0.4	40	1.5	45.26
5.	*Boerhavia diffusa* L.	5	0.04	4.38	0.4	40	1.25	44.38
6.	*Cleome viscosa* L.	6	0.05	5.26	0.4	40	1.5	45.26
7.	*Commelina benghalensis* L.	6	0.05	5.26	0.4	40	1.5	45.26
8.	*Cynodon dactylon* (L.) Pers.	4	0.03	3.51	0.3	30	1.33	33.51
9.	*Cyperus rotundus* L.	8	0.07	7.01	0.4	40	2.0	47.01
10.	*Dactylotaenium aegyptium* Willd.	9	0.08	7.89	0.7	70	1.28	77.81
11.	*Digera muricata* (L.) C.Martius	4	0.03	3.51	0.3	30	1.33	33.51
12.	*Eclipta prostrata* L.	5	0.04	4.38	0.4	40	1.25	44.38
13.	*Eragrostis plumosa,* Link.	5	0.04	4.38	0.4	40	1.25	44.38
14.	*Euphorbia hirta* L.	3	0.02	2.63	0.2	20	1.5	22.63
15.	*Euphorbia prostrata* Ait.	4	0.03	3.51	0.3	30	1.33	33.51
16.	*Glinus pentaphylla* Linn.	1	0.01	0.87	0.1	10	1.0	10.87
17.	*Gynandropsis pentaphylla* DC.	4	0.03	3.51	0.2	20	2.0	23.51
18.	*Leucas aspera* (Willd.) Link.	2	0.02	1.75	0.2	20	1.0	21.75
19.	*Oldenlandia umbellata* L.	4	0.03	3.51	0.3	30	1.33	33.51
20	*Phyllanthus amarus* Schum and Thonn.	7	0.06	6.14	0.4	40	1.75	46.14
21.	*Physalis minima* Linn.	3	0.02	2.63	0.2	20	1.5	22.63
22.	*Portulaca oleraceae* L.	2	0.02	1.75	0.2	20	1.0	21.75
23.	*Portulaca quadrifida* L.	5	0.04	4.38	0.4	40	1.25	44.38
24.	*Trianthema portulacastrum,* Link.	5	0.04	4.38	0.4	40	1.25	44.38
25.	*Tridax procumbens* L.	4	0.03	3.51	0.3	30	1.33	33.51
26.	*Triumfetta annua* L.	4	0.03	3.51	0.3	30	1.33	33.51

important feature of weed control adopted by the farmers is a preventive one. This is achieved by using the cleanest seed *i.e*. using seeds free from noxious weed seeds. Before sowing seeds, they were subjected to seed cleaning methods. The public concern about the side effects of herbicides on the environment and human health resulted in the practice of conventional methods of weed control by the farmers. In the present study, it was noted that the common type of methods followed in weed control are: 1. Burning the soil debris before sowing the mixed crop seeds. 2. Hand weeding and 3. Hoeing. The farmers did not resort to the use of herbicides.

Hand weeding/hoeing resulted in the reduction of emergence of weeds. Infact, the first hand weeding might have removed the later emerging weeds and improved aeration and nutrients by the crop. With two manual weeding/hoeing, weed control efficiency was noticed as evidenced from the data (Table 4). Considering the cost of other weed management techniques and also the scarcity of labour, it was found that frequent hand weeding is the most effective and a low cost weed control method in the study area.

Table 4 : Total number of weed species encountered during the three phases of weed flora study

Sr. No.	Variables	I	II	III
1.	Total number of genera	28	27	23
2.	Total number of families	17	18	14
3.	Total number of dicot weed species	26	25	21
4.	Total number of monocot weed species	5	5	5
5.	Total number of individuals in the study area	794	447	114

Stages I, II and III correspond to 20, 40 and 60 DAS.

Acknowledgment:

The author is highly grateful to Miss K. Suguna for the help in carrying out this work.

REFERENCES

Bana, O.V. (1987). Eco-physiological responses of the mixed crops, weeds and soil fungi of sugarcane against certain agro-chemicals. Ph.D. Thesis, Meerut University, Meerut, India.

Cottam, G. and Curtis, J.T. (1956). The use of distance measure in phyto-sociological sampling, *Ecology*, **37**: 451 – 460.

Crafts, A.S. and Robbins, W.W. (1973). *Weed control*. TMH Edition, New Delhi, pp. 85 – 119.

Gamble, J.S. and Fischer, C.E.C. (1915 – 1938). *Flora of the Presidency of Madras*. Vol. I – III. Adlord and Sons Ltd., London.

Matthew, K.M. (1982). *Illustrations on the flora of the Tamil Nadu Carnatic* (Vol. 2). The Rapinat Herbarium, St. Joseph's College, Tiruchirpalli, India.

Matthew, K.M. (1988). *Further illustrations on the flora of the Tamil Nadu Carnatic* (Vol. 4). The Rapinat Herbarium, St. Joseph's College, Tiruchirpalli, India.

Matthew, K.M. (1991). *An excursion flora of Central Tamil Nadu, India*. Oxford and IBH Publ. Co., New Delhi, India.

Moore, R.M. (1954). The nature of weeds. *Pastoral Rev*., 64: 497-499.

Nair, K.P., Patel, U.K., Singh, R.P. and Kaushik, M.K. (1979). Evaluation of legume intercropping in conservation of fertilizer nitrogen in maize culture, *J. agric. Sci.*, **93**: 189 – 193.

Ojha, J. (1983). Eco-physiological studies in linseed crop. Ph.D. Thesis. Magadh University, Bodh Gaya, Bihar.

Patil, B. P. and Mahendra, P. (1988). Influence of pearlmillet and legume intercropping systems on physico-chemical properties of soil, *Indian J. Agron.*, **33** (4) : 389 – 392.

Rai, P. (1986). Effect of intercropping annual grain legumes on the productivity of anjan grass, *Indian J. Agron*., **31**(2) : 147 – 153.

Rai, J.P.N and Tripathi, R.S. (1984). Population dynamics of different seedling. Cohorts of two co-existing annual weeds, *Galinsoga ciliata* and *G. parviflora*, on two contrasting sites. Acta Decologica (Series). *Decologia Plantarum*, **5** : 357 – 368.

Ramdoss, G., Thirumurugan, V., Subramanian, A. and Chamy, A. (1980). Intercropping studies in red gram, *Madras agric. J*., **67** (7): 464 – 466.

Sharma, K.C. Singh, Y., Gupta, P.L., Tripathi, S.K., Bhardwaj, A.K. and Singh, J.P. (1986). Plant population as spatial arrangement in wheat-mustard intercropping, *Indian J. Agron.*, **31** (2): 154 – 157.

Shah, M.H., Kaul, P.K., Khanday, B.A. and Kachroo, D. (1991). Production potential and monetary advantage index of maize intercropped with different grain legumes, *Indian J. Agron.*, **36** (1): 23 – 28.

Singh, G. and Singh, B.P. (1978). Chemical weed control in spring planted sugarcane, *Indian J. Sugarcane Tech.*, **1** (1): 23 – 28.

Srivastava, S., Deshawar, N. and Singh, L. (1988). Studies on weed flora of sugarcane and its mixed crops in Muzafffarnagar, *Ad. Plant Sci.*, **1** (2) : 144 – 151.

****
*****