Weed Management in Cotton

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INTRODUCTION

Cotton (*Gossypium* spp.; Figure 1) has played an important role in the U.S. economy for more than 200 years. In the colonial period, due to lack of profitability, cotton plantations were mainly concentrated in the eastern U.S. However, as a result of techno-economical advancements, cotton production rapidly expanded throughout the southern and southwestern parts of the country, and today cotton is a vital agricultural commodity for many growers in these areas. In New Mexico, the commercial production of cotton started in early 1900, and since 1922 it has become a major socioeconomic crop in the state. Despite unsteady trends in cotton prices during the past several years, cotton still remains a major crop in the state; more than 56,000 acres were harvested in 2019 (USDA-NASS, 2019). Among the agronomic constraints of cotton production, weed infestations have historically been a major issue. Despite many advances in weed management technology, cotton growers still face significant challenges from weeds.

Figure 1. **Cotton (*Gossypium* spp.) has been an important crop in New Mexico for over 100 years.**

In cotton, weeds cause several direct and/or indirect negative impacts, such as (a) reducing fiber quality, (b) reducing crop yield, (c) increasing production costs, (d) reducing irrigation efficiency, and (e) serving as hosts and habitats for insect pests, disease-causing pathogens, nematodes, and rodents. Weeds can directly hinder cotton growth by competing for available resources and, in some cases, by releasing allelopathic, or growth-suppressing, chemicals. However, the degree of damage from weed competition is related to the weed species composition (type of weeds), weed densities, and the duration of weed-cotton competition as related to the lifecycle of the cotton plants.

Certain weeds are more competitive with cotton than others, mainly because of differences in their growth habit. For example, any weed species that grows taller than the cotton plants would limit light availability to the cotton, thus causing competition even at low weed densities. In general, as the weed density in cotton fields increases, the damage on fiber yield and quality also increases. It is important to recognize that the direct negative impact from weeds varies

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significantly throughout the lifecycle of cotton. During the early stages of cotton development (i.e., first 8 to 10 weeks after planting, depending on the location), weeds can out-compete cotton seedlings and cause serious damage by reducing plant vigor. This often results in a reduction in the formation of squares and bolls. However, when the crop has become well-established, the cotton plants will be competitive against weeds, and the direct negative impact of the weeds on the crop will be minimal. Therefore, for effective weed management in cotton, growers should concentrate their efforts on weed management in the early part of the growing season.

The minimum time period during which the crop must be kept free of weeds to prevent crop yield loss is referred to as the critical period of weed control (CPWC). Interference from weeds before or after the CPWC will not result in unacceptable (more than 5%) reductions in yield. However, the CPWC is directly related to weed species composition, weed density, and other crop production practices (fertilization, row spacing, etc.), and for this reason the CPWC could vary from field to field. More competitive weed species (e.g., Johnsongrass, Palmer amaranth) at higher population densities should be controlled earlier in the crop cycle than less competitive species (e.g., prickly sida) at lower population densities.

INTEGRATED WEED MANAGEMENT

There are five general weed management strategies: preventive, cultural, mechanical, biological, and chemical. Integrated weed management (IWM) requires a system that integrates these management strategies. However, management strategies must be selected based on the field characteristics because the efficacy of each strategy could vary depending on the local environmental conditions. In other words, an effective management strategy in one location might not be as effective in other locations, even within the same field. Field characteristics, such as soil type, soil pH, water conditions, climatic conditions (hardiness zone), rotational crops, and, most importantly, weed species, should be considered when selecting effective weed management strategies. Therefore, IWM uses a combination of effective weed management strategies depending on the environmental conditions and specific field characteristics. Instead of relying on one particular method of weed control, an IWM system uses a combination of methods. By following the principles of an IWM system, we can reduce the use of herbicides and still obtain optimal economic returns. The use of IWM has been shown to be the most economical and sustainable way to manage weeds.

WEED IDENTIFICATION

The first step to weed management is to correctly identify and maintain a record of weeds present in the field from season to season. Weeds can be identified using resources such as weed identification books, websites, Cooperative Extension Service publications, and Extension personnel such as county agents or specialists (https://aces.nmsu.edu/county/). In order to make sound management decisions, it is also important to know the biology (lifecycle and reproductive mode and capacity) of the weeds present. Keep in mind that some weeds may have several common names, or the same name may refer to different species. Cross referencing weeds by their scientific (Latin) names can help confirm the identity of weeds present in a field regardless of region. Accurate information on the biology of the weeds can help growers select effective management techniques. Weeds are often more susceptible to management techniques during specific stages of their development. Weeds, including grasses, sedges, and broadleaves, are categorized based on their lifecycle into annuals (summer annuals and winter annuals), biennials, and perennials (herbaceous perennials and simple perennials). Some of the common weeds found in New Mexico agricultural fields and their lifecycles are listed in Table 1.

WEED MANAGEMENT STRATEGIES

i. Prevention

The most important part of integrated weed management (IWM) is prevention. Growers can prevent weeds from getting into the field by managing weeds in the fencerow or along ditches, controlling weeds before they set seed, planting certified seed, and removing weeds from tillage and harvesting equipment when moving from one field to another. Many of the troublesome weeds, such as field bindweed, Johnsongrass, sandbur, and Palmer amaranth, can be spread from one field to another by harvesting equipment. Preventive management also requires continuous monitoring of the fields to detect weed issues as early as possible. Once a weed problem is discovered, rapid responses in the form of weed management can prevent target weeds from setting seed and spreading to other areas of the field. For example, small populations of recently introduced weed species can be controlled effectively in the “skip” of skip-row cotton, in row ends, and in turn rows before they have a chance to move into the actual cotton rows. The cost and difficulty of control increases with the size and maturity of the weed patch, so it is best to control small weed infestations early and before they become big infestations.

ii. Cultural Control

Studies have demonstrated that cultural crop production practices (e.g., fertilization, rotation, cover crops, row spacing, and planting date) can influence weed-crop interactions and duration of the CPWC. Cultural weed control emphasizes agronomic practices that benefit the growth of cotton because they create the most favorable environment for cotton while simultaneously creating the least favorable environment for the weeds. Management

decisions, such as seedbed preparation, time of planting, soil fertility and pH, planting pattern, and moisture, can be manipulated so that cotton is favored. For example, cotton planted in a narrow row spacing (25 inches) requires a shorter weed-free maintenance period and becomes more competitive with weeds than cotton planted with a wider row spacing (38–40 inches). The use of cover crops is also a cultural approach to prevent weed seed germination and increase weed suppression. Crop rotation also has a significant impact on specific weed problems and aids in long-term weed management. For example, including sudex (sorghum-sudangrass hybrid) either as a cover crop or in a rotation has been shown to suppress weeds during the following cropping season.

iii. Mechanical Control

Mechanical weed control is best described as a nonselective control option that is particularly effective against annual weeds. Mechanical control is physical weed damage or removal by tools such as hoes, disks, cultivators, rotary weeders, or mechanical choppers. These devices are designed to cover, uproot, or cut weed seedlings.

Mechanical weed control starts with the annual primary and secondary tillage practices. Moldboard plowing of the soil leads to the uprooting and shredding of large weeds that have grown in a field during the fall to the early spring season. Moldboard plowing can also bury the weed seeds deep within the soil where they will not be able to emerge. Secondary tillage, such as disking and harrowing, leads to the shredding of the weed biomass and further dislodging of shallow-rooted weeds. Tillage practices are also useful for incorporating some herbicides into the soil to enhance their effectiveness. Although both primary and secondary tillage often lead to a quick destruction of weeds in a field, they do not provide a lasting solution, especially if weed seeds are still present close to the surface of the soil. Follow-up practices using different types of cultivators may be necessary to dislodge and uproot the weeds that emerge after tillage. Mechanical weed control after the planting of cotton is more successful when the weeds are relatively small. Therefore, cultivating a cotton field early in the season when the weeds are young will give better results than waiting until later.

Table 1. Some of the Common Weeds Associated with Agricultural Fields in New Mexico

Common Name	Scientific Name	Class
Annuals (plants that complete their lifecycle within one year and reproduce by seed only)		
Summer Annuals		
Barnyardgrass	*Echinochloa crus-galli*	Grass
Junglerice	*Echinochloa colona*	Grass
Marestail	*Conyza canadensis*	Broadleaf
Pigweed	*Amaranthus* spp.	Broadleaf
Sandbur	*Cenchrus* spp.	Grass
Sprangletop	*Leptochloa* spp.	Grass
Foxtail	*Setaria* spp.	Grass
Kochia	*Kochia scoparia*	Broadleaf
Morning glory	*Ipomoea* spp.	Broadleaf
Russian thistle	*Salsola kali*	Broadleaf
Southwestern cupgrass	*Eriochloa acuminata*	Grass
Lambsquarters	*Chenopodium album*	Broadleaf
Winter Annuals		
Downy brome	*Bromus tectorum*	Grass
London rocket	*Sisymbrium irio*	Broadleaf
Shepherd's purse	*Capsella bursa-pastoris*	Broadleaf
Flixweed	*Descurainia sophia*	Broadleaf
Rescuegrass	*Bromus catharticus*	Grass
Tansymustard	*Descurainia pinnata*	Broadleaf
Biennials (plants that require two years to complete their lifecycle and reproduce by seed only)		
Common mallow	*Malva neglecta*	Broadleaf
Musk thistle	*Carduus nutans*	Broadleaf
Perennials (plants that live more than two years and reproduce by seed and vegetative reproductive structures, such as root buds, rhizomes, crowns, tubers, stolons, and/or bulbs)		
Simple Perennials		
Curled dock	*Rumex crispus*	Broadleaf
Dandelion	*Taraxacum officinale*	Broadleaf
Creeping Perennials		
Bermudagrass	*Cynodon dactylon*	Grass
Johnsongrass	*Sorghum halepense*	Grass
Silverleaf nightshade	*Solanum elaeagnifolium*	Broadleaf
Field bindweed	*Convolvulus arvensis*	Broadleaf
Texas blueweed	*Helianthus ciliaris*	Broadleaf
Yellow nutsedge	*Cyperus esculentus*	Sedge
Purple nutsedge	*Cyperus rotundus*	Sedge

However, there are some disadvantages that can result from soil disturbances created by tillage and mechanical weed control implements.

- Tillage tends to create favorable conditions for the germination of weed seeds near the soil surface and bring up new seeds from deeper depths in the soil profile.
- Tillage aids in the dispersal of perennial weeds by breaking up their underground vegetative structures and spreading them throughout the field.
- Frequent tillage could also lead to soil degradation via structure loss, erosion, and compaction.

It is therefore advised to combine mechanical methods with other weed management methods to achieve effective weed control in a cotton field.

iv. Biological Control

Over the past several decades, the concept of biological control of weeds in cotton has received significant interest. A considerable diversity of biological agents has been used to control weeds, including geese, insects, pathogens, and nematodes. However, these biological methods have shown limited successes in effective control of specific weeds in agronomic crops on their own, particularly cotton. Biological control must be implemented with a combination of management practices in order to increase their efficacy.

v. Chemical Control

Weed control in agronomics, including cotton, has relied mostly on herbicides, consisting of various functional groups (active ingredients) that are capable of impeding the growth and development of weeds. A list of currently registered herbicides for cotton in New Mexico and some information regarding their usage is given in Table 2. Successful chemical weed control requires uniform application of the correct quantity of herbicide(s) over the target area, as per the directions on the label. This makes the application of herbicides a precision operation, and accurate calibrations of sprayers are therefore very important since rates that are too high may injure the crop and rates that are too low may not provide adequate weed control. It is also important to use the herbicides at a time when the crop is at its maximum tolerance and the weeds are at their maximum susceptibility to injury. The susceptibility of both crops and weeds to herbicides is related to the time of application.

The following are the terms describing the times at which herbicides may be applied. Unless otherwise specified, they refer to the stage of development of the cotton. All label instructions and precautions must be followed carefully. An herbicide's poor performance or nonperformance can often be traced to improper use and failure to follow label directions.

Pre-plant. Registered herbicides for pre-plant application fall into two categories (Table 2):

Pre-plant incorporated (PPI) herbicides, such as trifluralin (Treflan) and pendimethalin (Prowl or Acumen), are applied and incorporated into the soil 2–4 inches deep prior to planting cotton to provide residual weed control. Cotton seed should be planted lower than the herbicide incorporation depth to prevent growth retardation.

Pre-plant burndown herbicides, such as thifensulfuron-methyl (Harmony GT XP) and tribenuron-methyl (Express with TotalSol), can be applied on emerged weeds prior to planting cotton for a burndown effect. Depending on their chemistry, these herbicides could have residual activity [e.g., flumioxazin (Chateau)] or no residual activity [e.g., glyphosate (Roundup)].

Post-plant. Registered herbicides for post-plant application fall into three categories (Table 2):

Pre-emergence herbicides are generally applied after planting cotton but prior to weed emergence for residual weed control. However, some herbicides, such as diuron (Direx) and pyrithiobac-sodium (Pyrimax 3.2L), have post-emergence activity that can control small seedlings of annual species and also provide residual weed control.

Post-emergence herbicides, such as oxyfluorfen (Galigan 2E or Goal), pyrithiobac-sodium (Pyrimax 3.2L or Staple), sethoxydim (Poast), fluazifop-p-butyl (Fusilade), and clethodim (Select Max or Arrow), are all applied after cotton emergence. However, some are registered for post-directed application. When cotton plants are 6 inches tall, directed sprays of these herbicides can be used to control small weed seedlings. While herbicides are directed to the row, mechanical control is used for weeds in the furrows.

Lay-by herbicide applications, timed at the final cultivation as the cotton closes over the furrow, prevent the growth of weeds when it is no longer possible to cultivate. Several herbicides are registered for lay-by applications in cotton (Table 2) and they are mainly applied prior to weed emergence (pre-emergence to weeds). In some cases, these applications are made to remaining small weeds that were not controlled by previous cultivation and early post-emergence herbicide applications. A lay-by herbicide should be applied as a directed application onto the target weed only to minimize contact with cotton plants, and can be especially beneficial when cotton plants are short and/or the stand is poor. Without such an application, weeds that escape the previous treatments readily grow and mature with little or no competition from the cotton plant.

Grass control. Certain herbicides, such as sethoxydim (Poast), fluazifop-p-butyl (Fusilade), quizalofop-p-ethyl (Assure II), and clethodim (Select Max), are effective against most grasses, including Johnsongrass and bermudagrass. Select Max is also effective against annual bluegrass. These herbicides are best applied to grasses that are actively growing and less than 6 inches tall. Competition from a vigorous and uniform stand of

Table 2. List of Herbicides Registered for Use on Cotton in New Mexico (2020)[a]					
Trade Name[b] (WSSA Grouping[c])	**Common Name**	**EPA Registration Number**	**Rate/Acre[d]**	**Application[e]**	**Weeds Controlled**
Prowl H2O **Group 3**	Pendimethalin	241-418	2.0–3.0 pt	PPI/PRE/lay-by	Grasses and broadleaf weeds such as kochia, spurge, and pigweed species
Aim EC **Group 14**	Carfentrazone-ethyl	279-3241	0.25–1.6 fl oz	POST/lay-by/ defoliant	Broadleaf weeds
Select 2 EC **Group 1**	Clethodim	59639-3	6–16 fl oz	POST	Annual and perennial grasses
Assure II **Group 1**	Quizalofop-p-ethyl	352-541	5–18 fl oz	POST	Annual and perennial grasses
Banvel **Group 4**	Dicamba	66330-276	8 fl oz	Pre-plant burndown	Broadleaf weeds
Caparol 4L **Group 5**	Prometryn	100-620	1.6–3.2 pt	PPI/PRE/POST	Annual grasses and broadleaf weeds
Chateau **Group 14**	Flumioxazin	59639-99	1–2 oz	Pre-plant burndown/ POST-direct/ lay-by	Broadleaf weeds
Cobra **Group 14**	Lactofen	59639-34	12.5 fl oz	POST-direct/ lay-by	Broadleaf weeds
Command 3ME **Group 11**	Clomazone	279-3158	21.3–53.3 fl oz	PRE	Annual grasses and broadleaf weeds
Cotoran 4L **Group 7**	Fluometuron	66222-181	2–4 pt	PPI/PRE/POST/ lay-by	Annual grasses and broadleaf weeds
Direx 4L **Group 7**	Diuron	66222-54	0.8–1.5 qt	PPI/PRE/POST-direct/lay-by	Annual grasses and broadleaf weeds
Dual II Magnum **Group 15**	S-metolachlor	100-818	1–1.33 pt	PPI/PRE	Yellow nutsedge, grasses, and broadleaf weeds such as pigweeds
Eptam 7-E **Group 8**	EPTC	10163-283	2.25 pt	PRE (after stand establishment)	Annual grasses and broadleaf weeds
ET Herbicide **Group 14**	Pyraflufen-ethyl	71711-7	1.5–2.75 fl oz	POST/lay-by/ defoliant	Annual broadleaf weeds
Express Herbicide **Group 2**	Tribenuron methyl	279-9594	0.25–0.5 oz	Pre-plant burndown	Annual broadleaf weeds
Fusilade DX **Group 1**	Fluazifop-p-butyl	100-1070	8–24 fl oz	POST	Annual and perennial grasses
Galigan 2E **Group 14**	Oxyfluorfen	66222-28	1–2 pt	POST-direct	Annual grasses and broadleaf weeds
Gramoxone SL 2.0 **Group 22**	Paraquat dichloride	100-1431	Variable rates	Pre-plant burndown/ POST-direct/ defoliant	Annual grasses and broadleaf weeds
Harmony GT XP **Group 2**	Thifensulfuron-methyl	352-446	0.2–0.33 oz	Pre-plant burndown	Broadleaf weeds

Trade Name[b] (WSSA Grouping[c])	Common Name	EPA Registration Number	Rate/Acre[d]	Application[e]	Weeds Controlled
K-pam HL **Group 27**	Metam-potassium	5481-483	30–60 gal	PPI	Grasses and broadleaf weeds
MSMA-6 Plus **Group 17**	MSMA	19713-42	1–2.66 pt	Pre-plant or post-plant burndown/ POST/POST-direct	Annual grasses and broadleaf weeds
Parallel **Group 15**	Metolachlor	66222-87	1–1.33 pt	PPI/PRE	Yellow nutsedge, grasses, and broadleaf weeds such as pigweeds
Poast **Group 1**	Sethoxydim	7969-58	2.5 pt	POST	Annual and perennial grasses
Pyrimax 3.2 L **Group 2**	Sethoxydim	7969-58	2.5 pt	POST	Annual and perennial grasses
Pyrimax 3.2 L **Group 2**	Pyrithiobac-sodium	66222-175	1–4 fl oz	PRE/POST/ POST-direct	Broadleaf weeds
Rely 280 **Group 10**	Glufosinate-ammonium	264-829	22–43 fl oz	POST/POST-direct	Annual grasses and broadleaf weeds
Roundup products **Group 9**	Glyphosate[f]	Various	Variable rates	POST/pre-plant burndown	Annual and perennial weeds
Sandea **Group 2**	Halosulfuron-methyl	81880-18-10163	0.66–1.33 oz	POST-direct	Broadleaf weeds and nutsedge species
Scythe **Group 27**	Pelargonic acid	10163-325	Variable rates 3–10%	Pre-plant burndown/ POST-direct/ defoliant	Annuals
Sectagon 42 **Group 27**	Metam-sodium	61842-6	Variable rates	PPI	Grasses and broadleaf weeds
Solicam DF **Group 12**	Norflurazon	100-849	0.6–1 lb	PRE	Annual grasses and broadleaf weeds
Treflan 4L **Group 3**	Trifluralin	34704-853	1–2 pt	PPI/PRE/lay-by	Grasses and broadleaf weeds such as kochia, common lambsquarters, and pigweed species

[a] The list is current as of February 2020; however, labels change frequently, and the herbicide's current label should be reviewed for the most recent conditions or restrictions before it is used. Read all labels carefully and comply with their site-use directions (e.g., pre-harvest interval, restricted-entry interval, registration). For the very latest label information on a given herbicide, contact the manufacturer, Cooperative Extension Service in your area, or the company or distributor that sells the product.

[b] Other trade names of mentioned active ingredients alone or in combination may be available in the market.

[c] Herbicide groupings follow the Weed Science Society of America's (WSSA) nationally accepted grouping. The grouping is based on the modes of action of herbicides. For effective herbicide resistance management it is imperative to rotate or mix the herbicides from different groups.

[d] Recommended rates can vary depending on environmental factors, such as soil texture, cotton variety, or weed species. Growers are advised to read the herbicide labels when selecting the correct rates based on the environmental conditions of their area. Most chemical labels can be accessed at either http://www.cdms.net or http://www.greenbook.net.

[e] PPI = pre-plant incorporated, PRE = pre-emergence, POST = post-emergence.

[f] Please see the **Roundup Ready System** section for information on over-the-top and post-directed application of glyphosate on Roundup Ready cotton.

cotton can further enhance Johnsongrass and bermudagrass control. Additionally, if the soil is dry, effective control of perennial grasses can also be obtained when rhizomes are cut into short segments by disking and cross-disking during land preparation. However, growers should be careful not to carry these rhizome segments to other locations within the same field, or to surrounding fields, to minimize any further spread of the weed.

Roundup Ready system. Glyphosate (Roundup) can be applied over-the-top and post-directed to Roundup Ready cotton varieties for the control of annual and perennial weeds. Best control is achieved when weeds are young seedlings and are actively growing. With Roundup Ready cotton, application timing must be between the cotyledon and 4th true leaf stage of the cotton. Later applications of Roundup can be made through lay-by (14th node). Roundup can also be used as a spot treatment to control isolated infestations of perennials, or applied with a hooded sprayer to control field bindweed and other persistent weeds to minimize herbicide injury to the cotton. However, Roundup Ready Flex varieties can be sprayed over-the-top with Roundup through lay-by and beyond. For better weed management, it is recommended that growers consider the CPWC and apply Roundup at early stages rather than late in the season.

Resistance to Roundup in weeds. Due to confirmation of resistance to Roundup in some Palmer amaranth populations in New Mexico, it is important that growers not rely only on Roundup for weed management in Roundup Ready cotton. The application of herbicides with other modes of action during the season will not only control Roundup-resistant species (if they exist) but will also prevent or delay the development of resistance in existing weed populations.

Liberty Link system. The Liberty Link system uses glufosinate (Rely 280), which has a different mode of action than Roundup, providing broad-spectrum annual weed control with no growth stage restrictions for over-the-top applications. It can be applied to non-Liberty Link cotton with hooded sprayers or post-directed with no rotational restrictions. Because weed injury to applications of Rely 280 is similar to that of a contact herbicide, it only provides control of small seedlings of annual species. Field experiments have shown that Rely 280 has better activity on broadleaf weeds than grasses.

Tank-mixing. Tank-mixing herbicides will provide broad-spectrum weed control; however, it is important to follow the label directions on mixing partners because some herbicides may not be compatible with each other. If such herbicides are mixed, the efficacy of one or both partners in the mixture can be reduced. For example, when Pyrimax is tank-mixed with Poast, Select Max, or Arrow, or if an application of Pyrimax is followed by a Poast or Select Max application, grass control may be delayed. If Pyrimax is tank-mixed with Fusilade or applied within seven days of a Fusilade application, reduced grass control may occur.

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