

## Integrated weed management for sugarcane (*Saccharum officinarum*) plant-ratoon cropping system

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### ABSTRACT

A field experiment was conducted during 2000-03 and 2001-04 to evolve suitable and economical integrated weed-management technologies for sugarcane (*Saccharum officinarum*) plant and ratoon crops. The treatments comprised four different weed-management practices for plant (chemical, integrated, interculture and weedy check) and ratoon (integrated, trash mulching, interculture and weedy check). In plant crop the integrated method (one hoeing after first irrigation followed by spraying of atrazine 2 kg/ha after second irrigation in moist soil) and in ratoon crop the integrated method (one hoeing followed by spraying of atrazine 2 kg/ha in moist soil at ratoon-initiation stage) or trash mulching were observed to be better weed-management technologies for cane production, involving less costs. Rice-mustard-sugarcane (plant)-ratoon-wheat cropping system was found more economical than rice-wheat-sugarcane (plant)-ratoon-wheat cropping system.

**Key words :** Weed control, Chemical, Interculture, Trash mulching, Sugarcane, Cropping system

Sugarcane (*Saccharum officinarum* L.) crop occupies an important position in Indian agriculture, as it sustains the second largest organized agro-industry in the country next only to textiles. However, its productivity in India is low compared with that in many other sugarcane growing countries of the world. Among the factors for low productivity, negligence towards weed management is the most important, as the losses due to weeds range from 40% reduction in cane yield to total crop failure (Srivastava, 2001). Large number of weeds flourish in sugarcane fields due to slow initial growth of the crop, wide spacing between the crop rows, frequent and heavy irrigations, application of heavy doses of manures and fertilizers, and the warm and humid climate during a large part of the growing season. Therefore integrated weed management in sugarcane crop is a vital necessity if good yields are aimed at.

### MATERIALS AND METHODS

To achieve this objective, field experiments were carried out during 2000-03 and 2001-04 at the farm of Regional Research Station of the University at Karnal in split-plot design replicated thrice. The treatments comprised of two cropping systems and four weed-management practices in sugarcane plant crop in main plot, and four weed-management practices in sugarcane ratoon crop in sub-plot. The cropping systems were : (i) rice-mustard-sug-

arcane (plant)-ratoon-wheat; and (ii) rice-wheat-sugarcane (plant)-ratoon-wheat.

The weed-management practices in sugarcane plant crop were : chemical atrazine 2.0 kg a.i/ha as pre-emergence, followed by 2,4-D Na 1.0 kg a.i/ha at 60 days after planting; (ii) integrated : one hoeing after first irrigation followed by atrazine 2.0 kg a.i/ha after second irrigation in moist soil, avoiding muddy condition; (ii) intercultural operations as per local practice; and (iv) weedy check. The weed management practices in sugarcane ratoon crop were: (i) integrated : one hoeing followed by atrazine 2.0 kg a.i/ha at ratoon-initiation stage in moist soil; (ii) trash mulching; (iii) intercultural operations as per local practice; and (iv) weedy check.

After growing rice (*Oryza sativa* L.), mustard (*Brassica juncea* L.), wheat (*Triticum aestivum* L. emend Fiori. & Paol.) crops were grown as per their recommended practices. The weed-management treatments were applied in sugarcane plant crop, which were superimposed by those of sugarcane ratoon crop. Wheat crop was taken at the end of the crop cycle as per recommended practices. Except weed-management treatments, all other agronomical practices for sugarcane plant and ratoon crops were followed as per recommendations. Soil of the experimental field was loamy, having pH 8.1, being medium in availability of P and K and low in that of N.

## RESULTS AND DISCUSSION

### Weed flora

The intensity of weeds varied due to various cropping systems. Major weeds present in the sugarcane plant crop grown after mustard were : *Cyperus rotundus* (51.4%) *Cynodon dactylon* (20.9%), *Trianthema monogyna* (17.7%) and *Convolvulus arvensis* (4.0%); and those in sugarcane after wheat were : *Cyperus rotundus* (42.7%), *Cynodon dactylon* (21.4%), *Trianthema monogyna* (19.7%) and *Echinochloa colonum* (10.2%). The prominent weeds in ratoon crop of sugarcane were: *Cyperus rotundus*, *Dactyloctenium aegyptium*, *Cynodon dactylon* and *Sphenochlea* spp; besides some others differing due to treatments applied in the preceding plant crop of sugarcane (Table 1).

### Effect on weeds

Although weed management in sugarcane through intercultural operations has always given good results, in

this study encouraging results have been observed also by integrated method. In the plant crop of sugarcane, weed density and dry-matter accumulation by weeds were observed minimum under intercultural operations, which were statistically on a par with that of integrated method and significantly superior to chemical treatment and weedy check (Table 2). In south India Mahadevaswamy *et al.* (1994) also reported reduction in the dry-matter accumulation of weeds by integrated method of weed management in sugarcane.

In ratoon crop of sugarcane, intercultural operations, trash mulching and integrated method, being statistically on a par with each other, significantly reduced the density and dry weight of weeds compared with the weedy check (Table 3). However, integrated method could not prove equal to intercultural operation during the first cycle of experimentation. It shows that trash mulching and integrated method can be successfully adopted for effective weed control in sugarcane ratoon. Under integrated

**Table 1.** Composition and intensity (%) of weed flora in sugarcane ratoon crop as affected by different treatments

| Treatment applied in plant cane | Rice-mustard-sugarcane-ratoon-wheat |      |      |     |     |      |      |      | Rice-wheat-sugarcane-ratoon-wheat |      |   |     |      |      |      |   |
|---------------------------------|-------------------------------------|------|------|-----|-----|------|------|------|-----------------------------------|------|---|-----|------|------|------|---|
|                                 | Weed species                        |      |      |     |     |      |      |      | Weed species                      |      |   |     |      |      |      |   |
|                                 | A                                   | B    | C    | D   | E   | F    | G    | H    | A                                 | B    | C | D   | E    | F    | G    | H |
| Chemical weed control           | 75.3                                | 15.1 | 2.4  | -   | -   | -    | -    | -    | 89.1                              | 8.6  | - | -   | 1.4  | 0.9  | -    | - |
| Intercultural weed control      | 53.6                                | 13.4 | 19.6 | 2.7 | 8.9 | 1.8  | -    | -    | 81.5                              | 7.3  | - | -   | 8.4  | 2.8  | -    | - |
| Integrated weed control         | 62.3                                | 16.4 | -    | 5.7 | 9.8 | 2.5  | 3.3  | -    | 82.8                              | 10.9 | - | 1.6 | 3.1  | 1.1  | 0.5  | - |
| Weedy-check                     | 73.3                                | 16.2 | -    | -   | 8.6 | -    | -    | 1.9  | 81.4                              | 6.8  | - | -   | 11.8 | -    | -    | - |
| Mean                            | 66.1                                | 15.3 | 5.8  | 3.0 | 7.4 | 1.07 | 0.82 | 0.47 | 83.7                              | 8.4  | - | 0.4 | 6.2  | 1.42 | 0.12 | - |

A=*Cyperus rotundus*; B=*Dactyloctenium aegyptium*; C=*Cynodon dactylon*; D=*Coronopus didymus*; E=*Sphenochlea* spp. F=*Melilotus alba*; G=*Convolvulus arvensis*; and H=*Fumaria parviflora*

**Table 2.** Population and dry weight of weeds, cost involved in weed-control treatments, and growth, yield and quality of sugarcane as affected by different weed-control methods applied in sugarcane plant crop under various sugarcane-based cropping systems

| Treatment                  | Population (no./m <sup>2</sup> ) |          | Dry weight of weeds (g/ha) |          | Cost (Rs/ha) involved in weed-control treatment |          | Sugarcane (plant) |          |                  |          |                          |          |                   |          |         |          |
|----------------------------|----------------------------------|----------|----------------------------|----------|-------------------------------------------------|----------|-------------------|----------|------------------|----------|--------------------------|----------|-------------------|----------|---------|----------|
|                            |                                  |          |                            |          |                                                 |          | Germination (%)   |          | Shoots ('000/ha) |          | Millable canes ('000/ha) |          | Cane yield (t/ha) |          | CCS (%) |          |
|                            | I cycle                          | II cycle | I cycle                    | II cycle | I cycle                                         | II cycle | I cycle           | II cycle | I cycle          | II cycle | I cycle                  | II cycle | I cycle           | II cycle | I cycle | II cycle |
|                            |                                  |          |                            |          |                                                 |          |                   |          |                  |          |                          |          |                   |          |         |          |
| <b>Weed-control method</b> |                                  |          |                            |          |                                                 |          |                   |          |                  |          |                          |          |                   |          |         |          |
| Chemical                   | 314                              | 402      | 4.7                        | 5.7      | 1,729                                           | 1,735    | 39.1              | 37.6     | 163.9            | 153.4    | 105.9                    | 96.3     | 74.4              | 67.1     | 11.6    | 11.9     |
| Interculture               | 262                              | 186      | 3.9                        | 3.1      | 4,740                                           | 4,800    | 39.2              | 37.9     | 185.5            | 174.9    | 117.3                    | 109.4    | 82.0              | 74.3     | 11.3    | 11.7     |
| Integrated                 | 292                              | 218      | 4.4                        | 3.9      | 2,897                                           | 2,920    | 39.3              | 37.9     | 173.5            | 166.3    | 113.4                    | 104.7    | 79.4              | 72.5     | 11.4    | 11.7     |
| Weedy check                | 732                              | 714      | 11.3                       | 12.0     |                                                 |          | 39.1              | 37.8     | 128.5            | 115.3    | 86.7                     | 78.1     | 60.0              | 53.4     | 11.6    | 11.8     |
| CD (P=0.05)                | 46                               | 45       | 0.8                        | 0.8      |                                                 |          | NS                | NS       | 11.5             | 12.1     | 7.1                      | 7.5      | 4.8               | 5.1      | NS      | NS       |
| <b>Cropping system*</b>    |                                  |          |                            |          |                                                 |          |                   |          |                  |          |                          |          |                   |          |         |          |
| R-m-s-r-w                  | 388                              | 369      | 5.9                        | 6.0      |                                                 |          | 38.2              | 37.8     | 166.4            | 153.2    | 108.1                    | 97.6     | 77.8              | 67.2     | 11.6    | 11.7     |
| R-w-s-r-w                  | 412                              | 391      | 6.2                        | 6.4      |                                                 |          | 40.2              | 37.8     | 159.3            | 151.7    | 103.5                    | 96.7     | 70.1              | 66.5     | 11.4    | 11.8     |
| CD (P=0.05)                | NS                               | NS       | NS                         | NS       |                                                 |          | NS                | NS       | NS               | NS       | NS                       | NS       | 3.4               | NS       | NS      | NS       |

\*R, rice; m-mustard; S, sugarcane (plant); r, ratoon; w, wheat

method, both in plant and ratoon crops, the initial populations of weeds were buried by one hoeing and thereafter atrazine spray minimized further emergence of weeds, thus keeping the competition of weeds with the crop below the critical level.

### Effect on sugarcane crop

Germination % of sugarcane was not affected by weed-management practices, but other growth and yield characters varied significantly due to these treatments. In the plant crop, the integrated method proved statistically on a par with intercultural operations in respect of shoot population, number of millable canes and cane yield; whereas chemical method was found significantly inferior to intercultural operations for these parameters (Table 2). The variations in growth and yield of sugarcane might be the result of varying weed population caused by different weed-management treatments. Thus integrated method was found an alternative to intercultural method of weed management for obtaining good yield of sugarcane. The quality of sugarcane did not vary due to weed management treatments.

In the ratoon crop all the three methods of weed management (intercultural, integrated and trash mulching) proved equally effective for the production of shoots, number of millable canes as well as cane yield, and these

treatments were significantly superior to weedy check (Table 3). However, during the first cycle of experimentation, the integrated method could not prove statistically on a par with intercultural operations. Thus the production of sugarcane ratoon was influenced mainly by the weed population present in the plots of respective weed-management treatments. It shows that successful cultivation of sugarcane ratoon can be done by controlling weeds through integrated method and trash mulching, replacing the old practice of intercultural operations, which requires a lot of manual labour. Encouraging results due to integrated weed management in sugarcane have been realized earlier also (Srivastava *et al.*, 1997).

The yields of the component crops of the systems, i.e. rice, mustard and wheat, were 56.4 q/ha (rice var. 'Govind'), 22.2 q/ha (mustard var. 'RH 30') and 47.8 q/ha (wheat var. 'PBW 343') during the first cycle of experimentation; and 21.0 q/ha (basmati rice var. 'HBC 19'), 11.0 q/ha (mustard var. 'RH 30') and 42.5 q/ha (wheat var. 'PBW 343') during the second cycle of experimentation. The reason of poor yield of mustard during the second cycle of experimentation might be very late sowing of mustard, i.e. on 19 November.

### Economics of treatments

The costs involved per hectare for weed-control treat-

**Table 3.** Population and dry weight of weeds, cost involved in weed-control treatment, yield and quality of ratoon sugarcane as affected by different weed-control treatments

| Treatment                                      | Weeds/m <sup>2</sup> |             | Dry weight<br>of weeds<br>(q/ha) |      | Cost<br>(Rs/ha)<br>involved in<br>weed-control<br>treatment |       | Sugarcane (ratoons) |             |                                |             |                         |             |            |             |
|------------------------------------------------|----------------------|-------------|----------------------------------|------|-------------------------------------------------------------|-------|---------------------|-------------|--------------------------------|-------------|-------------------------|-------------|------------|-------------|
|                                                | I<br>cycle           | II<br>cycle |                                  |      |                                                             |       | Shoots<br>('000/ha) |             | Millable<br>canes<br>('000/ha) |             | Cane<br>yield<br>(t/ha) |             | CCS<br>(%) |             |
|                                                |                      |             |                                  |      |                                                             |       | I<br>cycle          | II<br>cycle | I<br>cycle                     | II<br>cycle | I<br>cycle              | II<br>cycle | I<br>cycle | II<br>cycle |
|                                                | I<br>cycle           | II<br>cycle |                                  |      |                                                             |       |                     |             |                                |             |                         |             |            |             |
|                                                |                      |             |                                  |      |                                                             |       |                     |             |                                |             |                         |             |            |             |
| <i>Weed-control method in ratoon sugarcane</i> |                      |             |                                  |      |                                                             |       |                     |             |                                |             |                         |             |            |             |
| Integrated                                     | 237                  | 61          | 3.7                              | 0.9  | 2,920                                                       | 3,150 | 163.5               | 169.3       | 97.1                           | 101.4       | 72.0                    | 70.8        | 12.0       | 12.1        |
| Interculture                                   | 52                   | 44          | 0.9                              | 0.6  | 4,800                                                       | 5,400 | 186.5               | 172.6       | 110.6                          | 103.5       | 81.8                    | 72.3        | 11.9       | 12.0        |
| Trash mulch                                    | 95                   | 87          | 1.5                              | 1.3  | 640                                                         | 720   | 180.9               | 166.5       | 107.4                          | 99.8        | 79.5                    | 70.1        | 11.9       | 11.9        |
| Weedy check                                    | 1,123                | 932         | 17.6                             | 14.0 |                                                             |       | 126.0               | 113.4       | 75.4                           | 66.7        | 54.3                    | 42.7        | 11.8       | 11.8        |
| CD (P=0.05)                                    | 52                   | 46          | 0.9                              | 0.7  |                                                             |       | 12.8                | 13.4        | 8.1                            | 8.6         | 5.4                     | 6.2         | NS         | NS          |
| <i>Weed-control method in plant cane</i>       |                      |             |                                  |      |                                                             |       |                     |             |                                |             |                         |             |            |             |
| Chemical                                       | 378                  | 264         | 5.9                              | 4.0  |                                                             |       | 164.2               | 156.8       | 98.0                           | 94.3        | 72.7                    | 65.1        | 11.9       | 11.8        |
| Interculture                                   | 281                  | 207         | 4.3                              | 3.1  |                                                             |       | 172.7               | 162.7       | 102.9                          | 97.5        | 75.7                    | 67.2        | 12.0       | 12.1        |
| Integrated                                     | 325                  | 232         | 5.4                              | 3.5  |                                                             |       | 169.4               | 158.4       | 100.7                          | 95.1        | 73.9                    | 66.5        | 11.9       | 11.9        |
| Weedy check                                    | 523                  | 421         | 8.2                              | 6.4  |                                                             |       | 150.7               | 144.1       | 88.8                           | 84.5        | 65.4                    | 57.1        | 11.9       | 11.8        |
| CD (P=0.05)                                    | 37                   | 33          | 0.6                              | 0.5  |                                                             |       | 9.0                 | 9.5         | 5.7                            | 6.1         | 3.8                     | 4.4         | NS         |             |
| <i>Cropping system*</i>                        |                      |             |                                  |      |                                                             |       |                     |             |                                |             |                         |             |            |             |
| R-m-s-r-w                                      | 435                  | 312         | 6.3                              | 4.7  |                                                             |       | 162.0               | 153.2       | 96.3                           | 92.1        | 71.2                    | 63.7        | 11.9       | 12.0        |
| R-w-s-r-w                                      | 318                  | 250         | 5.6                              | 3.7  |                                                             |       | 166.5               | 157.7       | 99.0                           | 93.6        | 72.6                    | 64.2        | 11.9       | 11.8        |
| CD (P=0.05)                                    | 26                   | 23          | 0.4                              | 0.4  |                                                             |       | 6.4                 | 6.7         | 4.1                            | 4.3         | 2.7                     | 3.1         | NS         | NS          |

\*R, rice; m-mustard; S, sugarcane (plant); r, ratoon; w, wheat

ments in plant crop were Rs 4,740 and Rs 4,800 for interculture; Rs 2,897 and Rs 2,920 for integrated weed management, and Rs 1,729 and Rs 1,735 for chemical method, during the first and second cycles of experimentation respectively (Table 2). These figure show that weed management through intercultural operations by manual labour requires more investment than integrated method, but without getting significantly higher cane yield from the former in comparison with the latter method. Therefore integrated method of weed management in sugarcane plant crop is appropriate from economic point of view also.

In ratoon crop also the intercultural method was costlier than integrated method and trash mulching (Table 3), but the cane yield did not differ statistically due to these weed-management treatments. Therefore it is appropriate

to adopt integrated or trash mulching method of controlling the weeds in sugarcane ratoon.

### **Economics of sugarcane and cropping systems**

The highest cost of cultivation and net return were obtained in interculture treatment of weed control in planted sugarcane, followed by integrated and chemical methods and lowest in weedy check treatment. The B:C ratio was highest in integrated weed management, followed by interculture, chemical and weedy check in plant cane (Table 4).

In ratoon cane net return and benefit : cost (B:C) ratio were highest in trash mulch method for weed control, followed by interculture, integrated weed management and weedy check treatment (Table 5).

It was concluded that rice-mustard-sugarcane (plant)-

**Table 4.** Cost of cultivation, gross return, net return and benefit: cost ratio of plant crop of sugarcane as affected by different treatments of weed management

| Treatment    | Cost of cultivation (Rs/ha) |          |        | Net return (Rs/ha) |          |        | B : C ratio |      |      |
|--------------|-----------------------------|----------|--------|--------------------|----------|--------|-------------|------|------|
|              | I cycle                     | II cycle | Mean   | I cycle            | II cycle | Mean   | I           | II   | Mean |
| Chemical     | 46,221                      | 45,603   | 45,912 | 31,155             | 24,181   | 27,668 | 1.67        | 1.53 | 1.60 |
| Interculture | 49,800                      | 49,254   | 49,527 | 35,480             | 28,018   | 31,749 | 1.71        | 1.56 | 1.64 |
| Integrated   | 47,749                      | 47,220   | 47,485 | 34,827             | 28,181   | 31,503 | 1.73        | 1.60 | 1.66 |
| Weedy check  | 43,300                      | 42,772   | 43,036 | 19,100             | 12,764   | 15,932 | 1.44        | 1.30 | 1.37 |
| Mean         | 46,768                      | 46,212   | 46,490 | 30,140             | 23,286   | 26,713 | 1.64        | 1.50 | 1.57 |

**Table 5.** Cost of cultivation, gross return, net return and benefit: cost ratio of ratoon crop as affected by different treatments of weed management

| Treatment    | Cost of cultivation (Rs/ha) |          |        | Net return (Rs/ha) |          |        | B : C ratio |          |      |
|--------------|-----------------------------|----------|--------|--------------------|----------|--------|-------------|----------|------|
|              | I cycle                     | II cycle | Mean   | I cycle            | II cycle | Mean   | I cycle     | II cycle | Mean |
| Integrated   | 30,167                      | 30,301   | 30,234 | 44,713             | 43,331   | 44,022 | 2.48        | 2.43     | 2.46 |
| Interculture | 32,831                      | 32,671   | 32,751 | 52,241             | 42,521   | 47,381 | 2.59        | 2.3      | 2.45 |
| Trash mulch  | 28,487                      | 27,815   | 28,151 | 54,193             | 45,089   | 49,641 | 2.90        | 2.62     | 2.76 |
| Weedy check  | 25,831                      | 24,903   | 25,367 | 30,641             | 19,505   | 25,073 | 2.19        | 1.78     | 1.98 |
| Mean         | 29,329                      | 28,923   | 29,126 | 45,447             | 37,611   | 41,529 | 2.55        | 2.30     | 2.42 |

**Table 6.** Cost of cultivation, gross return and benefit : cost ratio of different sugarcane-based cropping systems (mean data 2 years)

| Cropping system             | Sugarcane-based cropping systems |         |                   |        |        |             |
|-----------------------------|----------------------------------|---------|-------------------|--------|--------|-------------|
|                             | Rice                             | Mustard | Sugarcane (plant) | Ratoon | Wheat  | Total       |
| Cost of cultivation (Rs/ha) | 20,500                           | 5,000   | 46,490            | 28,776 | 16,173 | 1,16,939    |
| Net returns (Rs/ha)         | 20,240                           | 17,402  | 26,713            | 41,529 | 11,956 | 1,17,840    |
| B:C ratio                   | 0.99                             | 3.48    | 0.57              | 1.43   | 0.74   | 1.44 (mean) |
| Cropping system             | Rice                             | Wheat   | Sugarcane (plant) | Ratoon | Wheat  | Total       |
| Cost of cultivation (Rs/ha) | 20,500                           | 16,173  | 46,490            | 29,126 | 16,173 | 1,28,462    |
| Net returns (Rs/Ha)         | 20,240                           | 12,033  | 26,713            | 41,529 | 11,705 | 1,12,220    |
| B : C ratio                 | 0.99                             | 0.75    | 0.57              | 1.43   | 0.75   | 0.90 (mean) |

ratoon-wheat cropping system is more economical than rice-wheat-sugarcane (plant)-ratoon – wheat cropping system (Table 6).

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