Integrated Weed Control Strategies for Green Bean, Tomato, and Hibiscus Production

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Abstract

Researchers of the IPM CRSP project have studied methods of weed control for protection of green bean, tomato, and hibiscus. The objective of the study was to increase production of these crops by minimizing the incidence of weeds, especially *Cyperus rotundus*. Use of locally available straw as a mulch material in green bean garden plots provides effective control of *C. rotundus* and other weeds as long as the mulch depth is at least 15 cm. These treatments provided weed control and crop yield equal to that of control plots that were frequently hand-weeded. Alternatively, studies confirmed the efficacy of potash solutions used as non-selective herbicides. Solutions of 200g potash (derived from ash of *Kaya senegalensis* wood), either alone or in combination with aqueous extracts of eucalyptus or neem leaves. All treatments reduced *C. rotundus* populations from 86 plants per square meter in control plots to less than 5.2 in the potash plots. Problems of potash carryover and subsequent phytotoxicity to crops remain to be resolved. Finally, the major weed species associated with hibiscus cultivation were identified as *C. rotundus*, *Cynodon dactylon*, *Digitaria horizonlis*, and *Portulaca quadrifida*.

Objectives, IPM Constraints

Objectives of this research are to increase the production of green bean, tomato and hibiscus by minimizing the incidence of weeds using simple techniques that are easily accessible to the farmers and friendly to the environment.

IPM constraints addressed in this research are the harmful effects of difficult-to-control weeds. The result of an inventory of weeds on horticultural plots of the periurban zone around Bamako identified five weed species that are difficult to control and that cause large losses of production. These are *Cyperus rotundus, Pilea microphylla, Cynodon dactylon, Imperata cylindrica*, and *Commelina benghalensis.*

Research Methods, Results and Discussion

Control of *Cyperus rotundus* in green beans and tomatoes.
One of the intriguing findings to emerge from field studies in 2000 was that solutions of potash could be effective non-selective herbicides for control of *Cyperus* species. Thus, experiments were conducted again to test the efficacy of potash, formulated either alone or in combination with extracts of neem or eucalyptus leaves. The crop tested was green beans.

Potash solutions were prepared as follows: Ash collected after burning 1 m^3 of *Kaya senegalensis* wood was mixed with water and filtered, and the filtrate heated to obtain potash. Tests were conducted with the following mixtures: 200g of potash plus 10 kg of eucalyptus or neem (*Azadirachta indica*) leaves crushed in 20 L of water. The solutions were used 24 hours after preparation. The treatments were made from November to December, 2001, by applying eight liters of the solutions to an area of 2 m^2 at an interval of 15 days. The plots were planted in green beans and the four major species of weeds present were counted after the treatments.

The data in the Table 1 shows that the population of *C. rotundus* was greatly reduced by all treatments involving potash. We observed that the mixtures containing neem and eucalyptus acted more rapidly on the *C. rotundus* than the simple mixture with water. We have also found that the residual toxicity of the potash in the soil persists for about 6 months for all formulations, after which it is possible to replant crops.

A sample of potash from *Kaya senegalensis* wood was obtained in Mali and analyzed by the Virginia Tech Soil Testing Laboratory. The pH of a 10% aqueous solution of potash was 11.44 and the major component was potassium (Table 2). The herbicidal effect of potash is likely due to the toxic effect of very high levels of potassium. Our results indicate that potash can be used as an effective broad-spectrum herbicide, its value is currently limited by its persistence in the soil. We are currently working on strategies to shorten this persistence.

Table 1. Response of major weed species to potash formulations.

	Cyperus rotundus	*Dactyloctenium aegyptium*	*Digitaria ciliaris*	*Eleusine indica*
		Weeds/m^2		
Control	86.5	57.5	39.0	31.7
Potash + neem	5.2	51.0	52.7	51.0
Potash + eucalyptus	3.5	52.5	56.5	53.5
Potash alone	4.5	48.0	54.2	36.2

Table 2. Concentrations of selected elements in a sample of potash from *Kaya senegalensis*.

Element	Concentration (ppm)	Element	Concentration (ppm)
K	41,020.0	Mg	1.293
S	883.0	Ba	0.596
P	253.8	Mo	0.2301
Na	67.2	Cu	0.1489
Si	61.7	Fe	0.0487
Ca	28.73	Mn	0.0014
B	1.817		

Use of mulch to control weeds in green beans.
Another mechanism for reducing levels of *C. rotundus* is to cover the soil surface with a mulch to exclude light. *Cyperus rotundus* is not tolerant of shade, so thick ground-covers can be effective in reducing the populations. At the end of the rainy season, before green beans are planted, large quantities of plant material are available for mulches in the garden.

The experiment was conducted on 2 m^2 plots, with straw applied to the soil surface just after emergence of the crop. Treatments consisted of straw applied to the depths of 5, 10, or 15 cm, and a hand-weeded control. Weed counts were taken over the entire surface of the plots every 15 days and green bean yields measured at the end of the season. Each treatment was replicated four times, and the data subjected to ANOVA and means separation.

Mulch applied at a depth of 15 cm proved to be an effective control strategy, comparable to the hand-weeded control in reducing weeds and increasing crop yields (Table 3). Although lower rates of mulch also appeared to have an effect on suppressing weed growth, these were not equal to the hand-weeded plots that represent the farmer's current practice. Mulches require more labor at the time of application, but once in place the plots require little further weeding and there can be benefits with respect to water use by covering the soil and reducing water loss. Mulches appear to be a very sound and effective solution for *C. rotundus* control in green beans.

Table 3. Effect of straw mulch on suppressing weeds and crop yield in green beans. Mulch was applied after emergence of the greenbeans, and weeds were counted one month later.

Treatment	Weeds (No./m^2)	Crop yield (T/ha)
Handweeding	5.8 c	18.0 a
5 cm straw	27.5 a	6.9 b
10 cm straw	18.0 b	8.3 b
15 cm straw	5.5 c	17.8 a

Values are means of four replicates. Means followed by different letters are significantly different according to Duncan's Multiple Range Test at alpha=0.05.

Survey of weeds of hibiscus.
One of the objectives for our research program on weeds of vegetable crops was to identify the most troublesome weeds in the hibiscus cultural system. Because techniques for weed control are highly dependent on the specific weed species present, it is important to have an accurate inventory of the major weeds associated with this crop. Such knowledge will facilitate proper choice of herbicides or other control measures.

Table 4. Survey of weeds found in hibiscus fields.

Family	Species	Frequency (% of plots)	Abundance (No. plants/m^2)	Degree of impact on crop[†]	Relative importance in survey (%)
Gramineae	***Cynodon dactylon***	15	13	3	16.7
	Digitaria horizontalis	10	4	3	
	Imperata cylindrica	2	10	2	
	Elytrigia repens	1	12	2	
Euphorbiaceae	***Euphorbia heterophylla***	15	2	1	4.2
	Phyllantus amarus	5	0.5	0	
Amaranthaceae	***Amaranthus viridus***	15	2	1	8.3
	Amaranthus spinosus	14	1	1	
Asteraceae	***Ageratum conyzoides***	12	3	1	12.5
	Bidens pilosa	10	2	1	
	Eclipta alba	7	1	1	
Fabaceae	***Teraminus labialus***	5	2	1	4.2
Cyperaceae	***Cyperus rotundus***	88	58	4	8.3
	Kyllinga squamulata	10	0.5	1	
Solanaceae	***Physalis angulata***	20	8	1	4.2
Portulacaceae	***Portulaca quadrifida***	1	60	3	8.3
	Portulaca oleraceae	28	5	2	
Nyctaginaceae	***Boerhavia erecta***	25	14	1	4.2
Rubiaceae	***Mitracarpus villosus***	13	4	1	8.3
	Spermacoce verticillata	12	3	1	
Ficodaceae	***Trianthema portulacastrum***	20	11	1	4.2
Commelinaceae	***Commelina benghalensis***	13	2	2	8.3
	Commelina diffusa	5	1	1	
Mimosaceae	***Mimosa pudica***	4	1	1	4.2

[†]Rated on scale of 0 – 4 where 0 = no impact and 4 = severe impact.

The weed inventory was conducted in the region of Baguinéda during the dry season, when the seeds of certain wet-season species were still dormant. The survey was done on three plots having different cultural histories. The first two plots had been planted with corn during the rainy season, and the third had been left fallow. The fields were subdivided into plots of 100 m^2 and the weeds were counted in each plot using a 1 m^2 frame. The frame was laid on the ground randomly and all weeds within this area were counted. After completion of this counting process, the entire field was quickly surveyed to ensure that all species present had been identified. These counts were done one month after the planting of hibiscus and the first weeding. The analysis focused on the diversity of flora (number of species in the field), the frequency of each species (percentage of plots in which a given species occurred), the abundance of the species (number of each species per square meter), and an estimation of the severity of impact of the weed on the crop.

The data in Table 4 shows that plots of hibiscus in the Baguinéda region during the dry season contain 24 species of weed representing 13 botanical families. The grasses (Gramineae family) represent the largest number of species with 16.7 %. This is followed by the Asteraceae at 12.5%, the Amaranthaceae, Cyperaceae, Portulacaceae, Rubiaceae and Commelinaceae, each of which make up 8.3% of the total number of species identified. Only a single species from the remaining families (about 4% of the total) were found in each plot. The count showed that the number of species identified per 100 m^2 plot varied from 8 to 21, with a mean of 14 different species per plot.

The most frequently encountered weed species in the hybiscus fields was *Cyperus rotundus*, which was observed in 88% of the plots. This was followed by *Portulaca oleraceae* (28%), *Boerhavia erecta* (25%), *Trianthema portulacastrum* (20%), and *Physalis angulata* (20%). The other weeds were found in 15% of the plots or less. The finding of *C. rotundus* in 88% of the plots can be explained by its adaptability to different types of soil and environments. This weed can be found equally on light, sandy soils as well as heavy, clay soils, and is not specific to either wet or dry conditions. *Cyperus rotundus* is readily dispersed accross fields by irrigation that carries its propagules, and it can easily move through irrigation canals to infest new fields.

In addition to being the most widespread, *C. rotundus* is also among the most abundant weeds in hibiscus fields in the Baguinéda region (Table 4). The density of this weed was found to average 58 plants/m^2, with the worst infestation in the region having 95 plants/m^2. This situation is the result of incompletely composted manure on the fields, which is the most common source of new weed propagules in garden situations. Another abundant weed in hibiscus is *Portulaca quadrifida*, which had a high density (60 plants/m^2) in the plots where it was found. However, it tends to occur in patches, and occurred at very low levels (1%) in other plots.

The weed species with the greatest negative impact on hibiscus was *C. rotundus*, as noted by the impact rating of 4 given to this weed (Table 4). The reason for this high impact is due to an ability to rapidly multiply, such that it can take over a plot in just a few weeks. It then becomes a very effective competitor with hibiscus to take water, nutrients and sunlight from the crop.

In addition to *C. rotundus*, three other species are particulary damaging and difficult to control in hibiscus. The first of these is *Cynodon dactylon*, which has a frequency of 15% and a mean of 13 plants/m^2, and which has a rhizome capable of growing deep into the soil. This weed quickly spreads to cover the soil faster than hibiscus. Another is *Digitaria horizontalis*, an annual weed with a stolon that helps it reproduce vegetatively in addition to its seed production. The other major weed species is *Portulaca quadrifida*, which spreads horizontally across the surface of the soil. This weed is very difficult to remove because it's stems fragment easily and can persist after a hand-weeding operation.

Networking Activities

J. Westwood traveled to Mali on November 8 to 16, 2001. This visit provided an opportunity to work with M. N'Diaye and B. Dembélé to discuss current research, see experiments in progress in the field, and plan future activities.

Training Output

M. N'Diaye visited Virginia Tech from May 15 to 18, 2002, for training with J. Westwood on data analysis and research planning, as well as to attend the annual IPM CRSP planning meeting.

Project Highlights

- Straw mulch covering plots to a depth of 15 cm provides excellent weed control (including *Cyperus rotundus*) in green bean plots.
- Research has identified potash as an effective non-selective treatment for controlling *Cyperus rotundus* and other weeds in green beans prior to the growing season.