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Efficacy of Three Different Herbicides to the Control of Wild Barley (*Hordeum spontaneum* C. Koch) in Relation to Plant Growth Stage and Nitrogen Fertilizer Additive

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***Abstract*—**To study the effect of nitrogenous additive spray solution on the efficacy of three herbicides i.e. pinoxaden (Trade name: Axial), sulfosulfuron+metsulfuron-methyl (Trade name: Total) and sulfosulfuron (Trade name: Apirus) in controlling wild barley (*Hordeum spontaneum* C. Koch), in different growth stages, a greenhouse experiment as a split plot in a completely randomized design in three replications was conducted. One month after treatments, all plants were harvested and growth parameters were determined. The data were analyzed with computer. The results showed that the herbicide applications with and without nitrogen additive caused significant reductions in growth parameters of wild barley at 2-4 leaf stage. However, the plants were not killed by this herbicide. Plants were killed completely due to applications of the two other herbicides i.e. Apirus and Total at 2-4 leaf. There was no significant difference between the effect of these two herbicides. There was no significant difference between the highest rate of each herbicide used alone and that of the lowest rate with nitrogenous additive.

***Keywords*—**Growth stage, herbicide, nitrogenous additive, wild barley.

I. Introduction

WHEAT (*Triticum aestivum*) is the first major food crop in today's world and plays a crucial role in our day-to-day lives. It is the main crop in Iran. Wheat productions provide a crucial source of food for people all around the globe [1]. Wild barley (*Hordeum spontaneum*) is one of the most important weeds in winter wheat farms [2]. '*Hordeum'* belongs to Poaceae and it is an annual grass [3]. Wild barley threatens wheat farms, according to this, it is essential to focus on this weed [4]. Wild barley exists as isolated populations throughout the Eastern Mediterranean, Middle East, Northern Asia and south west China [5].

Nitrogen is the main nutrient that is added to enhance crop yield, but addition of nitrogen can increase the competition between crops and weeds. Therefore, it is obvious that in recent years, there have been more and more countries involved and interested in using herbicides and adjuvant [6]. However, overuse of using herbicides on the earth is a severe problem.

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TABLE I
Effect of Three Herbicides and Nitrogenous Additive Applications on Chlorophyll of Wild Barley, Two Weeks after Treatments in 3 Growth Stages (Mean of 3 repls.)

Chlorophyll (mg/g)			herbicide doses	growth stages
a+*b*	*b*	*a*		
0/76c	0/45c	0/31c	0	2 to 4 leaves
0/74c	0/44c	0/30c	Axial 450 ml/ha	
0/74c	0/44c	0/30c	Axial 450 ml/ha+N	
0/74c	0/44c	0/30c	Axial 400 ml/ha+N	
0/40e	0/25e	0/15e	Total 40g/ha	
0/40e	0/24e	0/14e	Total 40g/ha+N	
0/40e	0/25e	0/15e	Total 35g/ha+N	
0/43e	0/27e	0/16e	Apirus 26.6 g/ha	
0/43e	0/26e	0/16e	Apirus 26.6 g/ha+N	
0/43e	0/27e	0/16e	Apirus 21.6 g/ha+N	
1/00b	0/55b	0/45b	0	tillering
0/98b	0/54b	0/44b	Axial 450 ml/ha	
0/98b	0/54b	0/44b	Axial 450 ml/ha+N	
0/98b	0/54b	0/44b	Axial 400 ml/ha+N	
0/60d	0/35d	0/25d	Total 40 g/ha	
0/60d	0/34d	0/24d	Total 40 g/ha+N	
0/60d	0/35d	0/25d	Total 35 g/ha+N	
0/60d	0/35d	0/25d	Apirus 26.6 g/ha	
0/60d	0/35d	0/24d	Apirus 26.6 g/ha+N	
0/60d	0/35d	0/25d	Apirus 21.6 g/ha+N	
1/21a	0/65a	0/56a	0	first node
1/21a	0/65a	0/56a	Axial 450 ml/ha	
1/21a	0/65a	0/56a	Axial 450 ml/ha+N	
1/21a	0/65a	0/56a	Axial 400 ml/ha+N	
0/80bc	0/45c	0/35bc	Total 40 g/ha	
0/80bc	0/44c	0/34bc	Total 40 g/ha+N	
0/80bc	0/45c	0/35bc	Total 35 g/ha+N	
0/80bc	0/45c	0/35bc	Apirus 26.6 g/ha	
0/80bc	0/45c	0/34bc	Apirus 26.6 g/ha+N	
0/80bc	0/45c	0/35bc	Apirus 21.6 g/ha+N	

In each column, the numbers with similar letter have no significant difference by Duncan Multiple Range Test (DMRT) at 5 % level [14].

Adjuvants are added to an herbicide formulation or added to the spray tank to improve herbicidal activity of application characteristics [7]. Adjuvants are helping to revolutionize their use by allowing high-dose applications to low-dose [8]. Adjuvants are divided into two groups: Activator adjuvants and utility adjuvants [9]. Obviously, nitrogen is an activator adjuvant and it can enhance herbicide quality [10].

In this survey, nitrogen is used as activator adjuvants which can increase herbicide activity [11].

II. Materials and Methods

An experiment was conducted under controlled conditions at the College of Agricultural Sciences, Islamic Azad

International Science Index, Agricultural and Biosystems Engineering Vol:10, No:9, 2016 waset.org/Publication/10006056

University, Iran in 2010. A split plot experiment in with three replications was used. The main plots were wild barley growth stages i.e. 2 to 4 leaves (GS=13), tillering (GS=23), first node (GS=31) and the sub-plots were doses of three herbicides; pinoxaden (trade name: Axial, chemical name: 8-(2,6-Diethyl-4-methylphenyl)-7-oxo-1,2,4,5-tetrahydro-7H-pyrazolo[1,2-d][1,4,5]oxadiazepin-9-yl pivalate), sulfosulfuron+metsulfuron-methyl (trade name: Total, chemical name: 1-(4,6-dimethoxyrimidin-2-y1)-3-(2-ethyl sulfonyl imidazo[1,2-a]pyridine-3-y1)sulfonylurea+methyl2-(4-methoxy-6-methyl-1,3,5-triazin-2-ylcarbamoyl sulfamoyl) benzoate, and sulfosulfuron, Trade name: Apirus, chemical name: 1-(4,6-dimethoxypyrimidin-2-y1)-3-(2-ethyl sulfonyl imidazo(1,2-a) pyridine-3-y1) [12]. The 10 doses of herbicides were: 1. no treatment, 2. Axial 450 ml/ha, 3. Axial 450 ml/ha+ 0.5% nitrogen fertilizer additive, 4. Axial 400 ml/ha+0.5% nitrogen fertilizer additive, 5. Total 40 g/ha, 6. Total 40 g/ha+ 0.5% nitrogen fertilizer additive, 7. Total 35 g/ha+0.5% nitrogen fertilizer additive, 8. Apirus 26.6 g/ha, 9. Apirus 26.6 g/ha+0.5% nitrogen fertilizer additive, 10. Apirus 21.6 g/ha+ 0.5% nitrogen fertilizer additive. Spraying was done by a solo hand-sprayer.

TABLE II
EFFECT OF THREE HERBICIDES AND NITROGENOUS ADDITIVE APPLICATIONS ON CHLOROPHYLL OF WILD BARLEY, FOUR WEEKS AFTER TREATMENTS IN 3 GROWTH STAGES (MEAN OF 3 REPLS.)

Chlorophyll (mg/g)			herbicide doses	growth stages
a+b	*b*	*a*		
0/94d	0/52e	0/42cd	0	2 to 4 leaves
0/76e	0/43f	0/33de	Axial 450 ml/ha	
0/62efg	0/37fg	0/25efg	Axial 450 ml/ha+N	
0/72ef	0/41f	0/31def	Axial 400 ml/ha+N	
0/05mn	0/03m	0/02i	Total 40 g/ha	
0/03n	0/02m	0/01i	Total 40 g/ha+N	
0/05mn	0/03m	0/02i	Total 35 g/ha+N	
0/05mn	0/03m	0/02i	Apirus 26.6 g/ha	
0/03n	0/02m	0/01i	Apirus 26.6 g/ha+N	
0/05mn	0/03m	0/02i	Apirus 21.6 g/ha+N	
1/22abc	0/66bc	0/56abc	0	tillering
1/10bcd	0/60cd	0/50bcd	Axial 450 ml/ha	
0/94c	0/52e	0/42cd	Axial 450 ml/ha+N	
1/06cd	0/58de	0/48bc	Axial 400 ml/ha+N	
0/28jkl	0/19kl	0/09hij	Total 40 g/ha	
0/20lmn	0/15l	0/05ij	Total 40 g/ha+N	
0/26jkl	0/18kl	0/08hij	Total 35 g/ha+N	
0/30ijkl	0/20jkl	0/10ghij	Apirus 26.6 g/ha	
0/22klm	0/16l	0/06ij	Apirus 26.6 g/ha+N	
0/28jkl	0/19kl	0/09hij	Apirus 21.6 g/ha+N	
1/40a	0/75a	0/65a	0	first node
1/36a	0/73a	0/63a	Axial 450 ml/ha	
1/26ab	0/68ab	0/58ab	Axial 450 ml/ha+N	
1/28ab	0/69ab	0/60ab	Axial 400 ml/ha+N	
0/50gh	0/30ghi	0/20efghi	Total 40 g/ha	
0/40hijk	0/25ijk	0/15ghij	Total 40 g/ha+N	
0/48ghi	0/29hi	0/19efghi	Total 35 g/ha+N	
0/56fgh	0/33gh	0/23efgh	Apirus 26.6 g/ha	
0/44ghij	0/27hij	0/17fghhij	Apirus 26.6 g/ha+N	
0/52gh	0/31ghi	0/21efghi	Apirus 21.6 g/ha+N	

In each column, the numbers with similar letter have no significant difference by Duncan Multiple Range Test (DMRT) at 5 % level [14].

After two and four weeks, chlorophyll content of leaves was measured. For this purpose, 0.3 g of wild barley's leaves were picked. After picking stage, the leaves were torn by hand and then they were put on ice container. Once the leaves were put on the ice container, 10 ml acetone was added. After which, the contents of the container were cleared with filter paper. Subsequently, chlorophyll extracted was read with spectrophotometer, at wavelengths of 663 and 645 nm [13]. All plants were harvested after 4 weeks. At harvest, growth parameters including stem and root lengths, and also fresh and dry weights of stems and roots were determined. The data were subjected to analysis of variance with computer facilities, using SAS program.

TABLE III
EFFECT OF THREE HERBICIDES AND NITROGENOUS ADDITIVE APPLICATIONS ON THE STEM FRESH AND DRY WEIGHTS OF WILD BARLEY AFTER 3 GROWTH STAGES (MEAN OF 3 REPLS.)

stem weight (mg)		herbicide doses	growth stages
dry	fresh		
491.3e	2767.0f	0	2 to 4 leaves
250.3g	1124.0j	Axial 450 ml/ha	
132.3i	650.3k	Axial 450 ml/ha+N	
235.3g	1024.0j	Axial 400 ml/ha+N	
50.7k	353.5l	Total 40 g/ha	
10.3 l	151.7m	Total 40 g/ha+N	
45/3k	349.7l	Total 35 g/ha+N	
65.3k	392/7l	Apirus 26.6 g/ha	
15.7l	173.0m	Apirus 26.6 g/ha+N	
60.3k	390.3l	Apirus 21.6 g/ha+N	
753.0c	4730.0 d	0	tillering
550.0d	3283.0 e	Axial 450 ml/ha	
406.7hi	2650.0 g	Axial 450 ml/ha+N	
512.7d	3190.0e	Axial 400 ml/ha+N	
230.0 i	1258.0f	Total 40 g/ha	
176.7 j	966.7h	Total 40 g/ha+N	
226.7 i	1248.0f	Total 35 g/ha+N	
278.3gh	1373.0e	Apirus 26.6 g/ha	
233.3 i	970/0gh	Apirus 26.6 g/ha+N	
260.0i	1370.0e	Apirus 21.6 g/ha+N	
1043.0a	6713.0 a	0	first node
965.0ab	6100.0ab	Axial 450 ml/ha	
820.0b	5230.0c	Axial 450 ml/ha+N	
943.0ab	5900.0b	Axial 400 ml/ha+N	
430.3f	2347.0f	Total 40 g/ha	
356.7hi	1783.0h	Total 40 g/ha+N	
451.3f	2333.0f	Total 35 g/ha+N	
445.3 f	2548.0 e	Apirus 26.6 g/ha	
370.7g	1880.0gh	Apirus 26.6 g/ha+N	
440.3f	2590.0 e	Apirus 21.6 g/ha+N	

In each column, the numbers with similar letter have no significant difference by Duncan Multiple Range Test (DMRT) at 5% level [14].

III. RESULTS AND DISCUSSION

Tables I and II highlight data about the effect of three herbicides and nitrogen additive on chlorophyll of wild barley, two and four weeks after treatments, in three growth stages. While Tables III and V highlight data about the effect of three herbicides and nitrogen additive on the stem and root weights of wild barley at three growth stages, furthermore Table IV gives information about the effect of three herbicides and nitrogen additive on the lengths of wild barley after three growth stages. Overall, initial impression from the tables is that the amounts of chlorophylls two weeks after treatment in without treatment and Axial herbicide were the highest and there was no significant difference between them, while Total and Apirus accounted for a much smaller. After 30 days, the amount of chlorophylls reduced significantly in both Apirus

International Science Index, Agricultural and Biosystems Engineering Vol:10, No:9, 2016 waset.org/Publication/10006056

and Total herbicides with nitrogen fertilizer additive. However, Axial herbicide remained unchanged. There was a significant difference between the plants that treatment with Axial and plants without treatment. It is obvious from the tables that the fresh and dry weights and lengths of wild barley plants without treatment were the highest while those with herbicide treatments account for a much smaller figure. Another interesting point is that the effects of two herbicides (Apirus and Total) were better than Axial.

TABLE V
EFFECT OF THREE HERBICIDES AND NITROGENOUS ADDITIVE APPLICATIONS ON THE ROOT FRESH AND DRY WEIGHTS OF WILD BARLEY AFTER 3 GROWTH STAGES (MEAN OF 3 REPLS.)

root weight (mg)		herbicide doses	growth stages
dry	fresh		
191.7e	1140.0d	0	2 to 4 leaves
83.3fg	403.3gh	Axial 450 ml/ha	
41.6klm	202.3j	Axial 450 ml/ha+N	
83.3fg	390.3gh	Axial 400 ml/ha+N	
16.3lm	108.3k	Total 40 g/ha	
2.3m	20.7 l	Total 40 g/ha+N	
14.3lm	106.7 k	Total 35 g/ha+N	
17.6lm	110.7 k	Apirus 26.6 g/ha	
3.3m	21.3l	Apirus 26.6 g/ha+N	
17.6lm	109.7 k	Apirus 21.6 g/ha+N	
350.0c	2115.0c	0	tillering
230.0d	1505.0f	Axial 450 ml/ha	
145.0ghij	950.3g	Axial 450 ml/ha+N	
195.0ef	1490.3f	Axial 400 ml/ha+N	
70.0ijk	428.3i	Total 40 g/ha	
46.6 jkl	311.7j	Total 40 g/ha+N	
70.0jk	403.3i	Total 35 g/ha+N	
80.0hjk	460.3 hi	Apirus 26.6 g/ha	
53.3 hijk	338.3j	Apirus 26.6 g/ha+N	
76.0hijk	460.0hi	Apirus 21.6 g/ha+N	
486.7a	3109.0a	0	first node
440.0ab	2860.0ab	Axial 450 ml/ha	
380.0b	2506.0 b	Axial 450 ml/ha+N	
430.0ab	2770.0ab	Axial 400 ml/ha+N	
150.0ghij	1014.0d	Total 40 g/ha	
110.0hijk	726.7 f	Total 40 g/ha+N	
145.0ghij	1013.0d	Total 35 g/ha+N	
160.0gh	1043.0d	Apirus 26.6 g/ha	
120.0hijk	801.7e	Apirus 26.6 g/ha+N	
154.0ghi	1040.0d	Apirus 21.6 g/ha+N	

In each column, the numbers with similar letter have no significant difference by Duncan Multiple Range Test (DMRT) at 5% level [14].

All herbicides in higher doses with nitrogen fertilizer illustrated a dramatic decrease in growth parameters of wild barley. Furthermore, as it is noticeable from the tables, there were no significant differences between the effects of Apirus and Total herbicides on the barley plants.

It would appear from the tables that Total herbicide was the best among the other herbicides throughout three stages of barley growth. It is obvious that the growth parameters of wild barley after using 40 $g.ha^{-1}$ of Total herbicide with and without nitrogenous additive reduced dramatically. Additionally, there was a sharp decrease in the proportion of growth parameters of this weed when nitrogen was added. Moreover, there was a substantial decrease in the proportion of weights and length of wild barley at 2-4 leaf stage, this means that this stage was the best stage for using herbicides. Also tillering stage was better stage than firs node stage in using herbicides with and without nitrogen fertilizer additive. Therefore, using herbicides with nitrogen fertilizer additive is more effective and can reduce the amount of herbicides, by doing that we can greatly help the environment and reduce the pollution from the herbicides dramatically.

TABLE IV
EFFECT OF THREE HERBICIDES AND NITROGENOUS ADDITIVE APPLICATIONS ON THE ROOT FRESH AND DRY LENGTH OF WILD BARLEY AFTER 3 GROWTH STAGES (MEAN OF 3 REPLS.)

Length (mm)		herbicide doses	growth stages
root	stem		
151.00d	143.00e	0	2 to 4 leaves
108.30 ij	99.00 j	Axial 450 ml/ha	
93.73jk	95.00k	Axial 450 ml/ha+N	
107.00hi	99.00 j	Axial 400 ml/ha+N	
76.73lm	65.83m	Total 40 g/ha	
72.00lm	60.00 m	Total 40 g/ha+N	
75.00lm	63.00m	Total 35 g/ha+N	
86.67kl	74.73kl	Apirus 26.6 g/ha	
83.00kl	70.00kl	Apirus 26.6 g/ha+N	
85.33kl	74.17kl	Apirus 21.6 g/ha+N	
204.00c	190.00c	0	tillering
162.10cd	150.67de	Axial 450 ml/ha	
145.00e	146.00d	Axial 450 ml/ha+N	
163.40cd	152.10de	Axial 400 ml/ha+N	
130.00fgh	111.10hi	Total 40 g/ha	
128.00fgh	110.00hi	Total 40 g/ha+N	
130.00fgh	112.50hi	Total 35 g/ha+N	
136.20def	117.10h	Apirus 26.6 g/ha	
132.00def	111.00h	Apirus 26.6 g/ha+N	
135.00def	113.70h	Apirus 21.6 g/ha+N	
255.00 a	235.70a	0	first node
249.00 a	231.00a	Axial 450 ml/ha	
239.00 b	230.00b	Axial 450 ml/ha+N	
248.00a	232.00a	Axial 400 ml/ha+N	
151.70d	137.20fg	Total 40 g/ha	
145.00d	130.00fg	Total 40 g/ha+N	
148.70 d	131.60fg	Total 35 g/ha+N	
153.70cde	140.90efg	Apirus 26.6 g/ha	
150.00cde	135.00efg	Apirus 26.6 g/ha+N	
152.00cde	139.00efg	Apirus 21.6 g/ha+N	

In each column, the numbers with similar letter have no significant difference by Duncan Multiple Range Test (DMRT) at 5% level [14].

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