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Tolerance of Maize (*Zea mays* L.) and Soybean [*Glycine max* (L.) Merr.] to Late Applications of Postemergence Herbicides

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Abstract

Seven maize (*Zea mays* L.) and three soybean [*Glycine max* (L.) Merr.] field experiments were conducted from 2006 to 2009 at various locations in southern Ontario, Canada to determine the tolerance of these crops to late applications of the maximum labeled herbicide dose. Single and sequential (simulating a spray overlap) applications were evaluated for visible injury, plant height, and crop yield in the absence of weed competition. Maize exhibited excellent tolerance to herbicides applied at the 9- to 10-leaf growth stage as visible injury levels for almost all tested herbicides was similar to the untreated control 7 days after treatment (DAT). However, the sequential application of dicamba/diflufenzopyr or foramsulfuron caused 6 and 8% injury 7 DAT and 8 and 14% reduction in maize height 28 DAT, respectively. The observed injury and stunting were transient as there were no differences in yield at harvest. Soybean displayed good tolerance to most herbicides applied at the 7th trifoliate leaf growth stage as visible injury levels were similar to the untreated control. However, thifensulfuron-methyl was injurious regardless of application and imazethapyr was injurious with sequential applications. For example, single thifensulfuron-methyl, sequential thifensulfuron-methyl, and sequential imazethapyr application treatments caused 35, 48, and 25% injury 7 DAT, respectively. Sequential thifensulfuron-methyl treatments also caused a 28 and 17% reduction in soybean height 14 and 28 DAT, respectively. Visual injury continued to be detected up to 56 DAT for single thifensulfuron-methyl, sequential thifensulfuron-methyl, and sequential imazethapyr treatments. But, soybean yields were reduced by 10% for only sequential thifensulfuron-methyl application treatments. For all other herbicides tested, the yields at harvest were similar to the untreated control. This research demonstrated that maize had exceptional tolerance to all the herbicides used in this study whereas soybean was tolerant to most of the herbicides used in this study.

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Keywords

Critical Weed-Free Period, Injury, Yield

1. Introduction

The critical weed-free period has provided Ontario growers with the knowledge of when to control the weeds that cause detrimental yield loss in maize [1] and soybean [2] for quite some time. Researchers have also recognized that the critical weed-free period can vary from year to year and location to location [3] [4], undermining the potential utility and implementation of this integrated weed management strategy [5]. Yet, research continues to be conducted as a better understanding of some of the underlying physiological mechanisms that underpin the critical weed-free period have recently been published [6] [7]. In general, crops need to be maintained under weed-free conditions from the start of the critical weed-free period until at least the 10-leaf stage in maize [1] [3] and the R1 (early flowing) stage in soybean [2] [3].

Ontario maize and soybean growers have numerous herbicide options [8] for managing weeds during the critical weed-free period. Unfortunately, growers can sometimes miss registered herbicide application windows due to adverse weather conditions or mechanical breakdowns which leave large, highly competitive weeds present in the crop at a point beyond the critical weed-free period when rapid yield loss occurs [1]-[3]. At this time, growers would like to apply a high dose of postemergence (POST) herbicide to ensure effective control of these large weeds, but growers also are concerned that crop injury could negatively impact yield. Regrettably, the tolerance of maize and soybean to a high herbicide dose at a late POST application timing is largely unknown. The exception to this is maize, which can tolerate over two-fold of the maximum labeled dose of glyphosate applied at the 10-leaf stage with minimal injury and little to no yield loss [9]. Furthermore, to the best of our knowledge, few studies have been conducted in the absence of confounding weed competition effects that examine both a range of herbicides comparing relative crop tolerance [10] and the tolerance of crops to a late POST herbicide application [11]. Therefore, the objective of this research was to determine the tolerance of maize and soybean to a late application of select POST herbicides in the absence of weed interference.

2. Materials and Methods

2.1. Study Establishment

A total of ten field experiments (seven for maize and three for soybean) were conducted over a four-year period (2006 to 2009) at various locations in southern Ontario, Canada (**Table 1**). Maize and soybean experiments were designed as a randomized complete block, replicated four times. Seven herbicides were used in maize and eight herbicides were used in soybean and all herbicides were applied in a single application of the maximum labeled dose in Ontario [8] or as sequential applications to simulate spray overlap. In the maize experiments, the herbicides used were nicosulfuron (25 g·ai·ha^{-1}), foramsulfuron (70 g·ai·ha^{-1}), dicamba/diflufenzopyr (200 g·ai·ha^{-1}), mesotrione + atrazine (100 + 280 g·ai·ha^{-1}), bromoxynil + atrazine (280 + 1500 g·ai·ha^{-1}), prosulfuron + dicamba (10 + 140 g·ai·ha^{-1}), and 2,4-D/atrazine (1404 g·ai·ha^{-1}). Whereas in the soybean experiments, the herbicides used were glyphosate (1800 g·ae·ha^{-1}), imazethapyr (100 g·ai·ha^{-1}), chlorimuron-ethyl (9 g·ai·ha^{-1}), thifensulfuron-methyl (6 g·ai·ha^{-1}), cloransulam-methyl (17.5 g·ai·ha^{-1}), fomesafen (240 g·ai·ha^{-1}), bentazon (1080 g·ai·ha^{-1}), and quizalofop-p-ethyl (72 g·ai·ha^{-1}). In all maize and soybean experiments, an untreated weed-free control treatment was included in addition to the single and sequential application POST herbicide treatments.

In both the maize and soybean experiments, each treatment plot was 2 m wide by 8 to 10 m long. Glyphosate-resistant maize hybrids (**Table 1**) were seeded 4 to 5 cm deep at a rate of approximately 75,000 seeds·ha^{-1} in rows spaced 0.75 m apart. Glyphosate-resistant soybean cultivars (**Table 1**) were seeded 2.5 to 3 cm deep at a rate of approximately 480,000 seeds·ha^{-1} in rows spaced 0.75 m apart. Herbicide treatments were applied to maize at the 9- to 10-leaf growth stage and to soybean at the 7th trifoliate leaf growth stage, both application timings were later than recommended [8]. At Exeter, herbicides were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 200 L·ha^{-1} at 240 kPa through Tee-Jet 8002 VS nozzles (Spraying Systems Co., Glendale Heights, IL). At Harrow, a CO_2 pressurized backpack sprayer delivered 222 L·ha^{-1} at 210 kPa through

Table 1. Seeding and emergence dates of maize hybrids and soybean cultivars and the spray date for postemergence herbicides used in ten field experiments established from 2006 to 2009 at various locations in Ontario, Canada to examine the tolerance of maize and soybean to late applications.

Location[a]	Year	Seeding Date	Emergence Date	Hybrid/Cultivar	Spray Date
Maize experiments					
Exeter	2006	May 1	May 11	Pioneer 38H65	June 20
	2007	April 26	May 9	Pioneer 38B86	June 13
Harrow	2007	May 24	May 31	Pioneer 36W68	June 26
Ridgetown, site A	2006	April 29	May 8	Pioneer 38H69	June 10
	2007	May 4	May 16	Pioneer 38W69	June 14
Ridgetown, site B	2006	April 29	May 8	Pioneer 38H69	June 20
	2007	May 4	May 16	Pioneer 38W69	June 18
Soybean experiments					
Ridgetown	2007	May 24	May 31	DeKalb 30-07R	July 6
	2008	May 22	May 31	Pioneer 30-07R	July 9
	2009	May 21	May 28	DeKalb 28-03R	July 7

[a]Exeter (43.3500˚N, 81.4833˚W), Harrow (42.0333˚N, 82.9167˚W), and Ridgetown sites A and B (42.4406˚N, 81.8842˚W).

Tee-Jet 11003 XR nozzles (Spraying Systems Co., Glendale Heights, IL). At Ridgetown, a CO_2 pressurized backpack sprayer delivered 200 L·ha^{-1} at 207 kPa through Ultra-Low Drift 120-02 nozzles (Hypro, New Brighton, MN). All plots were maintained weed-free for the entire growing season using preemergence herbicides and hand weeding as needed.

2.2. Data Collection and Analysis

In both the maize and soybean experiments, visible crop injury was rated 3, 7, 14, 21, 28, and 56 days after treatment (DAT) based on a scale of 0 (no injury) to 100% (complete plant death) relative to untreated, weed-free control plants. Average plant height was recorded 28 and 56 DAT in maize by measuring the height of the crop from the soil surface to the extended leaf height and 14 and 28 DAT in soybean by measuring the height of the crop from the soil surface to the growing point of the plant. Both crops were harvested at maturity using a small plot combine and crop moisture and weight were recorded; final yields were adjusted to 15.5 and 13% moisture content for maize and soybean, respectively. Data for crop injury, crop height, and crop yield were analyzed separately by crop using PROC MIXED (SAS Ver. 9.2, SAS Institute Inc., Cary, NC). In the individual analysis of the maize and soybean experiments, variances were divided into fixed (herbicide treatment) and random effects [block; environment (*i.e.*, year or location-year combinations); and the herbicide treatment × environment interaction]. The significance of the fixed effect in the maize and soybean experiments was tested using an F-test and the significance of random effects was tested using a Z-test of the variance estimate. PROC UNIVARIATE in SAS was used to test data for normality and homogeneity of variance. The herbicide treatment × environment interactions in maize and soybean experiments were not significant and therefore the data for each set of experiments were pooled across environments within each crop. Means were separated using Fisher's Protected LSD at $P < 0.05$.

3. Results and Discussion

3.1. Maize Experiments

Maize exhibited excellent tolerance to the POST herbicides applied at the 9- to 10-leaf growth stage. At 3 DAT, only the sequential application of 2,4-D/atrazine caused significant visible injury of 9% (**Table 2**). At 7 DAT, the sequential application treatments of dicamba/diflufenzopyr, foramsulfuron, and 2,4-D/atrazine caused 6, 8, and 9% injury, respectively (**Table 2**). Sequential applications tended to cause at least two-fold greater injury than a single application. For example, 3% injury was observed for a single foramsulfuron application whereas the sequential application treatment caused 7% injury 14 DAT (**Table 2**). Furthermore, a single application of

Table 2. Visible injury of maize after late applications of postemergence herbicides at three locations (Exeter, Harrow, and Ridgetown) in Ontario, Canada in 2006 and 2007.[ab]

Treatment	Dose	Maize Injury (%)					
	$g \cdot ai \cdot ha^{-1}$	3 DAT	7 DAT	14 DAT	21 DAT	28 DAT	56 DAT
Untreated		0b	0d	0c	0b	0b	0a
Nicosulfuron[c]	25	0b	1cd	0c	0b	0b	0a
Nicosulfuron[c] *fb* Nicosulfuron[c]	25 *fb* 25	2b	3abcd	3bc	2ab	1b	1a
Foramsulfuron[d]	70	2b	4abcd	3bc	2ab	0b	0a
Foramsulfuron[d] *fb* Foramsulfuron[d]	70 *fb* 70	4ab	8ab	7a	4ab	2ab	1a
Dicamba/diflufenzopyr[e]	200	2b	1cd	0c	1ab	0b	0a
Dicamba/diflufenzopyr[e] *fb* Dicamba/diflufenzopyr[e]	200 *fb* 200	5ab	6abc	6ab	5a	2ab	2a
Mesotrione + atrazine[c]	100 + 280	0b	0d	0c	0b	0b	0a
Mesotrione + atrazine[c] *fb* Mesotrione + atrazine[c]	100 + 280 *fb* 100 + 280	1b	1cd	1bc	1ab	1b	0a
Bromoxynil + atrazine	280 + 1500	2b	2bcd	1bc	0b	0b	0a
Bromoxynil + atrazine *fb* Bromoxynil + atrazine	280 + 1500 *fb* 280 + 1500	4ab	4abcd	2bc	1ab	1b	0a
Prosulfuron + dicamba[c]	10 + 140	0b	0d	0c	0b	0b	0a
Prosulfuron + dicamba[c] *fb* Prosulfuron + dicamba[c]	10 + 140 *fb* 10 + 140	2b	2bcd	2bc	1ab	1b	0a
2,4-D/atrazine	1404	4ab	4abcd	2bc	2ab	3ab	2a
2,4-D/atrazine *fb* 2,4-D/atrazine	1404 *fb* 1404	9a	9a	5abc	4ab	6a	3a

[a]Abbreviations: DAT, days after treatment; *fb*, followed immediately by. [b]Means followed by the same letter within a column are not significantly different according to Fisher's Protected LSD ($P < 0.05$). [c]Included Agral 90 at 0.2% v/v. [d]Included 28% UAN at 2.5 $L \cdot ha^{-1}$. [e]Included Agral 90 at 0.25% v/v and 28% UAN at 1.25% v/v.

dicamba/diflufenzopyr caused no injury, but the sequential application caused 6% injury 14 DAT (**Table 2**). Similar levels of injury to maize by foramsulfuron [12]-[15] and dicamba/diflufenzopyr [16]-[19] have been reported. Conversely, up to 16% injury 3 DAT has been found in maize treated with twice the labeled dose of foramsulfuron and 23% injury 7 DAT for maize treated with twice the dose of dicamba/diflufenzopyr [10]. Maize tolerance to foramsulfuron can vary considerably by application timing and maize hybrid [20] [21]. In the current study, the visible injury was transient with reduced injury observed at 21, 28, and 56 DAT. At 56 DAT, there were no differences in injury among the treated and non-treated maize (**Table 2**). Although little to no visible injury was detected for the foramsulfuron or dicamba/diflufenzopyr treatments 28 DAT (**Table 2**), maize plants at this time were shorter than the untreated control. For example, a 9% reduction in maize height was recorded for a single foramsulfuron application and the sequential application treatment caused a 14% reduction in height 28 DAT (**Table 3**). The height of maize plants treated with a single application of dicamba/diflufenzopyr was similar to the untreated control, whereas sequential applications caused an 8% reduction in height 28 DAT (**Table 3**). This is similar to other studies which demonstrated stunting or reduced growth in maize due to applications of foramsulfuron or dicamba/diflufenzopyr [10] [12]-[14]. Nevertheless, the observed reductions in height in this study were transient as no differences were detected among the treated and non-treated maize by 56 DAT. Furthermore, the excellent tolerance to the herbicides used in this study was confirmed as the final maize yields were similar to the untreated control across all treatments (**Table 3**), consistent with other studies [10] [16] [19].

3.2. Soybean Experiments

Soybean displayed good tolerance to most of the POST herbicides applied in a single application at the 7th trifoliate leaf growth stage as visible injury levels 3 and 7 DAT for almost all of these treatments were similar to the untreated control. The exception to this trend was thifensulfuron-methyl, which caused 27% injury 3 DAT and 35% injury 7 DAT (**Table 4**), which concurs with other studies [22] [23]. Injury levels observed 7 DAT for se-

Table 3. Maize height and yield after late applications of postemergence herbicides at three locations (Exeter, Harrow, and Ridgetown) in Ontario, Canada in 2006 and 2007.[ab]

Treatment	Dose	Height (m)		Yield
	g·ai·ha^{-1}	28 DAT	56 DAT	T·ha^{-1}
Untreated		1.6a	2.2a	11.6a
Nicosulfuron[c]	25	1.6ab	2.2a	11.6a
Nicosulfuron[c] *fb* Nicosulfuron[c]	25 *fb* 25	1.5abc	2.2a	11.2a
Foramsulfuron[d]	70	1.4cd	2.1a	11.5a
Foramsulfuron[d] *fb* Foramsulfuron[d]	70 *fb*70	1.4d	2.1a	11.1a
Dicamba/diflufenzopyr[e]	200	1.6a	2.2a	11.8a
Dicamba/diflufenzopyr[e] *fb* Dicamba/diflufenzopyr[e]	200 *fb* 200	1.5bcd	2.1a	11.1a
Mesotrione + atrazine[c]	100 + 280	1.5abc	2.2a	11.8a
Mesotrione + atrazine[c] *fb* Mesotrione + atrazine[c]	100 + 280 *fb* 100 + 280	1.5abc	2.2a	11.3a
Bromoxynil + atrazine	280 + 1500	1.6ab	2.2a	11.5a
Bromoxynil + atrazine *fb* Bromoxynil + atrazine	280 + 1500 *fb* 280 + 1500	1.6ab	2.2a	11.5a
Prosulfuron + dicamba[c]	10 + 140	1.6ab	2.2a	11.8a
Prosulfuron + dicamba[c] *fb* Prosulfuron + dicamba[c]	10 + 140 *fb* 10 + 140	1.5abc	2.2a	11.2a
2,4-D/atrazine	1404	1.6ab	2.2a	11.5a
2,4-D/atrazine *fb* 2,4-D/atrazine	1404 *fb* 1404	1.5abc	2.2a	11.3a

[a]Abbreviations: DAT, days after treatment; *fb*, followed immediately by. [b]Means followed by the same letter within a column are not significantly different according to Fisher's Protected LSD ($P < 0.05$). [c]Included Agral 90 at 0.2% v/v. [d]Included 28% UAN at 2.5 L·ha^{-1}. [e]Included Agral 90 at 0.25% v/v and 28% UAN at 1.25% v/v.

Table 4. Visible injury of soybean after late applications of postemergence herbicides at Ridgetown, Ontario, Canada in 2007 to 2009.[ab]

Treatment	Dose	Soybean Injury (%)					
	g·ae·ha^{-1}/ g·ai·ha^{-1}	3 DAT	7 DAT	14 DAT	21 DAT	28 DAT	56 DAT
Untreated		0d	0e	0d	0d	0d	0d
Glyphosate	1800	1d	1de	0d	0d	0d	0d
Glyphosate *fb* Glyphosate	1800 *fb* 1800	1d	2de	1d	1d	0d	0d
Imazethapyr[c]	100	8cd	8cde	6cd	4cd	3cd	4cd
Imazethapyr[c] *fb* Imazethapyr[c]	100 *fb* 100	20bc	25bc	20bc	15bc	12bc	13bc
Chlorimuron-ethyl[d]	9	7cd	8cde	5cd	3cd	2cd	3d
Chlorimuron-ethyl[d] *fb* Chlorimuron-ethyl[d]	9 *fb* 9	21bc	19bcd	14bcd	8bcd	7bcd	8cd
Thifensulfuron-methyl[e]	6	27ab	35ab	28ab	21ab	16ab	20ab
Thifensulfuron-methyl[e] *fb* Thifensulfuron-methyl[e]	6 *fb* 6	38a	48a	41a	32a	26a	29a
Cloransulam-methyl[f]	17.5	9cd	9cde	8cd	5cd	4cd	4cd
Cloransulam-methyl[f] *fb* Cloransulam-methyl[f]	17.5 *fb* 17.5	13bcd	13cde	10cd	7cd	6bcd	8cd
Fomesafen[g]	240	6cd	6de	2d	1d	0d	0d
Fomesafen[g] *fb* Fomesafen[g]	240 *fb* 240	14bcd	12cde	8cd	3cd	2cd	0d
Bentazon[h]	1080	7cd	7cde	4cd	1d	0d	0d
Bentazon[h] *fb* Bentazon[h]	1080 *fb* 1080	14bcd	10cde	4cd	2d	1d	0d
Quizalofop-p-ethyl[i]	72	2d	2de	1d	0d	0d	0d
Quizalofop-p-ethyl[i] *fb* Quizalofop-p-ethyl[i]	72 *fb* 72	4cd	4de	2d	1d	0d	0d

[a]Abbreviations: DAT, days after treatment; *fb*, followed immediately by. [b]Means followed by the same letter within a column are not significantly different according to Fisher's Protected LSD ($P < 0.05$). [c]Included Agral 90 at 0.25% v/v and 28% UAN at 2 L·ha^{-1}. [d]Included Agral 90 at 0.2% v/v and 28% UAN at 2 L·ha^{-1}. [e]Included Agral 90 at 0.1% v/v and 28% UAN at 8 L·ha^{-1}. [f]Included Agral 90 at 0.25% v/v and 28% UAN at 2.5 L·ha^{-1}. [g]Included Turbocharge at 0.5% v/v. [h]Included 28% UAN at 10 L·ha^{-1}. [i]Included Sure-mix at 0.5% v/v.

quential chlorimuron-ethyl, sequential imazethapyr, and sequential thifensulfuron-methyl treatments were greater than the untreated control with 19, 25, and 48% injury, respectively (**Table 4**). This is similar to other studies which demonstrated 15 to 20% injury from chlorimuron-ethyl [24] [25], 16 to 30% injury from imazethapyr [22] [23] [26]-[28], and up to 44% injury from thifensulfuron-methyl [29]. In this study, soybean injury decreased over time across all treatments. However, soybean injury continued to be detected up to 56 DAT for sequential imazethapyr, single thifensulfuron-methyl, and sequential thifensulfuron-methyl treatments with 13, 20, and 29% injury, respectively (**Table 4**). For sequential thifensulfuron-methyl treatments, visual injury symptoms were also coupled with decreased plant height. For example, sequential thifensulfuron-methyl treatments caused a 28 and 17% reduction in plant height 14 and 28 DAT, respectively (**Table 5**), similar to previous research [26] [29]. In the current study, persistent observations of injury and reduced height resulted in a 10% reduction in soybean yield for sequential thifensulfuron-methyl treatments (**Table 5**), consistent with other studies [22] [26] [27] [29]. For all other treatments used in this study, soybean exhibited good tolerance to these herbicides as the yields at harvest were similar to the untreated control (**Table 5**).

4. Conclusions

For Ontario maize and soybean growers concerned about crop injury when a high dose of herbicide is applied later than recommended [8], this research demonstrated that maize had exceptional tolerance to all the herbicides applied at the 9- to 10-leaf growth stage. This study expands upon related work with glyphosate in maize [9]. The most injurious treatments in this study, sequential foramsulfuron and sequential 2,4-D/atrazine treatments, caused only 8 and 9% injury 7 DAT, respectively. Yet, by harvest, these and the other herbicides tested

Table 5. Soybean height and yield after late applications of postemergence herbicides at Ridgetown, Ontario, Canada in 2007 to 2009.[ab]

Treatment	Dose	Height (m)		Yield
	$g \cdot ae \cdot ha^{-1}/g \cdot ai \cdot ha^{-1}$	14 DAT	28 DAT	$T \cdot ha^{-1}$
Untreated		0.8a	1.0abc	3.8ab
Glyphosate	1800	0.8a	1.0abc	3.8ab
Glyphosate *fb* Glyphosate	1800 *fb* 1800	0.8a	1.0abc	3.7abc
Imazethapyr[c]	100	0.7abc	0.9bcd	3.6abc
Imazethapyr[c] *fb* Imazethapyr[c]	100 *fb* 100	0.7abc	0.9bcd	3.6abc
Chlorimuron-ethyl[d]	9	0.8a	1.0abc	3.8ab
Chlorimuron-ethyl[d] *fb* Chlorimuron-ethyl[d]	9 *fb* 9	0.7abc	0.9bcd	3.6abc
Thifensulfuron-methyl[e]	6	0.7abc	0.9bcd	3.5bc
Thifensulfuron-methyl[e] *fb* Thifensulfuron-methyl[e]	6 *fb* 6	0.6c	0.8de	3.4c
Cloransulam-methyl[f]	17.5	0.7abc	0.9bcd	3.8a
Cloransulam-methyl[f] *fb* Cloransulam-methyl[f]	17.5 *fb* 17.5	0.7abc	0.9bcd	3.8ab
Fomesafen[g]	240	0.8a	1.0abc	3.7ab
Fomesafen[g] *fb* Fomesafen[g]	240 *fb* 240	0.8a	1.0abc	3.7ab
Bentazon[h]	1080	0.8a	1.0abc	3.8ab
Bentazon[h] *fb* Bentazon[h]	1080 *fb* 1080	0.8a	1.0abc	3.8ab
Quizalofop-p-ethyl [i]	72	0.8a	1.0abc	3.8ab
Quizalofop-p-ethyl[i] *fb* Quizalofop-p-ethyl[i]	72 *fb* 72	0.8a	1.0abc	3.8ab

[a]Abbreviations: DAT, days after treatment; *fb*, followed immediately by. [b]Means followed by the same letter within a column are not significantly different according to Fisher's Protected LSD ($P < 0.05$). [c]Included Agral 90 at 0.25% v/v and 28% UAN at 2 $L \cdot ha^{-1}$. [d]Included Agral 90 at 0.2% v/v and 28% UAN at 2 $L \cdot ha^{-1}$. [e]Included Agral 90 at 0.1% v/v and 28% UAN at 8 $L \cdot ha^{-1}$. [f]Included Agral 90 at 0.25% v/v and 28% UAN at 2.5 $L \cdot ha^{-1}$. [g]Included Turbocharge at 0.5% v/v. [h]Included 28% UAN at 10 $L \cdot ha^{-1}$. [i]Included Sure-mix at 0.5% v/v.

had no effect on yield when compared to the untreated weed-free control. Conversely, soybean growers needing a late POST application using a high dose should exercise some caution during herbicide selection as soybean was tolerant to most of the herbicides used in this study. Thifensulfuron-methyl was injurious regardless of application and imazethapyr was injurious with sequential applications as significant soybean injury was detected from 3 to 56 DAT for these herbicides. However, soybean yield were reduced by 10% for only sequential thifensulfuron-methyl treatments. For the remaining herbicides, soybean yields at harvest were similar to the untreated control, indicative of good tolerance.

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Abbreviations

DAT, days after treatment;
POST, postemergence.


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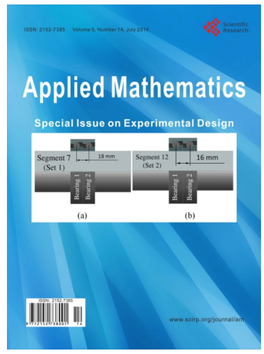
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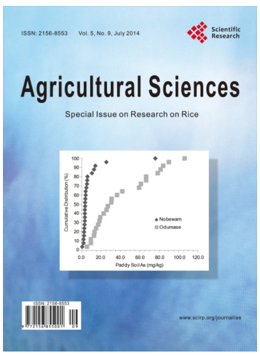
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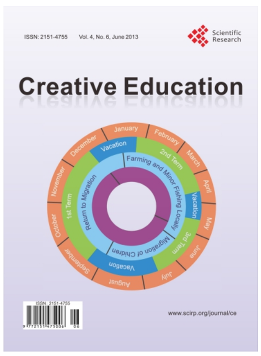
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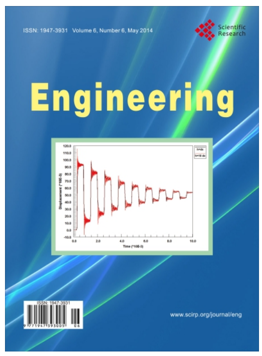
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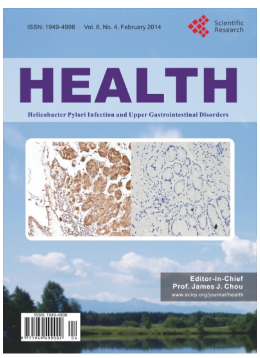
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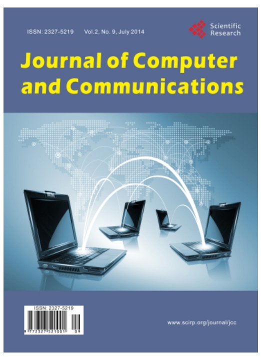
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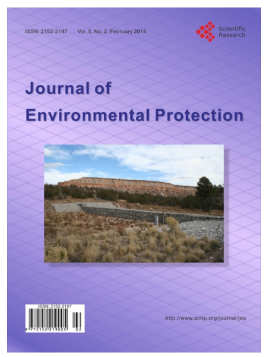
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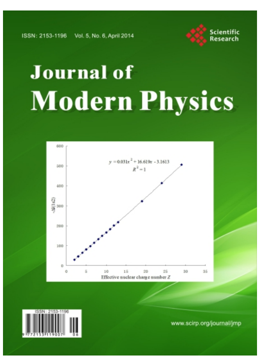
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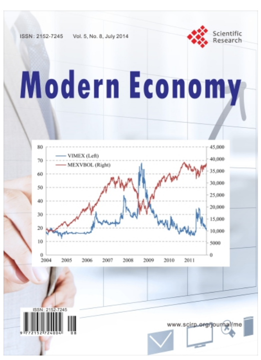
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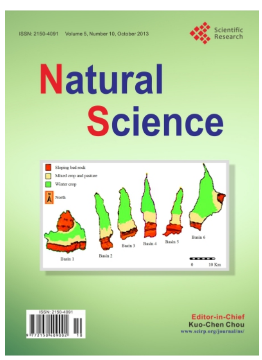
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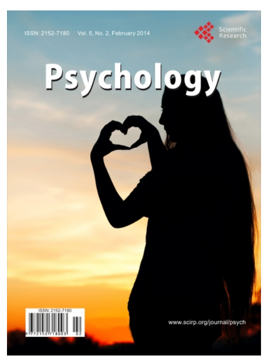
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