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Phytotoxic Effect of Herbicides with and without Surfactant on Weed Growth and Yield of Wheat

A. Tanveer[1], M. Ayub[1], R. Ahmad[2] and A. Ali[1]

[1]Department of Agronomy, [2]Department of Crop Physiology, University of Agriculture, Faisalabad, Pakistan

السمية النباتية لمبيدات الأعشاب مع أو بدون المواد ذات الفاعلية السطحية وتأثيرها على نمو الأعشاب الطفيلية وإنتاجية القمح

الملخص: يعتبر إستخدام المواد ذات الفاعلية السطحية أسلوبا فعالا في تحسين كفاءة مبيدات الأعشاب. تم تقييم مبيدات الأعشاب التالية: ميثابينزاثيرون وكلورتولورون وأسوبروتورون في إمكانية سيطرتها على الأعشاب الطفيلية عند معدلات موصى بها هي: ١,٢٦ و ١,٥ و ٠,٩٧ كجم/ هكتار على التوالي، مقارنة بمعدلات أقل بنسبة ١٢,٥ و ٢٥% بعد إضافة ٠,٢% من مادة ذات فعالية سطحية. تبين أن استخدام مبيدات الأعشاب مع تلك المواد حتى مع المعدلات الأدنى، كان مؤثرا بنفس درجة المعدلات الموصى بها للسيطرة على الأعشاب الطفيلية مع زيادة في معدلات الإنتاج للقمح. زادت إنتاجية الغلة من الحبوب باستخدام مبيدات الأعشاب بنسبة بلغت ٢٠,٨ إلى ٤٥,٣% و٢٦,٣ إلى ٣٨,١% أعلى من التجربة الحاكمة وذلك في عامي ٩٢-١٩٩٣م و ٩٣-١٩٩٤م على التوالي. وبالتالي فإنه ولتحقيق سيطرة اقتصادية على الأعشاب يوصى باستخدام معدل منخفض من المبيدات العشبية مع إضافة المواد ذات الفاعلية السطحية.

ABSTRACT: Use of surfactants is an effective mean of improving herbicide efficiency. The herbicides methabenzthiazuron [1,3-Dimethyl-3-(2-benzothiazolyl)urea], chlortoluron[N-(3, Chloro-4-methyl phenyl)-N-N-dimethyl urea] + MCPA [2-Methyl-4-chlorophenoxy acetic acid] and Isoproturon [3-(4-isopropylphenyl)-1, 1-dimethyl urea] were evaluated for weed control at recommended rates of 1.26, 1.50 and 0.97 a.i. kg ha^{-1}, respectively, in comparison with a 12.5 and 25% less rate after the addition of 0.2% surfactant. Application of herbicides with surfactant even at lower rates was as effective as recommended rates in controlling weeds and increasing grain yield. Grain yield ranged from 20.8 to 45.3 % and 26.3 to 38.1 % more than the weedy check in 1992-93 and 1993-94, respectively, for various herbicide concentrations. Thus for economical weed control, a lower rate of herbicide with the addition of surfactant should be recommended.

Herbicides have been shown to be a beneficial and very effective means for controlling weeds in a wheat (*Triticum aestivum* L.) crop. Water is generally used as a carrier for application of herbicides. However, due to high surface tension, water molecules tend to form small spherical droplets and are repelled by the waxy cuticle layer of leaves which affects penetration and retention of herbicides. Use of a surfactant lowers the surface tension of water, increases the wetting power of herbicides, fills the air spaces between herbicide solution and leaf cuticle and also increases the retention and absorption of the herbicide solution (Jansen, 1964; Ruiter *et al.*, 1990).

Malik *et al.* (1985) stated that addition of surfactant (0.1% Selvet) to isoproturon [3-(4-isopropylphenyl)-1, 1-dimethyl urea] and metoxuron [N-(3-Chloro-4-methoxyphenyl)n-n-dimethyl urea] applied at 25% of normal rates increased the percentage control of weeds. The efficiency of methabenz-thiazuron [1,3-Dimethyl-3-(2-benzothiazolyl)urea] with and without surfactant was less than with other herbicides. Isoproturon and metoxuron at normal rates and with surfactant at reduced rates significantly increased grain yield. Bhan (1987) observed that methabenzthiazuron, metoxuron and isoproturon in combination with surfactant (0.1% Selvet) proved better for control of *Phalaris minor* Retz. and broad leaf weeds than without surfactant. Gill and Mehra (1987) concluded that the addition of 0.1% wetting agent (Hyoxidx-100) increased the efficiency of methabenz-thiazuron for controlling *Phalaris minor* Retz., enabling the normal rates of 0.7 and 1.05 a.i. kg

ha^{-1} to be reduced to 0.525 a.i. kg ha^{-1} without impairing control. Shad and Ghafoor (1987) found that rate of herbicide PP 604 could be reduced substantially with the addition of surfactant Agral-90. Herbicide PP 604 @ 0.10 kg a.i. ha^{-1} with surfactant resulted in better control of *Phalaris minor* Retz. than a 0.15 kg a.i. ha^{-1} rate without surfactant. Malik *et al.* (1989) found that addition of 0.1% Selvet greatly increased the toxicity of metoxuron to wild pea (*Lathyrus aphaca* L.), wild oat (*Avena sterilis* sub. spp. Indoviciana), common vetch (*Vicia sativa* L.) and Lambsquarter (*Chenopodium album* L.). Reduced rates of isoproturon in combination with surfactant provided similar yields to those from higher rates of isoproturon alone. Varsheney and Singh (1990) found that tank mixing of surfactant Triton 11 XE @ 0.5% with metoxuron @ 1.0 a.i. kg ha^{-1}, terbutryn @ 0.5 a.i. kg ha^{-1}, isoproturon @ 0.5 a.i. kg ha^{-1} and methabenzthiazuron @ a.i. 1.0 kg ha^{-1} reduced weed density and biomass by 52-67% and enhanced grain yield by 33% over herbicide without surfactant. Panwar and Malik (1991) reported that total dry weight of *Lathyrus aphaca* L., *Vicia sativa* L. and *Chenopodium album* L. 90 days after sowing was reduced to 6.6 g m^{-2} by the application of isoproturon @ 0.2 kg ha^{-1} + 0.1% surfactant compared to 80 g m^{-2} in the weedy check. According to Sarwar (1994) chemical weed control resulted in an increased number of fertile tillers, grains $spike^{-1}$, and 1000- kernel weight. Grain and straw yield and harvest index of herbicide treatments were significantly greater than those without herbicides.

The present study was conducted to evaluate the effectiveness of adding surfactant to herbicides against weeds in a wheat crop.

Materials and Methods

Studies were conducted at the Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan, during the year 1992-93 and 1993-94. Experimental area was selected based on the field history to ensure the availability of different weed species. The soil contained 0.06% N, 6.5 ppm available P and 214 ppm available K for the 1992-1993 season and 0.05 N, 5.5 ppm available P and 180 ppm available K for the 1993-194 season. The sowing time for the experiment was 8th December and 7th November in 1992-93 and 1993-94, respectively. The experiment was laid out in a randomized complete block design with a plot size of 1.5 x 7.5 m and four replications. Wheat variety "Pasban-90" was sown mannually using a single row hand drill in 25 cm spaced rows at 100 kg ha^{-1} seeding rate.

Nitrogen and phosphorus in the form of urea and single super phosphate, respectively, were applied at the rate of 115 kg ha^{-1} each. Half of nitrogen and all of phosphorus was applied at sowing and the remaining half of nitrogen with the first irrigation when crop was at two leaf stage. Four irrigations of 7.5 cm each were applied to the crop in both the seasons. Treatments are as follows:

- Weedy check
- Methabenzthiazuron (Tribunil 70 WP)@ 1.26 a.i. kg ha^{-1} (recommended)
- Methabenzthiazuron (Tribunil 70 WP) @ 1.26 a.i. kg ha^{-1} + 0.2% surfactant (Triton)
- Methabenzthiazuron (Tribunil 70 WP) @ 1.05 a.i. kg ha^{-1} (12.5 % less than recommended) + 0.2% surfactant (Triton)
- Methabenzthiazuron (Tribunil 70 WP)@ 0.91 a.i. kg ha^{-1} (25% less than recommended) + 0.2% surfactant (Triton)
- Chlortoluron + MCPA (Agmolcombi 60 WP) @ 1.50 a.i. kg ha^{-1} (recommended)
- Chlortoluron + MCPA (Agmolcombi 60 WP) @ 1.50 a.i. kg ha^{-1} + 0.2% surfactant (Triton)
- Chlortoluron + MCPA (Agmolcombi 60 WP)@ 1.32 a.i. kg ha^{-1} (12.5% less than recommended) + 0.2% surfactant (Triton)
- Chlortoluron + MCPA (Agmolcombi 60 WP) @ 1.14 a.i. kg ha^{-1} (25% less than recommended) + 0.2% surfactant (Triton)
- Isoproturon (Milron 75 WP) @ .97 a.i. kg ha^{-1} (recommended)
- Isoproturon (Milron 75 WP) @ 0.97 a.i. kg ha^{-1} + 0.2% surfactant (Triton)
- Isoproturon (Milron 75 WP) @) 0.82 a.i kg ha^{-1} (12.5% less than recommended) + 0.2% surfactant (Triton)
- Isoproturon (Milron 75 WP) @ 0.67 a.i. kg ha^{-1} (25% less than recommended) + 0.2% surfactant (Triton)

All herbicides were applied after the first irrigation, at 3-4 leaf of crop growth, when the soil was moist. Weeds were at 2-3 leaf stage at that time. Herbicides were applied with a "Solo" brand hand sprayer fitted with a flat fan nozzle. A unit area of 1 sq. m was selected to count and record the weeds and spike bearing tillers 40 days after application and at harvesting, respectively.

Data collected were analysed statistically using Fisher's analysis of variance technique. The least significant difference test at 5% probability was applied to compre the treatment means (Steel and Torrie, 1984).

Results and Discussion

WEED COUNT 40 DAYS AFTER HERBICIDE APPLICATION: The common weeds *P. minor* Retz. (little canary

grass), *Medicago denticulata* (wild sunsupurge), *Rumex dentatus* L. (dock) and *Coronopus didymus* L. (swine cress) were observed in the field both years. *Phalaris minor* was the most dominant weed each year, and the weed infestation was generally greater in 1993-94. Total number of weeds (Table 1) at 40 days after application indicates that weeds were significantly reduced with different herbicidal treatments. Herbicide efficiency in each year ranged from 90-96 per cent and 93-95 percent for the two seasons, respectively, showing the effectiveness of all the herbicidal treatments against weeds (Table 2). Herbicide application at a 25 percent lower rate plus surfactant was as effective as the recommended dose for the herbicide.

Phalaris minor counts presented in Table 1 indicate that different herbicides with or without surfactant were quite effective in controlling the weed. Weed control ranged from 89.5 to 95.6 per cent in 1992-93 and was over 97 per cent in 1993-94 (Table 2).

Herbicide application with or without surfactant was also quite effective in controlling the weed population of *M. denticulata* (Table 1). Weed control varied between 62.5 to 100 per cent and 71.5 to 86.2 per cent in 1992-93 and 1993-94, respectively. Again 25 per cent reduction in all herbicide rates with the addition of surfactant was found to be beneficial.

Application of herbicides with or without surfactant effectively controlled *R. dentatus* (Table 1) during both years. During 1992-93, control of *R. dentatus* was from 92.30 to 100 per cent while it varied between 77.7 to 89.3 per cent in 1993-94. Addition of surfactant was more beneficial similar to that with weed species mentioned above.

In *C. didymus*, except methabenzthiazuron @ 1.26 a.i. kg ha^{-1} and chlortoluron + MCPA @ 1.50 a.i. kg ha^{-1}, weed count in herbicide treated plots were not statistically different in the first season (Table 1). Weed control ranged between 88.4 to 100 per cent. In 1993-94, all herbicidal treatments were similar in their effectiveness and gave 82.8 to 89.9 per cent control of *C. didymus* (Table 2).

The application of herbicides with or without surfactant was in general very effective in limiting the weed population. When herbicide rate was reduced by 25 percent and mixed with surfactant, herbicidal effect was not changed. It appears that retention of herbicide droplets on the leaf was improved thus enhancing the activity of the herbicide. Efficiency of different

TABLE 1

Effect of herbicides with and without surfactant on weeds 40 days after spray.

Treatment	Total Weeds		*P. minor*		*M. denticulata*		*R. dentatus*		*C. dydimus*	
	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94
Weedy check	221.00^{a}	509.75^{a}	114.00^{a}	377.75^{a}	12.00^{a}	30.75^{a}	52.00^{a}	28.00^{a}	43.00^{a}	68.25^{a}
Methabenztyhiazuron (a.i. kg ha^{-1})										
1.26	17.00^{bc}	27.50^{b}	8.00^{cdef}	7.75^{b}	2.00^{cde}	5.50^{cd}	2.00^{bcd}	6.25^{b}	5.00^{b}	8.00^{b}
1.26 + surfactant	11.50^{de}	31.75^{b}	6.00^{ef}	8.25^{b}	4.50^{b}	5.75^{bcd}	0.00^{d}	5.00^{b}	1.00^{d}	12.25^{b}
1.05 + surfactant	13.25^{cd}	28.50^{b}	7.00^{def}	8.50^{b}	4.00^{bc}	5.75^{bcd}	1.50^{bcd}	4.75^{b}	0.75^{d}	9.50^{b}
0.91 + surfactant	15.00^{cd}	25.25^{b}	9.00^{bcde}	6.50^{b}	3.00^{bcd}	4.25^{d}	3.00^{bc}	5.75^{b}	0.00^{d}	8.75^{b}
Chlortoluron+MCPA (a.i. kg ha^{-1})										
1.5	21.00^{b}	27.25^{b}	12.00^{b}	8.25^{b}	3.00^{bcd}	5.00^{d}	2.00^{bcd}	6.00^{b}	4.00^{bc}	8.00^{b}
1.50 + surfactant	13.00^{cd}	33.75^{b}	10.00^{bcd}	8.25^{b}	3.00^{bcd}	5.75^{b}	2.00^{bcd}	6.00^{b}	0.00^{d}	10.75^{b}
1.32 + surfactant	16.00^{c}	30.50^{b}	10.50^{bc}	10.25^{b}	3.25^{bcd}	6.00^{bcd}	1.00^{cd}	5.00^{b}	1.25^{d}	9.25^{b}
1.14 + surfactant	16.00^{c}	31.25^{b}	11.00^{bc}	9.00^{b}	1.00^{de}	8.75^{b}	3.00^{bc}	6.25^{b}	1.00^{d}	7.25^{b}
Isoproturon (a.i. kg ha^{-1})										
0.97	13.00^{cd}	29.00^{b}	8.00^{cdef}	7.75^{b}	1.00^{de}	5.75^{bcd}	4.00^{b}	3.75^{b}	0.00^{d}	11.75^{b}
0.97 + surfactant	11.00^{def}	27.50^{b}	8.00^{cdef}	7.75^{b}	1.00^{de}	4.75cd	0.00^{d}	7.50^{b}	2.00^{d}	7.50^{b}
0.82 + surfactant	8.25^{ef}	26.50^{b}	6.50^{ef}	6.25^{b}	0.50^{e}	7.75cd	0.75^{cd}	3.75^{b}	0.50^{d}	8.50^{b}
0.67 + surfactant	7.00^{f}	27.75^{b}	5.00^{f}	9.75^{b}	0.00^{e}	6.50^{bcd}	2.00^{bcd}	3.00^{b}	0.00^{d}	8.50^{b}

In column, means having the same letter do not differ significantly at 5% probability level.

TABLE 2

Percent weed control by herbicides with and without surfactant.

Treatment	Total Weeds		*P. minor*		*M. denticulata*		*R. dentatus*		*C. dydimus*	
	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94
Weedy check	-	-	-	-	-	-	-	-	-	-
Methabenztyhiazuron (a.i. kg ha^{-1})										
1.26	92.3	94.6	93.0	97.3	83.3	82.1	96.1	77.7	88.4	88.3
1.26 + surfactant	94.8	93.8	94.7	97.8	62.5	81.1	100.0	82.1	97.7	82.0
1.05 + surfactant	94.0	94.4	93.8	97.7	66.6	81.3	97.1	83.0	98.2	86.1
0.91 + surfactant	93.2	95.1	92.1	98.3	75.0	86.2	94.2	79.5	100.0	83.5
Chlortoluron+MCPA (a.i. kg ha^{-1})										
1.5	90.5	94.6	89.5	97.8	75.0	83.7	96.1	78.6	90.7	88.3
1.50 + surfactant	94.1	93.4	91.2	97.8	75.0	71.5	100.0	78.6	100.0	84.2
1.32 + surfactant	92.8	94.0	90.8	97.3	73.0	80.5	98.0	82.1	97.0	86.4
1.14 + surfactant	92.8	93.8	90.3	97.6	91.6	71.5	94.2	77.7	97.0	85.7
Isoproturon (a.i. kg ha^{-1})										
0.97	94.1	94.3	93.0	98.0	91.6	81.1	92.3	86.6	100.0	82.8
0.97 + surfactant	95.0	94.6	93.0	98.0	91.6	84.5	100.0	73.2	95.3	90.0
0.82 + surfactant	96.3	94.8	94.3	93.3	95.8	74.5	98.5	86.6	98.8	87.5
0.67 + surfactant	97.0	94.5	95.6	97.4	100.0	78.8	96.1	89.3	100.0	87.5

herbicides in controlling *M. denticulata* was relatively low. This might be due to more resistance by this weed. Enhanced weed control efficiency of herbicides with surfactant, even at a 25 per cent lower rate than recommended, has been reported by Malik *et al.* (1985), Bhan (1987), Gill and Mehra (1987), Varsheney and Singh (1990) and Panwar and Malik (1991).

SPIKE BEARING TILLERS OF WHEAT: Data presented in Table 3 indicated that reduced number of spike bearing tillers were found in the weedy check than in herbicide treatments both the years. Herbicide application in combination with surfactant resulted in increasing number of spike bearing tillers in the wheat crop. Increase in spike bearing tillers in herbicidal treated plots was most probably due to better plant development because of less competition with weeds for soil moisture and nutrients due to control and suppression of weeds. These results are in agreement with those of Sarwar (1994) who reported an increase in number of spike bearing tillers by weed control.

GRAIN YIELD: Grain yield is the final indicator of crop behaviour under different management practices. Grain yield values presented in Table 3 indicate that grain yield significantly varied among different treatments. In 1992-93, use of methabenzthiazuron @ 1.26 a.i. kg ha^{-1} and isoproturon @ 0.67 a.i. kg ha^{-1}, with surfactant, resulted in maximum and equal grain yields. These herbicides were followed by chlortoluron + MCPA @ 1.50 a.i. kg ha^{-1} and isoproturon @ 0.82 a.i. kg ha^{-1} with surfactant. Overall grain yield was 20.8 to 45.3 per cent more than the weedy check in 1992-1993.

In 1993-94, all herbicide treatments were statistically similar for grain yield. Grain yield in herbicide treatment was 26.4 to 38.1 per cent more than the weedy check.

Grain yield is a function of the combined effect of individual yield components. More grain yield in herbicide treated plots was attributed to control of weeds which favoured wheat growth. Consequently, wheat plants produced more spike bearing tillers. This yield component ultimately contributed to more grain yield. Greater grain yield in 1992-93 than in 1993-94 might have been due to lesser weeds and comparatively more spike bearing tillers. Another possibility may have been earlier sowing of wheat in 1992-93 which resulted in better early growth of wheat and longer duration.

It has been shown that under lower rates of herbicides with the addition of surfactant, there was no difference between the treatments affecting different components of yield. This was also reflected in grain yield. The results are supported by the findings of Malik *et al.*(1985), Gill and Mehra (1987), Malik *et al.* (1989) and Varshney and Singh (1990) who found significant increases in grain yield even by reducing recommended

TABLE 3

Effect of herbicides with and without surfactant on spike bearing tillers and grain yield of wheat.

Treatments	Spike bearing tillers (m^{-2})		Grain yield (kg ha^{-1})	
	1992-93	1993-94	1992-93	1993-94
Weedy check	325.75^{d}	257.25^{e}	3337.60^{f}	2511.00^{b}
Methabenztyhiazuron (a.i. kg ha^{-1})				
1.26	487.50^{c}	469.75^{cd}	4117.50^{de}	3241.50^{a}
1.26 + surfactant	504.75^{bc}	494.25^{abc}	4720.00^{a}	3328.75^{a}
1.05 + surfactant	486.50^{c}	506.25^{ab}	4160.00^{de}	3468.75^{a}
0.91 + surfactant	483.50^{c}	481.00^{bcd}	4160.00^{de}	3172.75^{a}
Chlortoluron+MCPA (a.i. kg ha^{-1})				
1.5	485.50^{c}	502.25^{ab}	4120.00^{de}	3313.00^{a}
1.50 + surfactant	503.75^{bc}	470.00^{cd}	4352.00^{b}	3285.25^{a}
1.32 + surfactant	484.25^{c}	494.75^{ab}	4242.50^{cd}	3415.15^{a}
1.14 + surfactant	484.00^{c}	488.75^{bcd}	4075.00^{e}	3215.75^{a}
Isoproturon (a.i. kg ha^{-1})				
0.97	511.75^{ab}	463.00^{d}	4250.00^{cd}	3243.25^{a}
0.97 + surfactant	495.00^{bc}	518.75^{a}	4032.50^{e}	3313.00^{a}
0.82 + surfactant	500.75^{bc}	466.25^{cd}	4437.50^{b}	3170.25^{a}
0.67 + surfactant	529.25^{a}	485.75^{bcd}	4850.00^{a}	3271.00^{a}

rates of herbicides with the addition of surfactant.

The herbicides rates, 25% lower than the recommended, in combination with 0.2% surfactant (Triton) proved as good as the recommended rates for controling weeds in wheat crop. Thus for economical weed control a lower rate of herbicide with addition of surfactant should be recommended.

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