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PROC. 8TH ASIAN-PACIFIC WEED SCI. SOC. CONF 1981. II VOL.

WEED RESEARCH: A COMPONENT OF ICRISAT'S FARMING SYSTEMS RESEARCH PROGRAM

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ABSTRACT

Weed research is an integral part of ICRISAT's farming systems research that aims to develop improved systems for the small farmer of limited means. Initial studies started in 1975 indicated that in the Indian Semi-Arid Tropics the farmer's level of weed control was usually satisfactory for his traditional systems, but it was concluded that he would respond to better weed control measures if they were part of improved and more remunerative systems. Some aspects of the ICRISAT research are described to illustrate how the cropping system itself may be manipulated to improve weed control. Some evidence is presented on the possible benefits of smother crops, and some examples are given of the role that herbicides could play in improved systems.

INTRODUCTION

ICRISAT was among the first of the international agricultural research centres to give formal recognition in its mandate to the need to supplement research on individual crops with research on farming systems. This research aims to develop technologies that are more productive, more stable and socio-economically viable, and it is primarily committed to helping the small farmer of limited means. It is multidisciplinary in nature and holistic in its approach. It covers a wide range of activities from Base Data Analysis, through On-Center Research to On-Farm Research.

Base Data Analysis consists of the compilation, synthesis and analysis of available data to determine research priorities and strategies and much of this work is carried out as farm surveys. On-Center Research examines those components of research that have important implications in technology development; research on individual components is often carried out in small plots but the integration of components into promising technologies is examined on an operational scale. On-Farm Research involves the further evaluation of promising technologies in a "real-world" farming situation, and it provides important feed back to the On-Center Research. As an integral part of farming systems research, weed research follows this same general pattern and it is within this framework that it is briefly discussed here.

BASE DATA ANALYSIS

From its inception in 1975, the weed research program was initially involved in a series of agro-economic on-farm investigations with the objectives of 1) evaluating the efficiency of farmers' own methods of weed control, 2) investigating whether alternate and improved methods of weed control were feasible and 3) assessing the pay off from additional weed control (Shetty, 1980).

These studies showed that in the Indian Semi-Arid Tropics farmer's weed control practices were based on rational consi-

derations in that the level of his weed control inputs were largely determined by the expected level of returns from those inputs (Binswanger and Shetty, 1977). Thus crops that were likely to give a good yield response were usually well weeded while those likely to give a poor response were often neglected. It was concluded from these studies that the farmer's level of weed control was appropriate for the farming systems that he practised. However, Binswanger and Shetty also considered that the farmer would accept increased weed control measures if these were an integral part of improved and more remunerative farming systems. Thus a primary objective of weed research at ICRISAT is to determine what weed management practices are suited to the improved farming systems being developed, and especially how these practices are best integrated with other components such as crop variety, cropping systems, machinery, tillage practices, fertility level, land and water management practices, and pest and disease management.

ON-CENTER RESEARCH

It is not the objective of this paper to give a detailed description of the On-Center Research, but rather to illustrate the kind of approach that is being used. As examples, some brief comments will be made on the importance of cropping system, on the possible role of herbicides, and on some of the operational research.

Cropping systems: The cropping systems of the small farmer of the Semi-Arid Tropics are complex and varied, and each may have its own weed problem and may require its own solution. This is well illustrated by some studies in millet/groundnut intercropping (Shetty and Rao, 1981). The dominant weeds in this system at ICRISAT center are *Digitaria ciliaris* Pers., *Celosia argentea* L., and *Cyperus rotundus* L., in terms of weed biomass, but their relative importance changes with the relative proportions of the two crops. As the proportion of groundnut increases, *Cyperus* decreases markedly, *Digitaria* increases a little, and *Celosia* increases markedly. The sharp increase in *Celosia* is attributed to the ability of this tall, competitive weed to dominate the groundnut canopy. The decrease in *Cyperus* on the other hand is attributed to the short stature of this weed and the severe shading caused by the groundnut canopy. Supplementary studies conducted with artificial shades also confirmed the extreme shade sensitivity of *Cyperus* compared to several other weeds. These findings emphasise how specific the weed problem may be to a particular cropping system and that in the case of intercropping systems, which are so important for the small farmers of the Semi-Arid Tropics, the problem may be considerably modified by the relative proportions of the component crops.

The intercropping system also serves as a good example of how the cropping system itself may be chosen to improve weed control. Studies have shown that in pigeonpea, a naturally slow-growing crop and a poor competitor against weeds, the weed infestation can be reduced by 50–75% with the introduction of intercrops such as cereals or low-canopy legumes (Rao and Shetty, 1976); indeed this is well known by farmers and the pigeonpea crop is very commonly intercropped. However, it should not be thought that intercropping always improves weed control. In the pigeonpea situation the improved control is brought about by the fact that the intercrop provides an *additional* population of plants so that the total population pressure on weeds is increased; moreover, the inter-

crop is usually much more competitive than the pigeonpea itself In other intercropping systems, such as the millet/groundnut one mentioned above, total population pressure is not increased because the introduction or increase in one component crop is offset by an equivalent decrease in the other Thus the severity of weed problems in these systems is usually intermediate between the problems of the respective sole crops, and largely dependent on the relative proportions of these crops

The importance of high plant populations has also been exploited in a 'smother-crop' system developed at ICRISAT Early maturing crops of cowpea [*Vigna unguiculata* (L) Walp] or mungbean [*V radiata* (L) Wilezek] have been added between the normal-spaced rows of cereal sole crops or cereal/pigeonpea intercrops Results indicated that this could reduce weeding costs by saving on one hand weeding Furthermore, the main crop yield was not significantly affected and the smother crop gave a small additional yield (Shetty, 1979)

Another aspect of increased plant population that has been studied is to reduce the within-row weeds by increasing the within-row competition from the crop For this purpose crops were grown in wider rows but the optimum plant population per unit area was still maintained by decreasing the within-row spacing In sorghum it was found that the common 45 cm width can be increased to 67 5 cm, and in some seasons to 90 cm without significant loss in grain yield Widening the rows has an additional advantage that the farmers can intercultivate more effectively with the local implements like blade harrows It was further observed that in these wider row widths the addition of a smother crop was likely to affect sorghum yields and, as indicated earlier, it could save on the costs of interrow weeding.

Herbicides On-Farm Studies (Binswanger and Shetty, 1977) showed that there is limited potential for herbicide use on rainfed crops in existing systems of the SAT areas of India because of cost considerations as well as the possible decrease in the income opportunities for the landless female labour However, in improved systems where the potential returns to improved weed control are high, herbicide use may be feasible in those situations where cultural control methods can be difficult An example of such a situation is the improved farming system developed at ICRISAT for the deep black soils of the Indian Semi-Arid Tropics in medium to high rainfall areas In these areas the land is traditionally left fallow during the rainy season and crops are grown during the post-rainy period on stored moisture These soils have a 50-60% content of montmorillonite clay and their major problem is limited workability during the rainy season, this restricts the opportunity for timely weed control either by cultivation or hand weeding An alternative system is the use of pre-emergence herbicides and thus a limited screening program has been conducted to identify those most suitable A further feature of the same farming system is a minimum tillage concept for establishing the post rainy season crop Thus by reducing the conventional tillage operations by using a herbicide, soil moisture conservation can be improved and the gap between harvesting of the rainy season crop and sowing of the post-rainy season crop can be minimised, both these features help towards greater assurance of establishment of the post-rainy season crop.

As a general point, ICRISAT experiments with herbicides have shown that

while herbicides give good control of susceptible weeds such as *Celosia argentea* L. on the red soils or *Brachiaria eruciformis* Griseb. on the black soils, this can lead to the proliferation of other weeds such as *Cyperus rotundus* L. and *Cynodon dactylon* Pers. The more practical weed management systems have thus been shown to be relatively low doses of herbicides combined with some measure of hand weeding and interculture to ensure the control of both susceptible and resistant weed species (Rao, 1980).

Operational research: An important feature of the ICRISAT weed research program is the testing of promising weed management options on a large scale to determine operational and economic feasibility. Currently, three different management systems are being tested on the operational watersheds on the deep black soils as part of a package of improved land and water management and improved cropping systems. These three systems are 1) a hand weeding system (two weedings in the rainy season crop and one in the post-rainy season crop), 2) a herbicide based system (a pre-emergence herbicide at the beginning of the rainy season crop with one hand weeding in the rainy season crop and one in the post-rainy season one), 3) a smother crop system in the rainy season crop and hand weeding as in 2). Results from the 1980-81 season (Table 1) indicated that for a sequential cropping system of maize followed by chickpea the hand weeding and herbicide based systems gave higher net returns than the smother crop system, largely because this last system reduced maize yields. In a sorghum/pigeonpea intercropping system, however, the herbicide based system and the smother crop system gave highest net returns. In each of the systems, weedy check and weed free treatments were included for comparison. In this year 5 hand weedings were required to keep the plots weed free. Interestingly, the weed free treatment gave the highest net returns indicating that in this particular season, even higher weeding input than used in the treatment was still economic.

Table 1. Effect of different weed management systems on crop yields and net returns from operational scale trials on deep black soils at ICRISAT center 1980-81.

	Sequential cropping system			Intercropping system		
	Maize (kg/ha)	Chickpea (kg/ha)	Net returns (Rs/ha)	Sorghum (kg/ha)	Pigeonpea (kg/ha)	Net return (Rs/ha)
Weedy check	2869	245	3686	1699	654	2974
Weed free	5307	512	6340	3841	1143	5213
Hand weeding system	4142	361	5022	2995	749	3874
Herbicide system	4321	415	5118	3080	936	4274
Smother crop system						
Mung	3411 (132)*	260	4333	2676 (105)	886	4266
Cowpea	3583 (156)	365	4874	2934 (171)	735	4265

* Figures in parentheses indicate the smother crop yields in kg/ha

FUTURE EMPHASIS

With the exception of the farm surveys for Base Data Analysis, weed research at ICRISAT to date has been confined to On-Center studies. These studies will continue to be an important part of the program, especially those that seek to exploit the natural competitiveness of the crop or cropping system. Herbicide use for specific situations will also continue to be explored. However, it is intended that successful testing of weed management systems on an operational scale at ICRISAT center will lead to further testing in the "real-world" situation of the farmer.

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