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Recent dramatic improvements in the quality of seeded bermudagrasses have expanded the use of this warm-season turfgrass for high quality turf sites including golf course fairways. Researchers at the University of Arkansas are determining the types of herbicides that can be safely used during bermudagrass establishment from seed.

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The purpose of *USGA Turfgrass and Environmental Research Online* is to effectively communicate the results of research projects funded under USGA's Turfgrass and Environmental Research Program to all who can benefit from such knowledge. Since 1983, the USGA has funded more than 290 projects at a cost of \$25 million. The private, non-profit research program provides funding opportunities to university faculty interested in working on environmental and turf management problems affecting golf courses. The outstanding playing conditions of today's golf courses are a direct result of ***using science to benefit golf.***

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# Choosing Appropriate Herbicides for Establishing Bermudagrass from Seed

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## SUMMARY

Bermudagrass continues to be the predominant turfgrass for southern golf course fairways, tees, and rough areas. In the past decade, improved seeded bermudagrass cultivars have been developed that have superior turfgrass quality compared to earlier seeded types and are now being incorporated into many turfgrass situations. When establishing a turfgrass such as bermudagrass from seed, a major concern is the control of weeds during the establishment phase, as excessive weed pressure can lead to delayed establishment and reduced quality. The overall objective of this research was to determine the types of herbicides that could be safely used during bermudagrass establishment. The major conclusions from this work included:

- Many of the most common herbicides that are used on mature bermudagrass can also be safely used on bermudagrass seedlings.
- Most herbicides were safely applied as early as two weeks after emergence.
- Herbicides that caused significant injury to bermudagrass seedlings included diclofop (Illoxan), metsulfuron (Manor), and metribuzin (Sencor). These herbicides should not be used until bermudagrass is fully established.
- Herbicides that demonstrated excellent safety on new bermudagrass seedlings included MSMA, quinclorac (Drive), and dicamba.
- Sulfonylurea herbicides such as flazasulfuron (Katana), foramsulfuron (Revolver), and trifloxysulfuron (Monument) exhibited excellent safety on seedling bermudagrass.

**B**ermudagrass (*Cynodon spp.* L.) is a widely-adapted warm-season turfgrass and is used in numerous golf course applications throughout transition zone and tropical regions of the world (1). Until recently, seeded bermudagrass cultivars

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were considered of low quality and did not perform as well as vegetative hybrids such as 'Tifway' or 'Midlawn'. Although lower quality, seeded cultivars provided an adequate turf for home lawns and utility areas, they did not produce an acceptable turf for golf course, sports field, or other high-maintenance applications.

In recent years, a renewed interest in seeded bermudagrass breeding has yielded several new seeded cultivars that perform much better than older seeded types and can even perform as well as the established vegetative hybrids. Of the new seeded cultivars, 'Princess', 'Yukon', and 'Riviera' have been widely accepted due to their very high shoot density, dark green color, and enhanced stress tolerance (16). These improvements in turf quality have stimulated considerable interest from the turfgrass industry, as a high quality bermudagrass turf is attainable using a seeded cultivar. As these cultivars are implemented in the turfgrass industry, management programs need to be developed that address specific issues related to seed propagation of bermudagrass.

The ability to control weeds during the



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Herbicide	Rate
	(lb a.i./acre)
MSMA	1.0
metsulfuron	0.019
diclofop	1.0
clopyralid	0.5
dicamba	0.5
2, 4-D amine	0.5
quinclorac	0.75

**Table 1.** Herbicides and rates used for Study 1

emergence and establishment period is a key factor in the success of these new seeded bermudagrass cultivars. Competition during the seedling stage, especially from warm-season, annual grasses such as crabgrass (*Digitaria spp.* (L.) Scop.) and goosegrass (*Eleusine indica* (L.) Gaertn.), can significantly inhibit stand establishment and reduce overall stand density.

Although numerous studies have investigated the efficacy and safety of postemergence herbicides on established bermudagrass turf, there have been limited studies that address postemergence herbicide tolerance on seeded bermudagrass, especially during the critical establishment period. Currently, Drive (quinclorac) is the only postemergence herbicide that is labeled for use during seedling establishment of bermudagrass and previous studies have confirmed its safety (10,15,19).

As the use of seeded bermudagrasses increases, it has become increasingly important to understand the types of herbicides that can be safely used during the establishment period. The objectives of our research were to examine the safety of a wide range of herbicides and tank-mixes on seedling bermudagrass.

### **Field Analysis of Herbicide Tolerance on 'Princess-77' and 'Riviera' bermudagrass**

Two field studies were each conducted over two growing seasons (Study 1 - 2000 and 2001; Study 2 - 2003 and 2004) at the University

of Arkansas Research and Extension Center, Fayetteville, AR. The soil at the site is captina silt loam (fine-silty, siliceous, active, mesic Typic Fragiudults) with an average pH of 6.2. Prior to planting, the sites were fumigated with methyl bromide (67%) and chloropicrin (33%) at 350 lb / acre. Fumigation of the soil provided a weed-free seed bed so injury effects of various herbicides and establishment rates of the bermudagrass could be more easily measured.

'Princess-77' was seeded at 1.0 lb. / 1000 ft<sup>2</sup> on May 31, 2000 and June 1, 2001. The site was irrigated with an automated irrigation system to provide optimum moisture conditions for germination and establishment of the seed and to maximize grow-in. Plots were amended with phosphorous and potassium prior to planting according to soil test recommendations. Nitrogen was applied as urea, beginning five days after first emergence, at a rate of 0.5 lb. N / 1000 ft<sup>2</sup>, and re-applied every two weeks during the test. Plots were mowed three times per week with a reel mower set to a bench height of 1.25 cm (0.5 inches) with grass clippings returned.

Seven herbicide treatments (Table 1) were applied at 1, 2, and 4 weeks after emergence (WAE). Full emergence was considered the point where seedlings had emerged on approximately 75 % of the plot based on a visual analysis. Plot size for all treatments was 4 x 6 ft. Visual injury ratings of each herbicide treatment were taken at 1, 3, 5, 7, 15, and 30 days after treatment (DAT) for both Study 1 and Study 2. Visual injury ratings were taken using a scale from 0 to 9 with 0 representing no injury and 9 being death of all plants. A score of 3 or less was considered an acceptable level of injury. For brevity, the only data that will be discussed are the 2 WAE treatment applications.

'Riviera' bermudagrass was seeded at 1.0 lb. / 1000 ft<sup>2</sup> on June 15, 2003 and June 1, 2004. Plot size, irrigation, fertilization, and mowing practices were similar to Study 1. Nine postemergence herbicide treatment combinations were applied at 2 and 4 WAE at a rate in compliance with the manufacturers' labels (Table 2). Visual injury ratings were taken on all plots at 3, 5, 7, 10,

Treatment	Chemical 1 (active ingredient)	Rate	Chemical 2	Rate
		(product / acre)		(lb. a.i. / acre)
1	Confront (clopyralid + triclopyr)	1.0 pt	MSMA	2.0
2	Drive (quinclorac)	1.0 lb	MSMA	2.0
3	Drive (quinclorac)	1.0 lb		
4	Katana (flazasulfuron)	3.0 oz.	MSMA	2.0
5	Lontrel (clopyralid)	1.0 pt	MSMA	2.0
6	Monument (trifloxysulfuron)	0.75 oz	MSMA	2.0
7	Revolver (foramsulfuron)	17.4 oz	MSMA	2.0
8	Sencor (metribuzin)	0.5 lb.	MSMA	2.0
9	Trimec Classic (2,4-D + mecoprop + dicamba)	3.5 pt	MSMA	2.0

**Table 2.** Herbicide combinations and rates used for Study 2

14, 21, and 28 DAT. For brevity, the only data that will be presented are the 2 WAE treatment applications.

## Results

### Study 1

In 2000 and 2001, diclofop caused unacceptable injury to seedling turf, with herbicide injury ratings approaching 6 in both years (Figure 1). The maximum injury with diclofop was observed between the 3 and 7 DAT for both seasons (Figure 1). Injury ratings remained above the acceptable level for at least 7 days in both years of the trial.

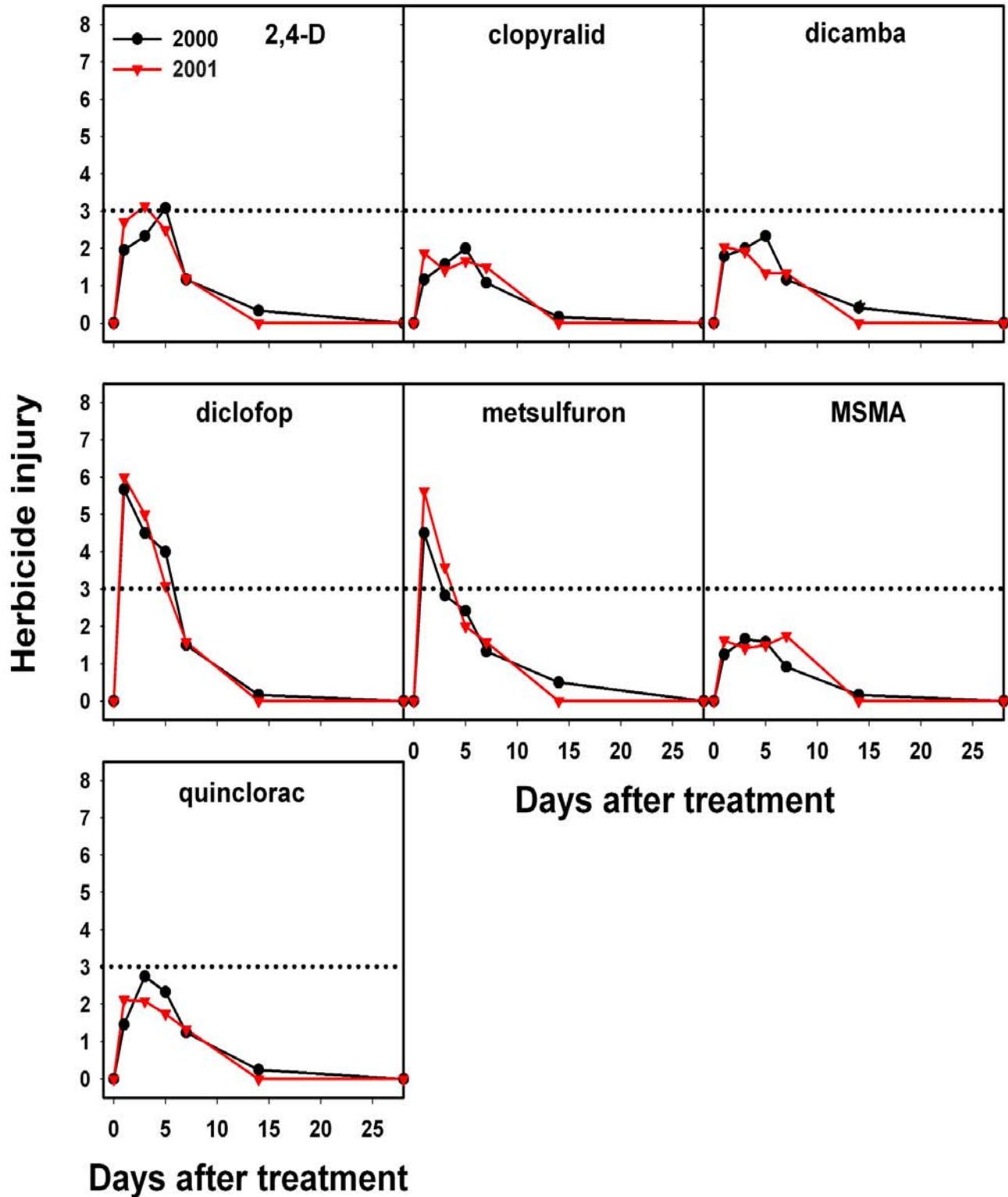
Diclofop has been used effectively on established hybrid bermudagrass (11, 12, 17) and Johnson (6) reported that a single application of diclofop at 1.0 lb. / acre was safe on established common bermudagrass. However, it is apparent from our studies that seedling bermudagrass is more sensitive to diclofop than mature bermudagrass. Although the turf eventually recovered from the diclofop injury, the current recommendation is to avoid applications of diclofop during establishment of bermudagrass unless goosegrass is present in high concentrations. Goosegrass could be a significant competitor of seedling bermudagrass turf, leading to a significant reduction in turfgrass stand if left untreated. In cases

with heavy infestations of goosegrass, the injury caused by diclofop would not be as damaging as the reduced stand caused by heavy competition from an aggressive weed such as goosegrass.

Metsulfuron also caused unacceptable levels of injury to the seedling bermudagrass in both seasons and the injury was generally most severe at 3 DAT (Figure 1). By 15 DAT, the seedlings began to recover and the injury was completely absent by 30 DAT. Although the injury observed with metsulfuron in this study is slightly more severe than what had been observed on mature ‘Tifway’ and ‘Tifdwarf’ bermudagrass (13), the turf recovered quickly and metsulfuron should not cause a serious problem if used during establishment.

Herbicide injury, on plots treated with 2,4-D, was highest between 3 and 5 DAT across both years of the study (Figure 1) and unacceptable levels of injury were observed at various times after treatment. However, these levels of injury were only observed for short periods of time each year and were never considered a serious problem. Coats et al. (4) found similar results on mature common bermudagrass, with injury from 2,4-D temporary and lasting only two weeks.

Much of the recent research involving 2,4-D has focused on its use in three-way herbicide combinations with dicamba and mecoprop. In those studies, it was found that three-way, broadleaf herbicide combinations caused more severe injury than 2,4-D alone, but injury was also



**Figure 1.** Herbicide injury on 'Princess-77' bermudagrass, as affected by seven herbicide treatments (2000 and 2001 data). Herbicides were applied at 2 weeks after emergence and injury was rated on a scale of 0-9, with 0=no injury and 9= complete death of seedlings. An injury rating of 3 or less was considered an acceptable level of injury.

temporary with those three-way combination products (2, 4, 5).

Dicamba, clopyralid (Lontrel), and quinclorac, which could be alternative broadleaf herbicides to 2,4-D, generally caused minimal levels of injury to bermudagrass seedlings in both years of the trial (Figure 1) which is consistent with previous results on these herbicides. Johnson (5) found that four established seeded cultivars were tolerant to dicamba at the 0.5 lb./acre rate and that common bermudagrass was more susceptible than improved seeded cultivars at that application rate. Johnson (8) reported that clopyralid caused moderate discoloration to established common bermudagrass, but full recovery occurred within one week. Numerous studies have shown that quinclorac can be safely used on both seedling bermudagrass (10, 15, 19, 20) and established hybrid bermudagrass (14).

MSMA (monsodium methanearsonate) caused minimal levels of injury to seedling bermudagrass in both 2000 and 2001 (Figure 1). These results are similar to those of Bell et al., (2), where MSMA caused minimal injury on established ‘Yukon’ bermudagrass. Injury caused by MSMA subsided completely by 30 DAT (Figure 1), similar to earlier reports (9, 18). Collectively, these data suggest that MSMA can be safely used on seedling bermudagrass during establishment to

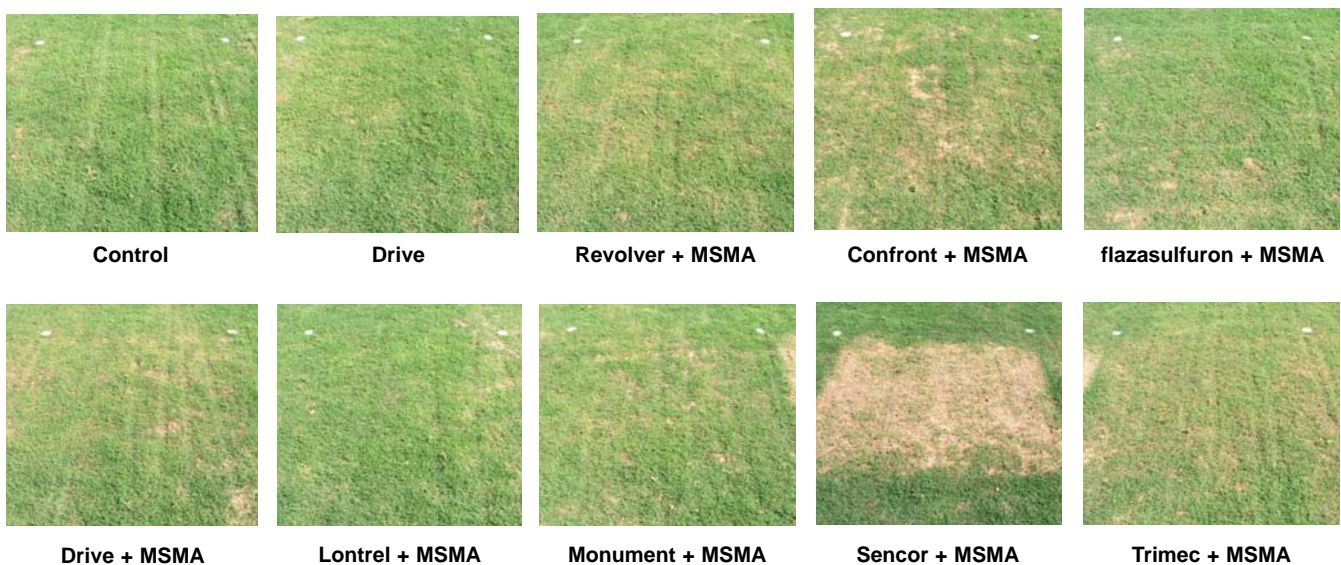
control problematic weeds such as crabgrass.

### Study 2

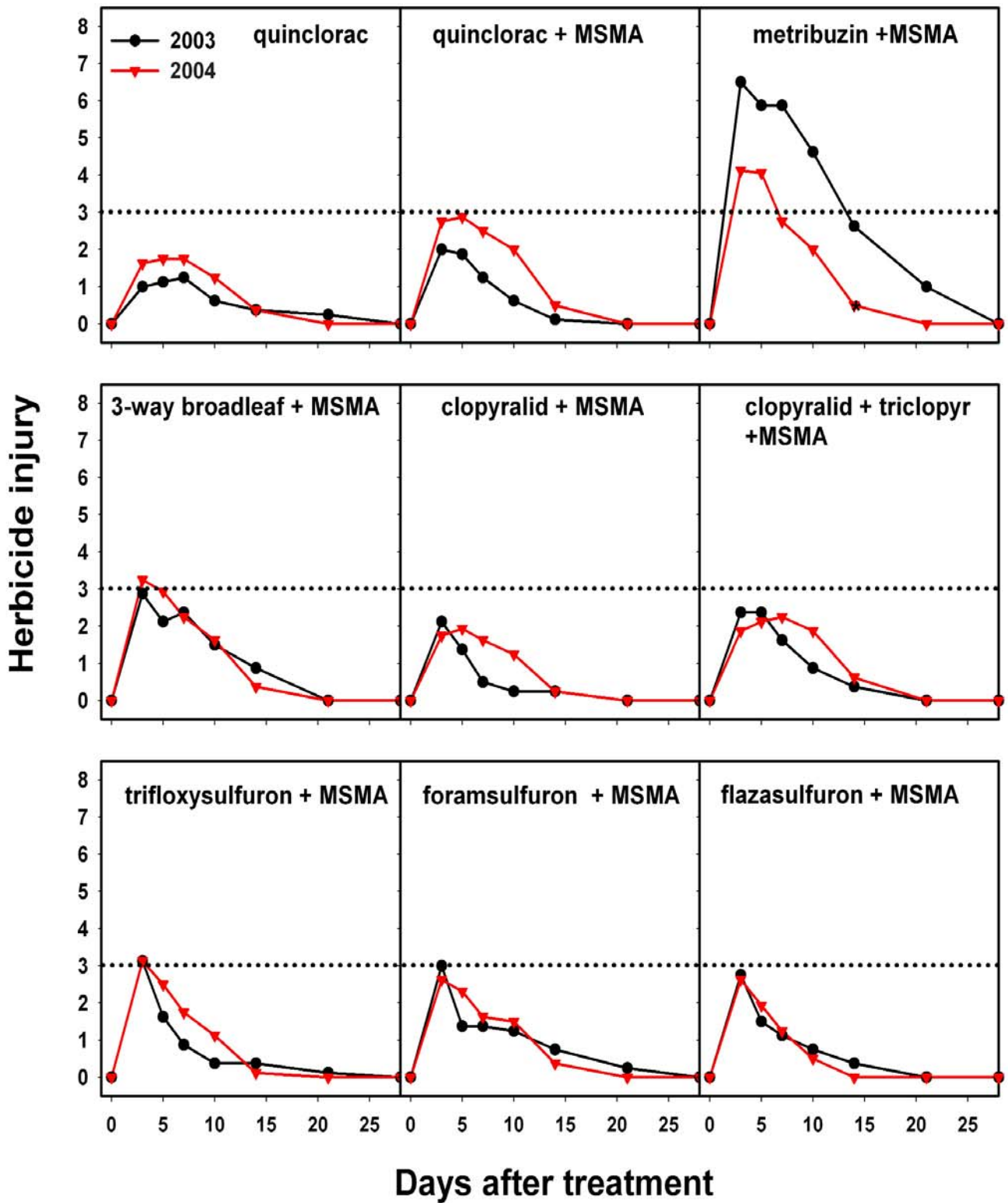
When the effects of herbicide combinations were evaluated in 2003 and 2004, metribuzin + MSMA was the only herbicide combination that caused unacceptable levels of injury for an extended period in both years of the trial (Figure 2). All of the herbicides caused some injury soon after application, but the bermudagrass recovered quickly, and most of the injury remained below acceptable levels throughout the evaluation period. Quinclorac generally caused the least amount of injury in both 2003 and 2004 (Figure 2).

For those herbicides that are used to control grassy weeds, quinclorac had good safety on seedling bermudagrass (Figure 2), which is in agreement with earlier reports (10, 15, 19). When quinclorac was tank-mixed with MSMA, herbicide injury was increased (Figure 2), but the injury remained at or below acceptable levels.

Metribuzin + MSMA caused significant damage to the seedling bermudagrass in both years of the trial (Figure 2), although the injury was greater in the 2003 trial compared to 2004. Although this is the first report of seedling bermudagrass tolerance to metribuzin + MSMA, McElroy and co-workers (15) reported very high



Seven days after treatment (7 DAT), different levels of phytotoxicity were observed from specific herbicides and tank mixes.



**Figure 2.** Herbicide injury on 'Riviera' bermudagrass as affected by nine herbicide treatment combinations (2003 and 2004 data). Herbicides were applied at 2 weeks after emergence and injury was rated on a scale of 0-9, with 0=no injury and 9= complete death of seedlings. An injury rating of 3 or less was considered an acceptable level of injury.



Herbicide (active ingredient)	Weeds Controlled	Rate/acre	Timing and Safety	Comments
MSMA	crabgrass, barnyardgrass, broadleaf signalgrass, sprangletop, annual sedges,	1.0-2.0 lb.	Apply 2 weeks after emergence. There will be some injury, but the grass recovers quickly.	No goosegrass control. Tank mix with Revolver if goosegrass is present.
Drive (quinclorac)	crabgrass, broadleaf signalgrass, barnyardgrass and some broadleaf weeds	0.75 lb.	Very little injury potential. Apply anytime before or after seeding.	May be weak on 2- to 6-tiller crabgrass. Add MSMA to improve crabgrass control. Does not control goosegrass.
Revolver (foramsulfuron)	goosegrass	17 to 26 oz	Safe to apply at 2 weeks after emergence.	Safer than Illoxan for goosegrass control. Inconsistent crabgrass control, so tank mix with MSMA for crabgrass control.
Monument (trifloxysulfuron)	carpetweed, annual sedges, yellow and purple nutsedge and some broadleaf weeds	0.56 oz	Apply 2 weeks after emergence.	Tank mix with MSMA for crabgrass control.
Trimec Classic	broadleaf weeds	3.5 pts	Apply 2 weeks after emergence.	Tank mix with MSMA for crabgrass control.
Manor/Blade (metsulfuron)	spurge and many other broadleaf weeds	0.5 oz	Apply 4 weeks after emergence. Some injury will occur.	Tank mix with MSMA for crab grass control.

**Table 3.** Suggested herbicides for weed control in seedling bermudagrass

levels of injury on seedling bermudagrass with atrazine, a herbicide with a similar mode of action to metribuzin. This herbicide combination also causes a significant reduction in turfgrass quality when applied to mature common bermudagrass types (5, 7, 11). Although metribuzin + MSMA is commonly used to control goosegrasses in established bermudagrass (3), the extent of injury observed on seedling bermudagrass suggests this is an unacceptable combination to use during the first few weeks of establishment.

The broadleaf herbicides tested in these trials caused modest levels of injury to seedling ‘Riviera’, but only exceeded unacceptable levels

of injury on a few evaluation dates (Figure 2). The three-way herbicide (2,4-D, dicamba, and mecoprop) + MSMA caused significant discoloration of the turf for up to 14 DAT, but the turf had fully recovered by 21 DAT (Figure 2). These findings are similar to those reported by McElroy et al. (15) on four seeded bermudagrass cultivars, including ‘Riviera’.

The clopyralid + triclopyr + MSMA treatment caused slightly higher injury ratings compared to the clopyralid + MSMA (Figure 2). Other researchers reported a 10% injury rating with clopyralid + triclopyr on juvenile ‘Riviera’ bermudagrass (15) which is similar to the injury

observed in the present trial (Figure 2). Mature common bermudagrass has also shown tolerance of clopyralid and clopyralid + triclopyr combinations (21).

Most of the broadleaf herbicides tested in this trial and by other researchers (10, 15) appear to have relatively good safety on seeded bermudagrass during establishment. Quinclorac also has good activity on numerous broadleaf weeds and has excellent safety on seedling bermudagrass (10, 15, 19). Therefore, a number of herbicide combinations are available to control both annual and perennial broadleaf weeds during the establishment of seeded bermudagrass.

Three herbicides tested in this trial fall under the sulfonyleurea class of herbicide, including foramsulfuron, trifloxysulfuron, and flazasulfuron. These herbicides, in combination with MSMA, caused relatively low levels of injury to 'Riviera' bermudagrass (Figure 2). Most of the injury was observed within the first 14 DAT and was not present at 21 DAT. The level of herbicide injury was similar for all three herbicides tested from this group (Figure 2). Foramsulfuron and trifloxysulfuron were tested in a previous trial against four seeded bermudagrass cultivars, including 'Riviera', and found to have good safety when applied at 4-7 weeks after emergence (15).

The present trial indicates that these herbicides can be safely used on seedling bermudagrass as early as two weeks after emergence. The sulfonyleurea herbicides have shown excellent herbicidal activity against a range of cool-season grasses and sedges (22) and will be a safe option to use on seedling bermudagrass turf. Foramsulfuron has also shown to have good activity against goosegrass (3) and will be a much safer option during seedling establishment than metribuzin + MSMA or diclofop (10).

### Conclusions

The herbicide combinations tested in these trials caused varying levels of turfgrass injury to seedling bermudagrass, but most of the injury was

generally short-lived and did not significantly reduce the rate of turfgrass coverage in most treatments. The treatments tested here offer broad-spectrum control for many of the problematic weeds that can reduce bermudagrass establishment (Table 3).

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