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SESSION IV

(Paper 1)

Possible Approaches to Weed Management in Sorghum[1]

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ABSTRACT

Weeds are one the major production hazards in the cultivation of Sorghum (*Sorghum vulgare pers*). Weeds compete efficiently for both nutrients and moisture which are the two main limiting factors in rainfed Sorghum. The major weed flora of sorghum vary from place to place, but weeds like *Cyperus*, *Cynodon* and some annual grasses and broad leaved weeds seem to be common. *Striga* is a serious semi-parasite in many parts of the world. The period between 3 to 6 weeks after planting is considered to be the most critical period of crop-weed competition. Atrazine and propazine are the two most commonly used herbicides on sorghum. In this paper a brief description of the nature and extent of weed problems in sorghum and the various control measures adopted have been outlined. The concept of an Integrated Weed Management involving cultural, cropping, rotational, biological and chemical methods is described in detail. The more recent "non conventional" weed research involving "Systems approach" is highlighted with examples. The role of herbicides in the Integrated Weed Management Systems is also described briefly.

Introduction:

In India though it occupies the second largest area (18 million ha.) sorghum is mainly grown in areas that are less suitable for other major food grains such as rice and wheat. In general, Asian and African farmers growing this "Food of poor farmer" practice a highly traditional form of agriculture with very little impact of modern technology. One of the major production limiting factors in this important crop is the Weed Control. As this crop is mainly grown under less favourable conditions, often highly efficient weeds establish prior to the crop, resulting in very poor yields. Initially sorghum is slow in establishing and relatively small and week seedlings do not compete with weeds favourably. Weeds have always been associated with the production of crops, and because the damage they cause is not as obvious as that caused by insects, diseases and other pests, there often has not been a true appreciation of the magnitude of weed damage. Based on a very conservative yield reduction of 10 percent, the losses due to weeds in India's Sorghum production may be estimated to be of the extent of one million tons. In farmers' fields, losses in yields due to weeds are often considerably more than 10 percent and may be as high as 80 percent.

Weeds are injurious in using nutrients, moisture or light that the crop requires to yield well. Crop-weed competition is critical in areas of rainfed sorghum as weeds utilize the moisture and nutrients that would otherwise be available to the crop One of the important practices to store a greater quantity of available water and nutrients is to manage the weeds. The water and nutrient requirements of many weeds are considerably greater than those of sorghum. The water requirements of *Cynodon* and *Tridax*—the two common weeds of sorghum, are 813 and 1402 units respectively as compared to that of sorghum which is 430 units (Kamtkar & Gokhale, 1960). It was shown that the weeds remove soil nutrients at a faster rate than the crop in the early stages. For every unit of 4.5, 15 and 4.0 kg of N, P and K respectively removed by the weeds there was a mean reduction of 100 kg of sorghum grain yield (Sankaran and Mani, 1971). Under limited moisture and nutrient supply the competition is often so acute that the yields of sorghum are drastically reduced. In drought conditions in Kansas one weed per each 90 cm of sorghum row (spaced 50 cm apart) completely prevented grain production under conditions where the weed free crop yielded about 1250 kg/ha (Philips, 1960).

The crop is grown both in Kharif and Rabi. In many areas the crop is planted just prior to or soon after the monsoon rains resulting in simultaneous germination of weeds along with crop posing a serious problem. The weed infestation is further increased after every effective rainfall as such the extent of weed competition is more during kharif than rabi (Table 1 and 2). The yield reduction ranges from 20 percent to complete failure of the crop depending upon the weed flora, the time of infestation, management practices and the rainfall patterns.

The weed flora of sorghum varies from place to place depending upon soil type, season and other ecological factors. However, weeds like *Brachiaria, Cyperus, Cynodon, Dactyloctenium, Panicum, Paspalum, Desmodium, Corchorus, Digera*

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Euphorbia, Phyllanthus, Trianthema, Solanum, Echinochloa, Eragrostis, Amaranthus, Convolvulus. Sida etc seem to be common. (Table 3). In many locations perennial and "difficult to control" weeds like *Cynodon* and *Cyperus* are common. *Striga*, a semi-parasitic plant, is a serious problem in sorghum production throughout the semi-arid Asia and Africa. It is considered that *Striga* Sp are injurious by robbing the host of its water and minerals and to some extent carbohydrates, but there is some evidence that the parasite may also produce a toxin. There are many spicies of *Striga* which are known to parasitize sorghum, maize, rice, sugarcane etc. Heavy losses of sorghum and millet yields occur in many states like Gujarat, Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh and Rajasthan. In many locations farmers have to discontinue growing sorghum and millets over a large acerage due to heavy *Striga* infestation. A single *Striga* plant can produce thousands of seeds per year and these minute seeds can remain dormant in soil more than 20 years (Lal 1975).

Weed Control Methods :

Hand weeding is the most common practice by the local farmers. It is effective when it is done in time. Timely weeding is important than the frequency of weeding. At the experiment station we observed that the most critical period of crop-weed competition in sorghum was around 3 to 6 weeks after sowing (Table 1). It is interesting to note that if the crop is kept weed free for the first 4 weeks, about 75% of the maximum yield could be obtained. Farmers usually wait till the weeds grow fully (or for the weeds to become fodder) and the late weedings often result in poor yields. Another reason for delay in weedings is due to heavy and frequent rainfall especially on medium to deep black soil regions.

Rotary hoeing is recommended and may be carried till the stems begin to stiffen. Intercultivations with cultivators for wide row sorghums are also practised. Usually 1 to 3 shallow cultivations are necessary and it is claimed that 90 percent of the weeds that emerge with the crop or soon afterwards would be destroyed. However, in some cases cultivations may also damage the young seedlings and in many other cases cultivations may not be possible at all due to continuous wet soil situation.

Herbicides :

Table 4 summarises the herbicides commnoly recomended for sorghum throughout the werld (Hepworth and Fine, 1971). No single chemical has consistently proved safe, but propazine appears to be the safest at this time. Atrazine usually gives better control but it is less safe than propazine. Mani and Sankaran (1970) recommended propazine 0.5 kg/ha. preemergence followed by later one weeding. Noruron and atrazine, preemergence are recommended in West Indies. In Zambia and Nigeria atrazine seems to be popular. Propazine and prometryne are both recommended in Ceylon, while in the USSR atrazine propazine, prometryne and simazine are all recommended as preemergence treatments. Recently Ciba-Geigy has also recommended fluometuron. Mixtures have been developed like noruron with atrazine, or propazine with linuron, propachlor with propazine depending on the weed flora to increase the safety and effectiveness of preemergence treatments (Kasasian 1971).

Low rate of 2,4-D (0.5 to kg/ha) are recommended between the time the crop is 15 cm tall and flowering. The safest period appears to be when the plants are between 10 and 30 cm tall. Early treatments can be injurious by damaging the root systems and later treatment may make the plants more liable to lodge. Weeds resistant to 2,4-D may prove susceptible to 2,4,5-T or to dicamba which may be applied at 0.25 kg/ha post emergence. Atrazine and propazine and the mixtures of atrazine and propachlor are also recommended as post-emergence treatments (Phillips and Ross, 1965). The efficiency of post emergence application of diuron, propazine and atrazine can be increased by mixing them with a non-toxic oil or with paraquat and these mixtures (and paraquat alone) proved successful when applied as basally directed sprays (Jowett and Doggett, 1964). Paraquat may also prove useful in destroying weeds that are already established before seeding.

Many other herbicides are also found useful. At ICRISAT a continuous Herbicide Screening Program is underway to determine the effective economical, broad spectrum and safe herbicides for sorghum and the cropping systems involving sorgum (Tables 5 & 6). With our limited experience we observed some promising herbicides like prometryne, terbutryne, 2, 4-D amine, dinitramine, Gesaprim, Destun, Basalin and Tribunil. Further testing of these, as well as other new herbicide will be continued. Investigations on residual effects of these herbicides are also underway.

Striga :

Although hand weedings will check further seed production of *striga* they as control measures are not always satisfactory, since most of the damage occurs underground. Plant breeders concentrate on evolving resistant varieties of sorghum. Varieties such as N-13, No. 109, Co. 20 and Nandyal are reported to have good resistance. Post-emergence of one or more applications of 2, 4-D or MCPA at 1 kg a.i./ha after emergence of *striga* on sorghum can be effective. In USA repeated post-emergence application of 2, 4-D is regarded as the most economical way of getting rid of *Striga* (Kasasian, 1971.

The quickest method of eradicating *Striga* from heavily infested soil is the planting of trap crops like cotton, soybean, sunflower, cowpea and linseed. Interplanting of these crops also may help. 'Catch Crops' like millet, panicum, sudan grass can also be grown to induce a high percentage of seed germination. The catch crop and the *striga* are then destroyed or plowed under, before flowering of *striga*. Since many grasses and broad leaved weeds act as hosts, an intensive weed control program would help to control *Striga* Success can only be achieved by the coordinations of a number of practices and is dependent in many casesupon a complete change in Farming Policy.

The Integrated Weed Management Approach :

Weed management is a case of learning to live with weeds and to keep them at a level that does not interfere with crop production. There is an interdependence among weed control methods and currently much interest is being given to integrated programs involving cultural, cropping and chemical

methods When new chemical methods are integrated into systems involving cultural, cropping, rotational and biological methods, the outlook for weed management seems more hopeful The proper combination of agronomical methods, mechanical tillage and supplemental use of herbicides give maximum stability to any integrated weed management (Bantilan and Harwood, 1974) The concept of an integrated approach to weed control is more feasible under Semi-arid farming conditions, where mechanization, capital and farm size are limited apart from variable soil and climatic conditions. The main objective of the weed management should be to create the environment more favourable to crops than to weeds. Thus, the weed management recommendations should be designed in the form of packages consisting of cropping methods, techniques of cultural practice and the judicial and supplemental use of herbicides. A combination of this type may make weed control economically within the reach of the small rainfed farmer.

The use of crops to manage weeds is well known. Under high intensity cropping (double cropping and/or intercropping) weed management is quite easy (Tables 7 and 8). In the areas where only one crop is grown the weed problem is usually severe (Table 7). As more crops are grown per year the weed competition effects change because of the frequent tillage and competition from crops. The year-round Tillage (Dryden and Krishnamurthy, 1976) should be practiced mainly to combat weeds and to plant early (dry seeding) under improved seed bed conditions with bullock power, tillage and sending equipment. We foresee the high potential of supplemental application of low rate preemergence herbicides along with later physical or cultural methods of weed control. During the kharif, the herbicides which can be used on dry seed bed have greater scope (should be relatively resistant to photodecomposition) Planting the seeds of good quality and free of weed seeds, providing optimum plant population, beginning inter row tillage and hand wedding as early as possible and avoiding the production of weed seeds by tillage immediately after harvest etc may assist the farmers considerably in compating weeds. Therefore the weed research effort at ICRISAT have been directed to follow the "System approach" looking at the different systems of Weed Control in an effort to evolve an integrated weed management system, which can be fit into any viable farming systems of the Semi-arid tropics (Shetty and Krantz, 1976).

The ability of the sorghum cultivars to compete with the weeds depends largely on the rapidity of germination, emergence and root and shoot growth during the early stages of sorghum development (Guneyli *et al*, 1969). Such type of competitive cultivars and also those which are tolerant to commonly used and economical herbicides (Burnside and Wicks 1972) may be identified and recommended for cultivation. Before recommending any herbicide on any particular cultivar it is necessary to make sure the degree of herbicide tolerance of the particular variety. Therefore at ICRISAT trials have been initiated in collaboration with breeders to determine the herbicide tolerance of different cultivars of sorghum.

Apart from the useful role of herbicides in an Integrated Weed Management Program some chemicals also play vital role in creating minimum or Zero tillage conditions which are often practiced in semi-arid tracts of the world, not only to reduce the cost of tillage but also to enhance the soil moisture starage. Herbicides may also prove useful in preventing sorghum from ratooning if the next crop in the rotation is the one other than the ratoon sorghum. Investigation is under-way to select herbicides which would fulfil these objectives

Thus, future weed management approaches in rainfed sorghum should be designed to minimize losses due to weeds by means of a combination of techniques involving all the possible and economical feasible methods including the supplemental use of herbicides.

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TABLE 1

Grain yield of Sorghum (CSH-5) as affected by different Weed Management Treatments –Kharif 1975.

	Treatments	Yield q/ha	Grain yield as percent weed free	Weed dry matter q/ha at harvest
1	Weed free upto 2 weeks after showing (WAS)	12 4	58.8	55.8
2	Weed free upto 4 WAS	15.8	74.9	21.8
3	Weed free upto 6 WAS	18.3	86.7	12.2
4	One hand weeding 4 WAS	11.4	54.0	42.4
5	2 Hand weedings 4, 8, WAS	16.9	80.0	8.5
6.	Weed Free	21.1	100 0	0.0
7.	*Paraquat PPL 1 Kg a.i./ha	1.9	9.0	25.1
8	2,4-D Amine 1 Kg a.i./ha, post 1 H.W.→ 5 WAS	19.8	93.9	12.5
9.	*Treatment 7 + one Hand weeding, 2 WAS	9.5	45.0	17.8
10	Check	6.4	30.3	56.8
	L.S.D. .05	3.1		17.2
	C.V. =	24.0		28.0

*The planting in paraquat treated plots were delayed for two weeks Just before the planting paraquat was sprayed on the weed seedlings.

TABLE 2

Grain yield of Sorghum (CSH-5) as affected by different weed management treatments—Rabi 1975-76.

	Treatments	Rate kg a.i./ha	Yield in q/ha	Grain yield as percent weed free	Weed dry matter q/ha
1.	Ametryne	1 pre	32.68	70.4	4.45
2	Atrazine	1 pre	35.1	75.6	0.85
3.	Atrazine	1.5 pre	33.58	72.3	2.67
4.	Treat 2 + Atrazine	0.5 post	38.45	82.8	1.37
5.	Prometryne	1 pre	42.2	90.9	1.82
6.	Prometryne	1.5 pre	34.88	75.1	1.32
7.	Gesaprim	1 pre	41.98	90.4	2.62
8.	Gesaprim	1.5 pre	32.65	70.3	4.42
9.	Terbutryne	1 pre	31.35	67.5	4.12
10.	Hoeing 4 weeks after sowing		44.95	96.8	2.25
11.	Weed free		46.45	100.0	—
12.	Check		38.43	82.7	6.17
	L.S.D. 05		N.S.		1.5

TABLE 3

Major Kharif Weeds of Sorghum. Experimental Fields, ICRISAT 1975.

Scientific Name	Common Name	Family	Intensity (approximate % of total weeds
MONOCOT			
Brachiaria cruciformis Stapf.	Signal grass	Gramineae	8
Commelina Sp.	Day flower	Commelinaceae	9
Cynodon dactylon (L.) Pers.	Bermudagrass	Gramineae	11
Cyperus Sp.	Nutgrass	Cyperaceae	15
Dactyloctenium aegyptium L.	Crowfoot grass	Gramineae	2
Digitaria Sp.	Crabgrass	Gramineae	2
Paspalum Sp.	Field Paspalum	Gramineae	13
DICOT			
Acalypha indica L.	Copper leaf	Euphorbiaceae	2
Alletotus alba L.		Papilionaceae	7
Amaranthus viridis L.	Pigweed	Amaranthaceae	2
Corchorus olitorius L.	Jews mallow	Tiliaceae	3
Crotalaria Sp.	Crotalaria	Papilionaceae	2
Desmodium triflorum L.	Thornapple	Papilionaceae	7
Digera arvensis Forsk.		Amaranthaceae	2
Euphorbia hirta L.	Garden spurge	Euphorbiaceae	2
Launea asplenifolia L.		Compositae	2
Phyllanthus niruri L.	Niruri	Euphorbiaceae	4
Sida Sp.	Sida	Malvaceae	3
Striga lutea Lour	Witchweed	Scrophulariaceae	2 (late in season)

TABLE 4

Herbicides used in Sorghum around the world

Herbicide	Kg a /ha	Principal weeds controlled	Time of application	Remarks
Atrazine	1.5-3	Most annual broad-leaf weeds and grasses	Pre or Early Post	Apply before weeds are 4 cm tall Sorghum is more tolerant to post-emergence treatment
CDAA	4	Some annual broad-leaf weeds and most grasses	Pre	
Daplpon	7 4	Grasses	Preplt	
Dicamba	0.125-0 25	Most annual broad-leaf weeds	Post	Apply from 10 days after emergence of crop up to 25 days after emergence.
Diuron	0.25-0 5	Most annual broad-leaf weeds and grasses.	Post	Apply after sorghum is 35 cm tall Apply when weeds are 5 to 10 cm tall.
MCPA	0.25-1	Most annual broad-leaf weeds	Post	Apply when the sorghum is 15 to 25 cm tall and before tasseling
Na PCP	20	Most annual broad-leaf weeds and grasses	Pre	
Norea	1-3	Many annual broad-leaf weeds and grasses	Pre	
Norea + Atrazine	0.8 + 1.6	Most annual broad-leaf weeds and grasses.	Pre	
Norea + Propazine	1-1.5 + 1	-DO-	Pre	
Propachlor	5-6	-DO-	Pre	
Propazine	2	-DO-	Pre	
Propham	4-6	Some annual broad-leaf weeds and most grasses	Pre	
2, 4-D	0 25-1	Most annual broad-leafed weeds	Post	Apply when the sorghum is 10 to 30 cm tall

TABLE 5

Herbicide screening for Sorghum ICRISAT Kharif, 1975
(Visual Evaluations of Percent Crop Injury and Weed Control)

0 — No Effect
100 — Complete kill

Treatments	Rate Kg a.i./ha	% Crop Injury I	% Crop Injury II	% Weed Control II	% Weed Control III
PRE-EMERGENCE					
Nitrofen	2.0	80	70	50	40
Alachlor	2.0	70	80	30	15
Amiben	2.0	20	5	30	30
Dinitramine	0.5	10	0	20	15
Ametryne	1.0	10	0	25	25
Premetryne	1.0	5	0	65	50
Terbutryne	1.5	2	0	50	40
Bromoxynil	0.5	20	0	10	10
Fenetrol Plus	10.0*	40	70	60	50
Amex-820	2.0	15	10	60	40
Trifluralin	1.0	70	0	25	20
Modown	2.0	5	0	5	0
POST-EMERGENCE					
2, 4-D Amine	1.0	5	10	75	80
2, 4-D Ester	1.0	60	10	70	60
2, 4-D Ester	1.5	50	10	40	40
2, 4-D Salt	1.0	60	20	30	20
Paraquat	0.5	100	100	95	90
Terbutryne	1.5	30	50	30	60
Bromoxynil	0.5	10	0	40	25
Fenetrol Plus	10.0*	80	60	40	30
Delapon	2.5	60	30	40	50

* Commercial Product

Date of Application :

Pre-emergence : July 3, 1975
Post-emergence : July 28, 1975

Date of Planting : June 30, 1975

Date of Evaluation : I - Crop Injury : July 15, 1975
II - Crop Injury & Weed Control : August 20, 1975
III - Weed Control : September 5, 1975

TABLE 6

Herbicides screening for Sorghum—Rabi 1976-76—Visual Evaluation of Percent Crop injury and weed control

Treatments	Rate kg a.i./ha	% Crop injury				% Weed control		
		I	II	III	IV	I	II	III
PRE-EMERGENCE								
Dinitramine	0 5	2	0	0	0	50	80	80
Eradicane	1 Lit/ha*	40	45	0	0	10	20	20
Prefar	4 Kg/ha*	10	10	0	0	15	10	20
Devrinol	2	5	15	0	0	40	50	40
Vernam	2	50	80	80	70	30	20	15
Sutan	2	50	60	0	0	5	10	10
Terbutryne	1	10	20	15	0	60	75	70
Ametryne	1	10	15	15	0	45	70	70
FMC 25213	1	0	10	5	0	15	20	30
Enide 50W	3	0	5	0	0	15	20	25
Tribunil	4 Kg/ha*	0	5	10	0	25	45	40
Gesaprim	1	5	10	10	0	45	60	50
Destun	1	2	10	10	0	30	50	40
Eptam	3	30	45	30	0	10	15	10
Basalin	2	5	5	0	0	70	70	60
RH 2512	0.5	80	70	60	40	10	10	15
RH 2915	0.5	80	70	70	50	10	10	10
RH 8817	0 5	40	30	25	0	10	10	10
U 27267	2	10	10	15	15	25	45	40
Tok-E-40	2	80	90	70	60	20	15	10
POST-EMERGENCE								
Ancrack	2		30	40	0	35	40	40
Monex-3	2		40	90	100	40	80	45
Ansar 529	4 Kg/ha*		30	95	90	25	5	10
Basagran	2 Kg/ha*		5	0	0	25	30	15
MBR 12325	1		5	40	0	15	15	10
Broadside	2		30	80	80	10	10	10

*Commercial Product.

Evaluation scale : 0 = No effect. 100 = Complete kill.

Date of planting : November 17, 1975

Dates of application : Pre-emergence : Nov. 20, 1975
Post-emergence : Dec. 15, 1975

Date of Evaluation : Crop. injury : I) Dec. 1, 75 (II) Dec. 19, 75
III) Jan. 4, 76 (IV) Feb. 2, 76
Weed control I) Jan. 4, 76 (II) Feb. 2, 76 (III) Feb. 25, 76

TABLE 7

Average weed Intensity of Rabi Crops as affected by Kharif fallow and Kharif cropping—Rabi 1975-76. (Block Soil research watersheds)

Crops	Karif Corpped				Kharif fallow			
	Monocot	Dicot	Total	Weed dry matter g/s m at harvest	Monocot	Dicot	Total	Weed dry matter g/sq. m. at harvest
	Weed counts/½ sq m				Weed counts ½ sq m			
Sorghum	36	20	56	17.7	92	50	142	30.8
Chickpea	41	23	64	30.4	162	39	208	63.5
Sunflower	12	15	27	8.2	85	59	144	20.6
Safflower	32	24	56	22.3	74	46	120	28.5

TABLE 8

Mean weed dry matter weights in 60 day crop of Pigeonpeas with and without Sorghum (CSHS) intercrop; Kharif 1975.

Pigeonpea Varietal Type	Spacings with and without Sorghum intercrop	Weed dry matter weights (g/sq.m)
Spreading	75 cm with intercrop	40
Compact	—do—	36
Spreading	75 cm no intercrop	156
Compact	—do—	228
Spreading	150 cm with intercrop	40
Compact	—do	48
Spreading	150 cm no intercrop	178
Compact	—do—	240