CHAPTER 2

CONTROL STRATEGIES FOR COMMON DANDELION (*Taraxacum officinale* Weber) IN NO-TILLAGE CROPPING SYSTEMS

Abstract: Common dandelion has developed into a troublesome agronomic weed for no-tillage corn and soybean producers in Michigan and throughout the North Central region. Field experiments were conducted on established populations of common dandelion in 2001-02 and 2002-03 to evaluate the effect of preplant herbicide applications and sequential herbicide applications for efficacy on established populations of common dandelion. Preplant treatments of glyphosate or 2,4-D ester were applied early fall, late fall, early spring, and late spring. Glyphosate was applied at 420 g ae ha^{-1} or 840 kg ae ha^{-1}; 2,4-D ester was applied at 560 g ai ha^{-1} or 1120 g ai ha^{-1}. A tank mixture of glyphosate plus 2,4-D ester was also evaluated at each of the preplant timings. Common dandelion control was evaluated at the time of crop planting. For both glyphosate and 2,4-D ester, the fall applications were more effective than the spring applications. The late fall application of glyphosate at 840 g ae was the most effective treatment, with 80 percent control of common dandelion. A single application of glyphosate or 2,4-D ester applied either in the fall or spring was not sufficient in providing season long control of common dandelion. A subsequent field experiment was conducted to evaluate the effectiveness of sequential applications of glyphosate to provide season long control of common dandelion.

Sequential treatments of glyphosate following either glyphosate or 2,4-D ester were effective in providing season-long control of common dandelion.

Nomenclature: *Taraxacum officinale*, TAROF, common dandelion; glyphosate, *N*-(phosphonomethyl) glycine; 2,4-D ester, (2,4-dichlorophenoxy) acetic acid.

Key words: application timing, preplant treatment, sequential treatment.

INTRODUCTION

Common dandelion (*Taraxacum officinale* Weber) has developed into a troublesome agronomic weed in Michigan and throughout the North Central region of the U.S. Typically considered a problematic weed unique to forage production and turf grass, the occurrence of common dandelion in no-tillage corn and soybean production is becoming more common. The increased use of herbicide-resistant crops in conjunction with the adoption of no-tillage cropping practices has resulted in an environment conducive to the establishment of common dandelion (Triplett and Lytle 1972).

Common dandelion is a simple perennial that possesses a large fragile taproot that is used for carbohydrate storage and to acquire needed resources. Tillage operations associated with conventional-tillage crop production are an effective method of controlling perennial weeds such common dandelion because tillage disrupts the establishment and development of the taproot (Triplett 1985). Adoption of no-tillage cropping practices by crop producers has occurred in response to environmental and economic incentives. Soil conservation and reduced input costs are the primary drivers for this adoption (Jasa et al. 1991). However, no-tillage cropping systems have a higher reliance on herbicides for weed control (Koskinen and McWhorter 1986), often requiring multiple herbicide applications to manage perennials (Buhler and Mercurio 1988; Buhler and Proost 1990).

Non-selective herbicides, such as glyphosate, are widely used for vegetation management prior to planting and postemergence in no-tillage glyphosate-resistant cropping systems. A disadvantage of the use of glyphosate as a preplant and postemergence treatment is the lack of residual soil activity (Sprankle et al. 1975a, 1975b). A consequence of the exclusive use of glyphosate without the addition of soil applied residual herbicides is the potential for weeds, including common dandelion seedlings, to emerge following the glyphosate application. Glyphosate is effective in controlling many troublesome perennial weeds (Davison 1972). However, common dandelion is often the one weed not completely controlled. Furthermore, as common dandelion seedlings become established, they become more difficult to control (Triplett et al. 1977).

The objectives of this research were to determine the effect of herbicide, application timing, and sequential applications on control of established populations of common dandelion in no-tillage cropping systems.

MATERIALS AND METHODS

Field experiments were conducted to evaluate control strategies for common dandelion using glyphosate[1] and 2,4-D ester[2]. Preplant treatments of glyphosate and/or 2,4-D ester were applied at four application timings. Additional experiments were conducted to evaluate sequential applications of glyphosate following either glyphosate or 2,4-D ester. Initial applications of glyphosate or 2,4-D ester were applied preplant either in the fall or spring. Sequential applications of glyphosate were applied postemergence in glyphosate-resistant soybean.

Effect of herbicide and application timing

Experiments to evaluate preplant applications of glyphosate or 2,4-D ester were conducted in 2001-02 and 2002-03 at the Michigan State University Clarksville Experiment Station. Two identical experiments were established on adjacent sites in both 2001-02 and 2002-03. Experiments were conducted on sites with established populations of common dandelion that had been in a no-tillage corn-soybean rotation for 3 years. The soil at the experimental site was a loam with pH 6.8 and 1.8% organic matter. Experimental sites were prepared by removing the previous corn crop as silage approximately one month before the initial fall applications. Plots measured 3 m wide by 9 m long. Herbicide treatments were applied with a tractor mounted, compressed-air sprayer calibrated to deliver 187 L ha^{-1} at 207 kPa through 8003 flat fan nozzles[3].

Treatments of glyphosate or 2,4-D ester were applied at four application timings prior to crop planting; early fall (EFALL), late fall (LFALL), early spring (ESPRING), and late spring (LSPRING) (Table 1). Glyphosate and 2,4-D ester were applied at typical use rates to evaluate common dandelion control. Glyphosate was applied at 420 g ae ha^{-1} and 840 g ae ha^{-1}; 2,4-D ester was applied at 560 g ai ha^{-1} and 1120 g ai ha^{-1}. A tank mixture of glyphosate plus 2,4-D ester at 420 g ae ha^{-1} and 560 g ae ha^{-1}, respectively, was also applied at each of the four preplant timings. All treatments containing glyphosate were applied with 2% (w/v) ammonium sulfate. Common dandelion control was evaluated visually at crop planting and was recorded as percent control as compared to the untreated; where 0 = no control and 100 = complete common dandelion death.

Effect of sequential applications

Field experiments were conducted in glyphosate-resistant soybean to evaluate the effectiveness of sequential applications of glyphosate following initial applications of either glyphosate or 2,4-D ester. Experiments were conducted in 2001-02 and 2002-03 at the Michigan State University Clarksville Experiment Station as described above. Glyphosate-resistant soybean[4] were planted at a population of 494,000 seeds ha^{-1} in 19-cm rows, approximately 3 weeks after the initial spring application. In 2002-03, *s*-metolachlor[5] was applied preemergence over the entire study at 1424 g ai ha^{-1} for annual weed control. A postemergence application of quizalofop-P-ethyl[6] at 49 g ai ha^{-1} was applied with non-ionic surfactant[7] at 0.25% (v/v) for grass control in both 2001-02 and 2002-03.

Initial treatments of either glyphosate or 2,4-D ester at 840 g ae and 1120 g ae, respectively, were applied at two preplant application timings; fall and spring. These application timings correspond with the LFALL and ESPRING timings described above in Table 1. Sequential treatments of glyphosate at 840 g ae were applied postemergence to glyphosate-resistant soybean at the V3 or V6 crop stage. The sequential application at the V6 stage of soybean was evaluated in 2002-03 only. Common dandelion control was evaluated visually and common dandelion plant density recorded at soybean harvest. Common dandelion density was recorded as the number of plants per square meter. Soybean yield was determined 2001-02 by hand-harvesting the middle 1.5 m of each 4.5 m long plot. In 2002-03, the middle 1.5 m of each 9 m long plot was mechanically harvested with a research plot harvester.

Statistical analysis

The herbicide and application timing experiment was conducted as a randomized complete block design. Treatments were replicated four times for each treatment and the experiment was conducted four times. Data were subjected to analysis of variance with SAS[8] and means separated using Fisher's Protected LSD ($\alpha = 0.05$). Variances were determined to be homogenous and the experiments combined.

The sequential application experiment was established as a split block with four replications in 2001-02; the whole plot was the initial application and the sub-plot was the sequential application. In 2002-03, the experiment was conducted as a randomized complete block design with four replications. Data were subjected to analysis of variance with SAS and means separated using Fisher's Protected LSD ($\alpha = 0.05$). Data collected in 2001-02 and 2002-03 are presented separately.

RESULTS AND DISCUSSION

Effect of herbicide and application timing

Significant differences in common dandelion control were observed between herbicides and herbicide rates. Both glyphosate or 2,4-D ester at higher rates were more effective than at lower rates at each of the four application timings (Figure 1). Glyphosate applied at 840 g ae was usually more effective than 2,4-D ester at 1120 g ae, regardless of application timing (Figure 2). The most effective herbicide treatment to control common dandelion was the LFALL application of glyphosate applied at 840 g ae, resulting in 80 percent control. The effectiveness of fall applications of glyphosate to control common dandelion has been consistently demonstrated (Buhler and Mercurio 1988; Buhler and Proost 1990). At the same LFALL timing, 2,4-D ester at 1120 g ae provided 58 percent common dandelion control. The most effective application timing for 2,4-D ester was the EFALL application timing which resulted in 60 percent control of common dandelion. Glyphosate applied at the same timing was more effective with 74 percent control of common dandelion. Glyphosate at the lower rate was consistently more effective than 2,4-D ester at the lower rate at all application timings (Figure 1).

Timing of the preplant application was as critical as the herbicide and herbicide rate applied. For both glyphosate and 2,4-D ester, the preplant applications in the fall were more effective than the spring applications (Figure 2), despite the fact that temperatures at the time of application were lower in the fall versus the spring, especially in 2001-02 (Table 1). Glyphosate applied at 840 g ae provided 80 and 74 percent control at the EFALL and LFALL timings, respectively. This same treatment at the ESPRING and LSPRING timings resulted in only 65 and 55 percent control, respectively. A similar trend of reduced control in the spring was also observed with 2,4-D ester (Figure 2). Reduced control of common dandelion by spring treatments may relate to growth patterns of the plant in the spring (Mann 1981; Rutherford and Deacon 1974). Root tissue of common dandelion has the ability to generate new shoots (Mann and Cavers 1979). Carbohydrates stored in the taproot are mobilized to the above ground biomass of the plant during rapid vegetative growth in the spring. Applications at this time result in insufficient herbicide translocation to the roots for complete control.

Glyphosate or 2,4-D ester applied at the lower rates in the fall tended to be more effective than the higher herbicide rates applied in the spring. Applications of 2,4-D ester at 560 g ae at the EFALL and LFALL timings provided 40 and 43 percent control, respectively (Figure 1). These treatments were more effective than the ESPRING and LSPRING applications of 2,4-D ester at 1120 g ae with 34 and 31 percent control, respectively. A similar trend was observed with glyphosate for the spring applications. The LFALL application of glyphosate at 420 g ae was more effective than the LSPRING application of glyphosate at 840 g ae.

Depending on application timing, a tank-mixture of glyphosate plus 2,4-D ester at reduced rates was effective in controlling common dandelion. Regardless of application timing, glyphosate applied at 840 g ae was more effective than the tank-mixture (Figure 1). At the LFALL application timing, the tank-mixture was more effective than 420 g ae of glyphosate. Common dandelion control with the tank-mixture was more effective than 2,4-D ester at 1120 g ae at the LFALL, ESPRING, and LSPRING application timings. The tank-mixture was as effective as 1120 g ae of 2,4-D ester at the EFALL application timing. The addition of 2,4-D ester to glyphosate did not antagonize common dandelion control when applied at the EFALL, LFALL, and LSPRING application timing. However, at the ESPRING application timing, the tank-mixture was less effective than 420 g ae of glyphosate.

Effect of sequential applications

A single application of glyphosate or 2,4-D ester either in the fall or spring did not provide season-long control of common dandelion (Figure 3). However, the addition of a sequential application of glyphosate following either glyphosate or 2,4-D ester was effective in providing season-long control of common dandelion. In both 2001-02 and 2002-03, glyphosate applied in the fall followed by the sequential application at the V3 stage of soybean provided greater than 80 percent control. In 2002-03, similar control was observed with the fall application followed by the sequential application at the V6 stage of soybean with 87 percent control.

In 2001-02, the spring application of glyphosate followed by the V3 stage of soybean provided 54 percent control. This was significantly lower than the same treatment in 2002-03 with 97 percent control. This discrepancy in control between years could be attributed to the lack of significant rainfall in 2002-03 following the spring application timing (Table 2). In 2002, the experimental site received over 160 mm of precipitation from January thru April. This was approximately 100 mm more than in 2003. The dry weather pattern reduced new seedling germination and plant regrowth. The lack of new plant growth in 2002-03 is evident from the spring-only treatment of glyphosate that provided 75 percent control at harvest. This same treatment in 2001-02 provided only 20 percent control.

Treatment with 2,4-D ester followed by a sequential application of glyphosate was also effective in controlling common dandelion, depending on the timing of the initial application (Figure 3). In 2001-02, the fall application of 2,4-D ester followed by glyphosate at the V3 stage of soybean provided 81 percent control of common dandelion. However, the spring application of 2,4-D ester followed by glyphosate at the V3 stage of soybean provided only 44 percent control in 2001-02. Fall treatments were again more effective in controlling established common dandelion. In 2001-02, the sequential application of glyphosate at the V3 stage of soybean controlled newly emerged common dandelion from the fall treatment. The initial spring treatment of glyphosate was less effective, resulting in more established plants at the sequential application at the V3 stage of soybean. These mature plants are more difficult to control than seedling common dandelion (Triplett et al. 1977).

Similar to the sequential treatments of glyphosate in 2001-02 and 2002-03, a sequential treatment of glyphosate following 2,4-D ester in the fall provided 81 and 80 percent control of common dandelion, respectively. Likewise, the spring application of 2,4-D ester followed by glyphosate at the V3 stage of soybean was less effective with only 44 percent control in 2001-02. This same treatment in 2002-03 provided 80 percent control of common dandelion at harvest. This differential response is likely a result of the extended period without rainfall in 2002-03. Delaying the sequential application until the V6 stage of soybean resulted in common dandelion control similar to the timing at the V3 stage of soybean regardless of timing of the initial application (Figure 3).

A single application of either glyphosate or 2,4-D ester applied in the fall or spring was not effective in reducing plant densities as compared to the untreated (Figure 4). However, the addition of a sequential application of glyphosate was effective in reducing common dandelion plant densities. In 2001-02, the addition of the sequential application of glyphosate at the V3 stage of soybean reduced common dandelion plant densities as compared to the fall only treatment of glyphosate. In 2002-03, delaying the sequential application until the V6 stage of soybean significantly reduced common dandelion densities as compared to the fall treatment of glyphosate. A sequential application of glyphosate following a spring treatment of glyphosate did not reduce common dandelion densities in either 2001-02 or 2002-03. A sequential application of glyphosate following 2,4-D ester applied in the fall or spring was effective in reducing common dandelion densities as compared to the initial treatment alone.

Timing of herbicide application had a significant effect on soybean yield. In 2001-02, the fall and spring applications of either glyphosate or 2,4-D ester did not result in soybean yield greater than the untreated (Figure 5). In 2002-03, the spring application of either glyphosate or 2,4-D ester resulted in soybean yield greater than the untreated or the fall application of either herbicide. It is likely that the lack of moisture that reduced weed seedling germination and regrowth in 2003 contributed to this observation. Soybean yields resulting from a fall application of either glyphosate or 2,4-D ester followed by the sequential application at the V3 stage of soybean were consistently among the highest in both 2001-02 and 2002-03. Delaying the sequential application of glyphosate until the V6 stage of soybean following the spring application of either glyphosate or 2,4-D ester did not affect soybean yield as compared with the sequential application at the V3 stage of soybean in 2002-03. However, delaying the sequential application following the initial fall application of either glyphosate or 2,4-D ester did result in reduced soybean yield. Reduction of soybean yield associated with the initial fall followed by the sequential application at the V6 stage of soybean is likely due to early-season competition from annual weeds not controlled by the preemergence application of *s*-metolachlor.

It is apparent that established populations of common dandelion pose a significant challenge to no-tillage crop producers. Common dandelion, when left uncontrolled, has the potential to negatively impact soybean production. An effective management strategy to control this weed includes field monitoring and multiple herbicide applications. The lack of residual control associated with glyphosate and 2,4-D ester makes sequential herbicide applications necessary to achieve season-long control of common dandelion. An effective strategy to control common dandelion in no-tillage crop production will include fall applications of herbicides such as glyphosate followed by a sequential postemergence application of glyphosate in glyphosate-resistant crops. The timing of this postemergence application will depend on environmental conditions and the presence of emerged weeds.

Source of Materials

[1] Roundup UltraMAX, Monsanto Company, St. Louis, MO 63167.

[2] 2,4-D ester, Tenkoz Inc., Alpharetta, GA 30202.

[3] Flat-fan spray nozzle, Spraying Systems Company, Wheaton, IL 60188.

[4] DK 23-51, Dekalb Genetics Corp., Monsanto Company, St. Louis MO 63167

[5] Dual II Magnum, Syngenta Crop Protection, Inc. Greensboro, NC 27409.

[6] Assure II, E. I. du Pont de Nemours and Company, Wilmington, DE 19898.

[7] Activator 90, Loveland Industries Inc., Greeley, CO 80632.

[8] SAS version 8.2, SAS Institute, SAS Circle, Box 8000, Cary, NC 27512-8000.

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Table 1. Application timing, application date, and average air temperature for glyphosate and 2,4-D ester applications for common dandelion control.

Application Timing	2001-2002				2002-2003			
	Date of application	Air temperature[a] (C)			Date of application	Air temperature[a] (C)		
		-1	0	+1		-1	0	+1
Early fall	October 18, 2001	5	8	10	October 9, 2002	11	14	13
Late fall	November 5, 2001	8	5	8	November 9, 2002	13	12	13
Early spring	April 16, 2002	23	24	20	April 15, 2003	16	23	11
Late spring	April 30, 2002	6	8	9	April 29, 2003	17	12	12

[a] Average air temperature on the day before (-1), the day of (0), and the day after (+1) herbicide application.

Table 2. Yearly accumulation of precipitation at the Michigan State University Clarksville Experiment Station from 2001 thru 2003.

Month	Annual precipitation		
	2001	2002	2003
	mm		
January	19	7	3
February	64	34	8
March	14	49	35
April	67	78	22
May	136	104	122
June	67	66	50
July	23	47	60
August	103	71	92
September	78	25	45
October	143	45	29
November	48	53	173
December	34	22	21
Total	796	608	670

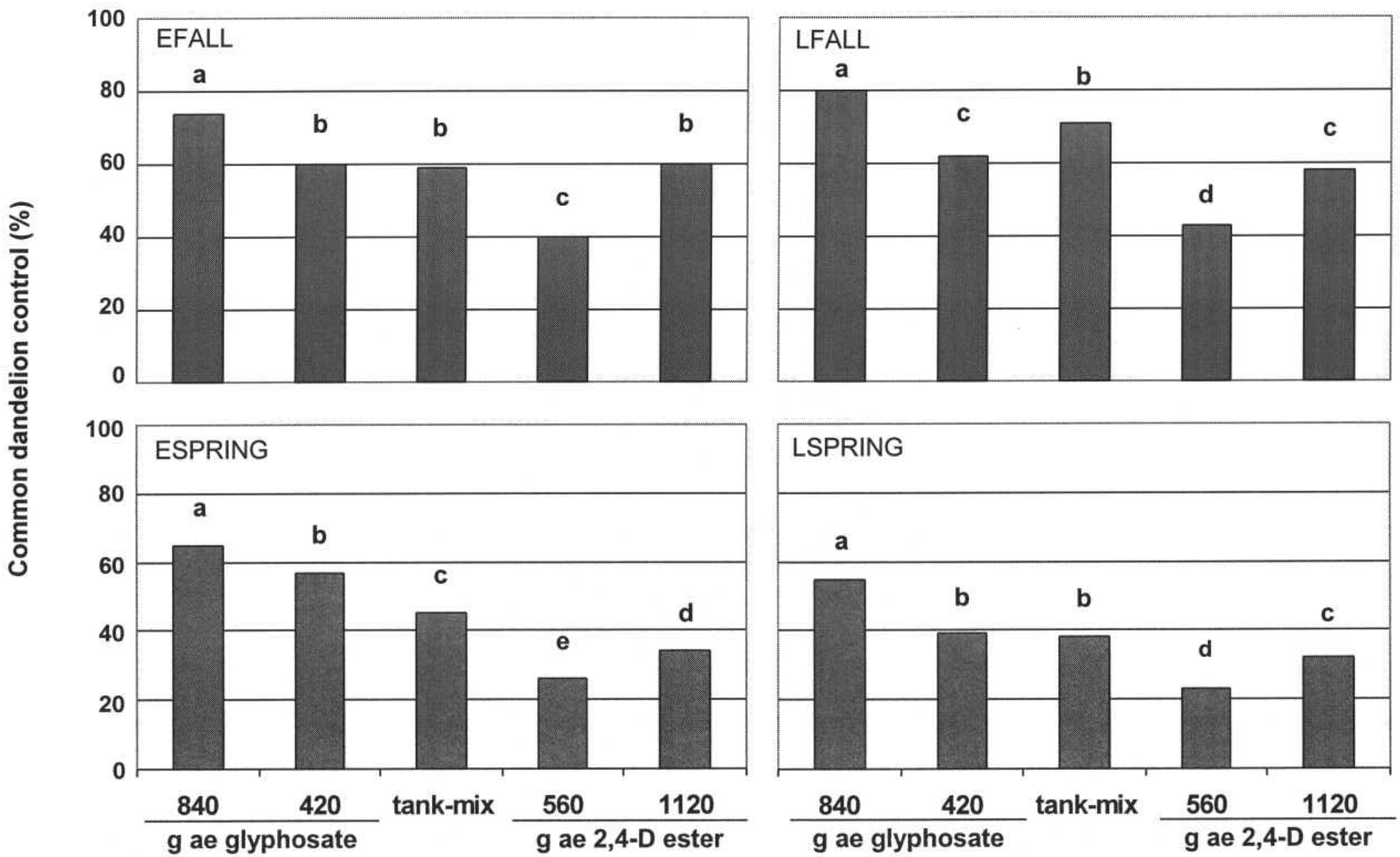

Figure 1. Common dandelion control at planting with preplant applications of glyphosate, 2,4-D ester and tank mixture of glyphosate plus 2,4-D ester at 420 g ae and 560 g ae, respectively, as affected by application timing. All treatments containing glyphosate were applied with 2% (w/v) ammonium sulfate. Means within application timing with the same letter are not significantly different ($\alpha = 0.05$).

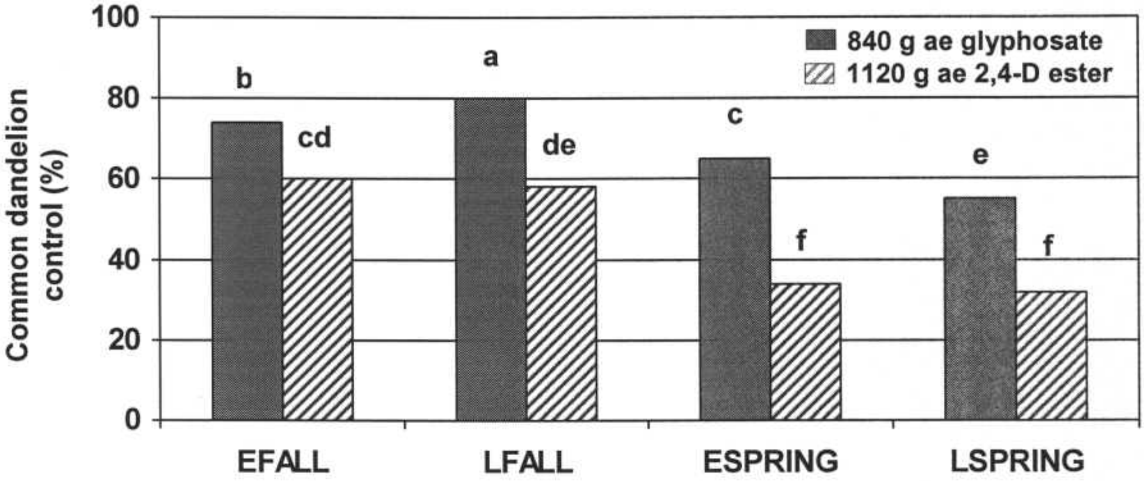

Figure 2. Common dandelion control at planting with glyphosate and 2,4-D ester as affected by application timing. Glyphosate applied with 2% (w/v) ammonium sulfate. Means with the same letter are not significantly different (α = 0.05)

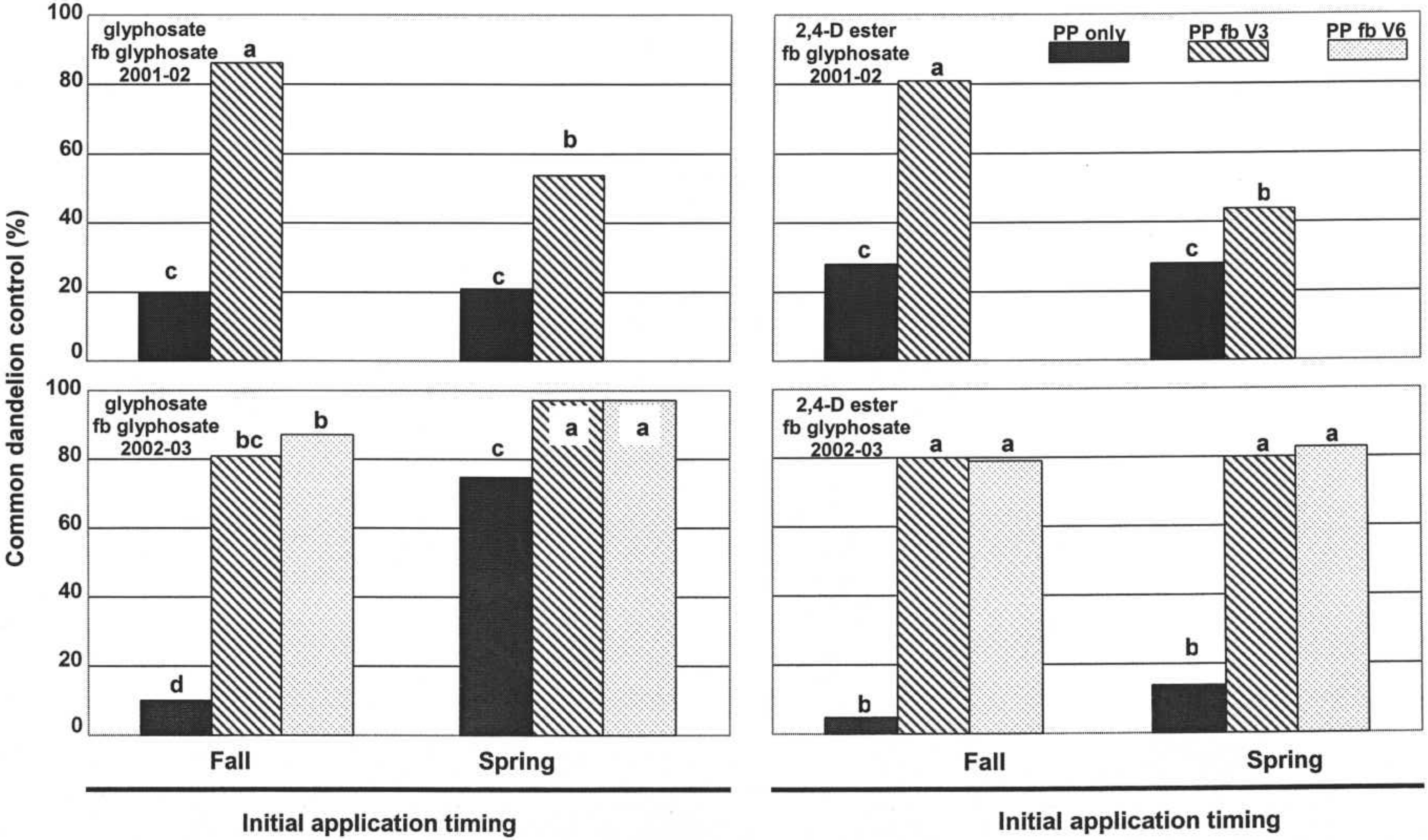

Figure 3. Common dandelion control at soybean harvest with single and sequential herbicide applications as affected by application timing. All treatments containing glyphosate were applied with 2% (w/v) ammonium sulfate. Means within each graph with the same letter are not significantly different ($\alpha = 0.05$).

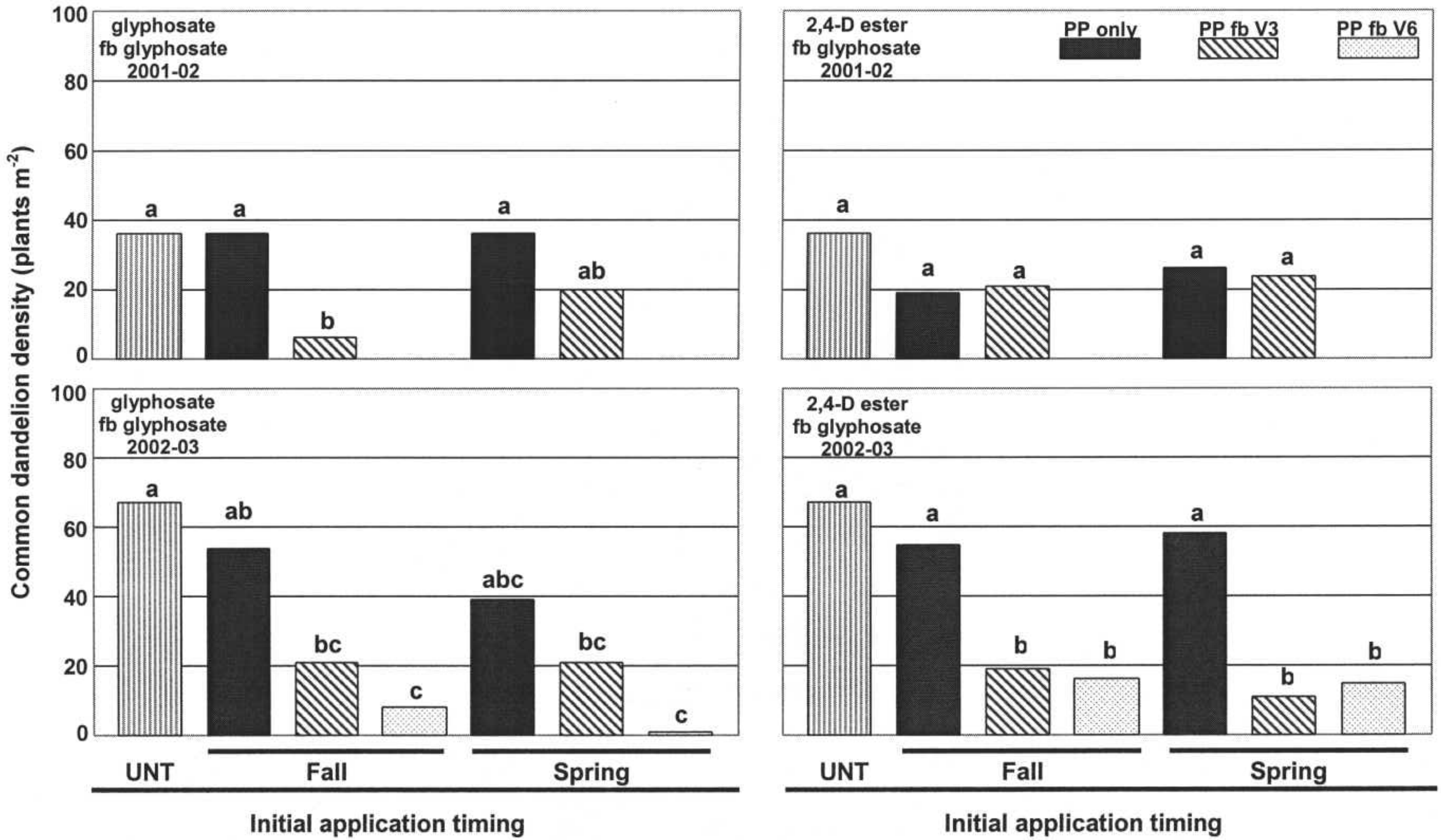

Figure 4. Common dandelion plant densities at soybean harvest with single and sequential herbicide applications as affected by application timing. All treatments containing glyphosate were applied with 2% (w/v) ammonium sulfate. Means within each graph with the same letter are not significantly different (α = 0.05).

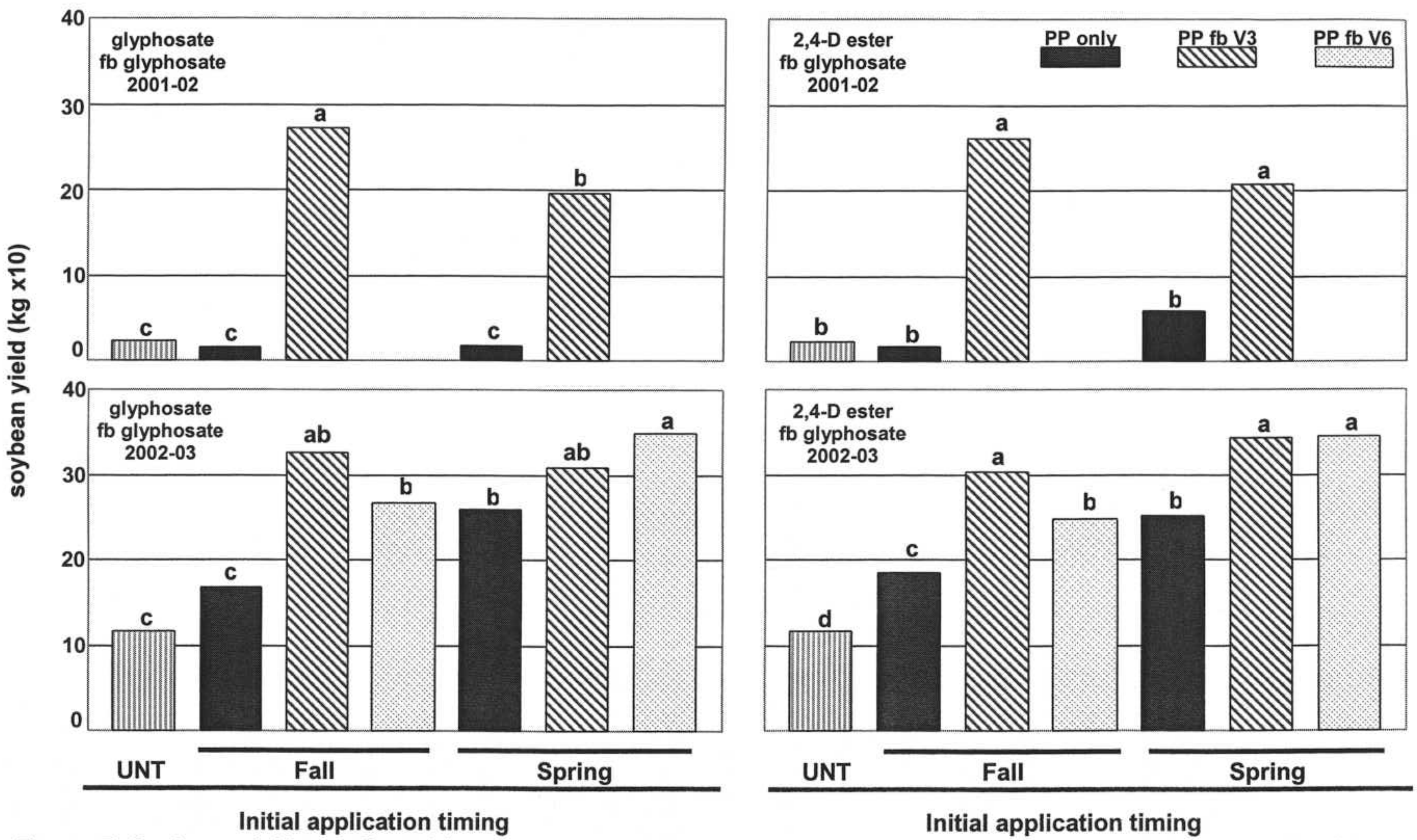

Figure 5. Soybean yield as affected by common dandelion control with single and sequential herbicide applications as affected by application timing. All treatments containing glyphosate were applied with 2% (w/v) ammonium sulfate. Means within each graph with the same letter are not significantly different ($\alpha = 0.05$).