

Weed management strategies

in sugarcane-based intercropping systems

**Lalita Rana*, Navnit Kumar, Anil Kumar, Jitendra Rajput,
Manish Kumar and A K Singh**

Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar 848 125

Sugarcane is generally grown as a sole crop but due to its wider row spacing (90–120 cm) and long-duration nature, there are immense opportunities for intercropping with pulses, oilseeds, vegetable crops, medicinal and aromatic crops. Growing intercrops in between sugarcane rows can provide effective weed control for increasing productivity of sugarcane but still, there is a need to develop best strategies for controlling weeds for sustainable production of sugarcane.

Keywords: Bio-agent, Bio-herbicides, Intercropping, Weed management

INCREASING demand for food, fibre, and fuel for the human population necessitates bringing more area under cultivation to increase the production per unit area of available land and water resources. Due to globalization, it is difficult to bring the additional area under cultivation. Sugarcane (*Saccharum officinarum* L.) is an important commercial crop of India. It is the main source of sugar (80%) globally and holds a prominent position as a cash crop. In Bihar, the area under sugarcane cultivation is 0.2 million ha with an annual production of 16.5 million tonnes and productivity of 68 t/ha. Sugarcane is a long-duration crop that gets matured in

one or more than one year's plantation in wider rows and the growth of the crop is initially slow (up to 90–120 days) which favours the growth and development of weeds in the sugarcane fields and compete with the cane for nutrients, light, water and space leading to a drastic reduction in crop productivity.

Sugarcane intercropping with other crops is recognized as a potential system for not only providing the additional income and employment generation without increasing the additional area under cultivation but also overcoming the weed problems. Intercropping can go a long way in economising sugarcane

cultivation with a surplus yield of both component crops and their smothering effect on weeds, though it invites a careful selection of weed management options. Weed management in an intercropping system has always been an issue as concentrated efforts are required to provide a weed-free environment at regular intervals to both main/base and component crops for attaining higher productivity levels.

Adoption of multiple cropping, especially intercropping, using a holistic approach for managing weeds holds great potential in boosting agricultural productivity (Table 1). Herbicide usage in sugarcane monocropping is common but innovative

Table 1. Intercropping in autumn and spring-planted sugarcane with pulses and their associated weeds

Sugarcane	Intercrop	Weed flora
Autumn planted	Bengal gram (Chick Pea), French bean, Field pea, Lentil, Lathyrus, Wheat, Maize, Toria/Rapeseed-Mustard, Radish, Carrot, Sugarbeet, Potato, Cauliflower, Cabbage, Coriander, Nigella etc.	Narrow-leaved weeds: <i>Phalaris minor</i> , <i>Avena fatua</i> , etc. Broad-leaved weeds: <i>Chenopodium album</i> , <i>Cirsium arvense</i> , <i>Euphorbia hirta</i> , <i>Melilotus alba</i> , <i>Medicago denticulata</i> , <i>Oxalis corniculata/latifolia</i> , <i>Anagallis arvensis</i> , <i>Amaranthus viridis</i> , <i>Solanum nigrum</i> , <i>Physalis minima</i> , <i>Vicia sativa</i> , etc. Sedges: <i>Cyperus rotundus</i> , <i>Fimbristylis</i> spp., <i>Fumaria parviflora</i>
Spring planted	Mash bean, Mung bean, Soybean, Cowpea, Pigeon pea, Mentha, Cucurbits, Okra, and Maize etc.	Narrow-leaved weeds: <i>Cynodon dactylon</i> , <i>Digitaria sanguinalis</i> , <i>Eleusine indica</i> , <i>Sorghum halepense</i> , <i>Dactyloctenium aegyptium</i> , <i>Brachiaria</i> spp., <i>Echinochloa colonum</i> Broad-leaved weeds: <i>Ageratum conyzoides</i> , <i>Rumex</i> spp. <i>Ipomea</i> spp. <i>Eclipta alba</i> , <i>Digera arvensis</i> Sedges: <i>Cyperus rotundus</i> , <i>C. iria</i> , <i>C. difformis</i>

strategies need to be developed for intercropping systems. Providing a weed-free environment in sugarcane is essential to realize the full potential of a variety and to make the best use of the key production factors like nutrients, moisture and other natural resources.

Damage/losses caused by weeds in sugarcane

1. Estimate of crop losses due to weeds is an important alarm to the farmers, agricultural scientists, policy makers and public administrators of the country. Losses caused by weeds may be from 5–10% in the agriculture of developed countries, while losses can be up to 20–30% in developing countries or emerging countries.
2. Weed infestation promotes poor sugarcane growth, leads to a decline in sugarcane quality. Weeds carry diseases and insect pests that harm sugarcane, resulting in indirect losses.
3. Bermuda grass (*Cynodon dactylon*),

Cogan grass (*Imperata cylindrica*), and other grassy weeds are known to be alternate hosts to Ratoon Stunting Disease (RSD) of sugarcane.

4. Twining weeds like *Ipomoea* spp. and *Convolvulus* spp. are becoming a problem in many sugarcane growing areas, escalating the cost of cultivation besides decreasing cane yields. The twining weeds also cause serious harvesting problems.

Critical period of crop-weed competition (CWC)

CWC is very important in weed management. The critical period of

Table 2. Critical period of different crops

Crop	Critical period (days after sowing/planting)	
	From	To
Sugarcane	30	120
Blackgram/Greengram	30	45
Soybean	15	45
Groundnut	30	50
Gram	30	45
Lentil	30	45
Field Pea	30	50

weed competition is the shortest period during crop growth when weeding results in the highest economic returns. The critical period of weed competition is approximately 1/3rd of the duration of the crop (Table 2). CWC plays a crucial role in every crop. If weeding is not done at this period, crop yield is drastically reduced.

Integrated approach of weed management (IWM)

Weeds are the most competitive in their early growth stages than at later stages and hence, the growth is affected resulting in the decrease of yield. For keeping the weed population below the threshold level, there is a need to evolve an effective integrated strategy involving chemical and mechanical methods.

What is IWM?

It is a holistic approach for managing weeds by employing all measures of weed control in an integrated manner. It includes all



Intercropping of sugarcane with other crops; weed infestation.

practices that enhance a crop's competitive ability and decrease weeds' ability to reduce yield.

Why IWM?

One method of weed control may or may not be effective. Reliance on one method of weed control particularly herbicide application led to the development of herbicide-resistant weeds necessitating the integrated approach of weed management rather than the single weed management options.

Components of an IWM Plan:

The goal of IWM is to amalgamate different methods of weed control in one go. These are as follows:

- (a) Cultural method
- (b) Mechanical or physical method
- (c) Biological method
- (d) Chemical method
- (e) Preventive measures

(a) Cultural method:

1. **Crop rotation:** Crop rotation can aid in weed control by disrupting weed continuity. Crop rotation is a good way to get rid of annual and associated weeds. Weed control is improved by diversifying cropping systems with legumes and pulses.
2. **Mulching:** Mulching is a simple and effective technique for controlling weeds, saving time, and reducing labour. It decreases evaporation from the soil surface and maintains soil temperature, among other things. Mulching inhibits weed growth by blocking light from reaching the soil surface, which is essential for weed seed sprouting. Weed suppression

is more popular with organic mulches.

3. **Crop density and maintenance of plant population:** Crop density is an important component of the crop's ability to compete with weeds. The establishment of the ideal number of plants is crucial for obtaining maximum profits while cropping different species together.

4. **Proper fertilizer and water management:** Weed control can be achieved through good water management and balanced fertilization. Weed diversity, emergence, growth, dormancy, persistence and crop-weed competition are all affected by fertilizer application.

(b) Mechanical/physical method

1. **Hand hoeing and weeding:** Weed control in the intercropping system is relatively more difficult than in the sole cropping of the component crops. The predominant method of weed control in intercropping is manual such as hand hoeing, hand weeding, etc.
2. **Use of weeder designed for intercropping:** Very few weeding implements have been developed for weed control in intercropping systems. However, it is very difficult to control weeds through a mechanical weeder.

(c) Biological method

In the biological control method, it is not possible to eradicate weeds but the weed population can be reduced although this strategy does

Table 3. Bio-agents for weed control

Bio-agents	Weeds
Flea beetle (<i>Agasicles hygrophila</i>)	Alligator weed (<i>Alternanthera philoxeroides</i>)
A shoot borer moth (<i>Bacteria</i> spp)	Nutsedge (<i>Cyperus rotundus</i>)
Beetle (<i>Zygogramma bicolorata</i>)	Congress/Carrot grass (<i>Parthenium hysterophorus</i>)

not work for all sorts of weeds. Biological control can be effective but usually requires long periods of quarantine, can be quite expensive, and has limited effectiveness. Due to the widespread use of pesticides and fungicides in modern agriculture, the bio-agent will not be able to function on the host weed (Table 3). However, it can be employed if pesticides are not used (herbicides). Bio-agents should be host specific and they should not attack other economic plant spp.

Bio-herbicides

Bioherbicides may be compounds derived from microbes such as fungi, bacteria or protozoa, phytotoxic plant residues, extract, or single compounds derived from other plant species. A bio-herbicide based on a fungus is called myco-herbicide. Bio-herbicides and other bio-pesticides are often referred to as "naturals". Some examples of bio-herbicide are given in Table 4.

2. Chemical method: Herbicides are being extensively used for weed control in many sugarcane growing countries of the world for the following reasons (1) Scarcity of Labour (2) Conventional methods

Tractor operated intra row cum inter row weeder for orchards

A low hp tractor operated intra row cum inter row weeder was developed. It is easy to extend and retract the rotary unit by swiveling action of hydro-mechanically controlled sensor. Hence, there is no need of ultra light sensor based movement of the arm. In the weeder, wrap around frame ensures upfront visibility to the operator. Mechanical linkages with hydraulic mechanism were used to reduce cost of the machine. The effective field capacity of the machine is 0.17 ha/h with 89% field efficiency in pomegranate orchard and 0.15 ha/h with 81% field efficiency in grape vineyard. The weeding efficiency of the machine is 95%. There is net saving of ₹1,775/ha in pomegranate orchard and ₹1,480/ha in grape vineyard over traditional method.



Source: ICAR Annual Report (2020)

Table 4. Bio-herbicide for weed control

Bio-herbicide/ Myco-herbicide	Microorganism	Weed
BioMal	A formulation of <i>Colletotrichum gloeosporioides</i> f.sp. <i>malvae</i> ,	Control of round leaf mallow (<i>Malva pusilla</i>)
Collego	<i>Colletotrichum gloeosporioides</i> f.sp. <i>aeschynomene</i>	Control of northern joint vetch (<i>Aeschynomene virginica</i>)
Sarritor	A formulation of <i>Sclerotinia minor</i>	Control of dandelion (<i>Taraxacum officinale</i>), white clover (<i>Trifolium repens</i>) and broadleaf plantain (<i>Plantago major</i>)
Bipolaris	A suspension of fungal spores of <i>Bipolaris sorghicola</i> .	Johnson grass (<i>Sorghum halepense</i>)

Table 5. Herbicides used in sugarcane intercropping system

Intercropping system	Herbicide use
Sugarcane + mung bean	Pendimethalin @0.75 kg a.i./ha (PE) at 10 DAP Trifluralin @1.0 kg a.i./ha (PE) at 10 DAP
Sugarcane + pigeon pea/ groundnut	Pendimethalin @1.0 kg a.i./ha (PE) at 7-10 DAP Fluchloralin @1.0 kg a.i./ha (PPI)
Sugarcane + soybean/blackgram/ groundnut	Thiobencarb @2.5 kg a.i./ha (PE) 10 at DAP
Sugarcane + soybean	Diuron @2.0 kg a.i./ha (PE) + Dimethametryn @3.0 kg a.i./ha (POE) at 90 DAP
Sugarcane + maize	Atrazine @1.5-2.0 kg a.i./ha
Sugarcane + potato	Metribuzin @0.75-1.0 kg a.i./ha
Sugarcane + wheat	Sulfosulfuron + metsulfuron @30 g/ha Mesosulfuron + iodosulfuron @21.6 g/ha Carfentrazone-ethyl @20 g/ha

PE = Pre emergence, PPI = Pre-plant incorporation, DAP = Days after planting

Note: If pulse crop is to be raised as an intercrop in sugarcane, do not use Atrazine.

being inefficient as they are time-consuming and costly (3) Initial weed growth cannot be controlled by conventional methods (4) Timely weeding is becoming difficult by conventional methods. One cannot

rely entirely on herbicides for weed control. Many weed species are developing herbicide resistance, making chemical control less effective and more costly. Because herbicides are crop-specific, it has been difficult to find compounds that control a broad spectrum of weeds without causing damage to the component crops of the intercropping systems. Even though some advances have been made in chemical control in intercropping systems (Table 5). Five important questions must be answered when considering the use of herbicides in an intercropping system including which herbicides are effective in producing a high level of mortality with a minimal need for re-treatment; what are the effects of herbicide on non-target species including residual effects of the herbicide soil; what is the most effective and cost-efficient mode of application; are skilled and trained personnel available to apply the herbicide or not, and are there local, state or federal restrictions for the use of a particular herbicide.

*Corresponding author's e-mail:
lalita@rpcu.ac.in

List of improved released varieties/hybrids of commercial crops

Variety	Area of adoption	Characters
Sugarcane (<i>Saccharum</i> sp. Hybrid)		
CoC 13339	Tamil Nadu, Andhra Pradesh and Odisha (Coastal areas)	Suitable for irrigated areas, average cane yield: 117.97 t/ha, moderately resistant to red rot and YLD, moderately resistant to smut.
Karan 14 (Co 13035)	Haryana, Rajasthan, Punjab, Uttarakhand and Central and Western Uttar Pradesh	Suitable for mid-late group for North-West zone, average cane yield 86.76 t/ha, Reaction to red rot is resistant to moderately resistant, least susceptible to shoot borer, top borer and stalk borer.
Sahaj-3 (CoS 12232)	Punjab, Haryana, Uttarakhand, Rajasthan and Central and Western Uttar Pradesh	Suitable for medium and high fertility soil under irrigated areas, average cane yield: 88.86 t/ha moderately resistant reaction to red rot and smut.
Sankalp (Co 12009)	Tamil Nadu, Kerala, Interior Andhra Pradesh, Telangana, Karnataka, Gujarat, Maharashtra, Madhya Pradesh and Chhattisgarh	Suitable for irrigated conditions, average cane yield: 119.65 t/ha, moderately resistant reaction to red rot, smut and YLD, less moderately susceptible to shoot fly and highly susceptible to internode borer.
Vasista/ Pampavathi [2009A 107 (CoA 14321)]	Andhra Pradesh	Suitable for irrigated and rainfed conditions, average cane yield: 131.07 t/ha, moderately resistant to red rot, smut, wilt and YLD diseases, moderately susceptible to early shoot borer, internode borer and scale insect pests.
Arundhati/Naveen [2009 A 252 (Co A 14-323)]	Andhra Pradesh	Suitable for irrigated condition, average cane yield: 124.10 t/ha, moderately resistant to red rot, smut, wilt and YLD diseases, moderately susceptible to early shoot borer, internode borer and scale insect pests.
Rajendra Ganna-1 (CoP16437) × (Co 08139)	Bihar	Suitable for irrigated upland condition, average cane yield: 99.50 t/ha, moderately resistant to red rot, smut and wilt diseases, moderately susceptible to shoot and root borer, top borer and stalk borer.

Source: ICAR Annual Report (2020)