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Chemical Weed Control in Wheat (*Triticum aestivum* L.) in Dongola Locality, Northern State, Sudan

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Abstract:

Weeds constitute a major biotic constraint that limits wheat production (*Triticum aestivum* L.) in Sudan. A herbicide experiment was conducted during two consecutive winter seasons of the years 2009/2010 and 2010/2011 at Elkarwat scheme, Dongola Locality, Northern State, Sudan to determine the magnitude of yield losses due to weed interference and to evaluate herbicidal efficacy of 2,4-D, Clodinafop-propargyl and their tank mixtures in wheat. Weeded and unweeded checks were included for comparison. 2,4-D at all rates gave consistent and effective control of broad-leaved weeds throughout the growing season, but its activity against grassy weeds was poor. Clodinafop-propargyl at both rates gave good control of grassy weeds, but its activity against broad-leaved weeds was poor. The herbicides in tank mixtures gave consistent and effective control of both grassy and broad-leaved weeds throughout the season. The highest grassy and broad-leaved weeds control was achieved by the herbicides tank mixtures. A significant weed control was achieved in terms of total weed biomass reduction with all herbicides rates and their tank mixtures compared to the weedy check. The highest weed biomass reduction was achieved by 2,4-D at 6.8 kg a.i./fed. in tank mixture with clodinafop-propargyl at 0.3 and 0.4 kg a.i./fed. Combined analysis of both winter seasons indicated that unrestricted weed growth significantly reduced wheat grain yield by 68.94% compared to the weed free treatment. The results showed that among all herbicides treatments the highest grain yield was achieved by 2,4-D at 6.8 kg. a.i/fed., in tank mixture with clodinafop-propargyl at 0.4 kg. a.i/fed., which gave a total grain yield comparable to weed free treatment.

Keywords: 2, 4-D, Clodinafop-propargyl and their tank mixture.

Introduction

Wheat (*Triticum aestivum* L.), belongs to the family Poaceae. It is the most important cereal crop in the world. It is one of the major food crops in the Sudan and is exclusively produced under traditional irrigation systems for local consumption. Also it is an important strategic crops in terms of food security. It ranks second after sorghum in Sudanese diet. Traditionally, wheat has been produced on small areas along the Nile in the northern Sudan, using animal-drawn implements and hand tools. In attempts to attain self-sufficiency wheat production has been extended to the central clay plain in several irrigated schemes, including the Gezira, New Halfa and

Rahad, where the winter season is shorter, warmer and with frequent hot spells than in the traditional producing areas in the northern Sudan (Mohammed, 2011).

Until lately, weeds were not a serious constraint to crop production in northern Sudan. However, use of uncertified seeds, animal grazing and flooding of the River Nile led to spread of some serious annual weeds, such as *Sorghum arundinaceum* (Dew.) Stapf., *Sinapis arvensis* L. and *Chenopodium album* L., throughout the Northern State (Bedry and Elamin, 2011 and Mukhtar, 2012). Now, weeds have become one of the main constraints in crop production in the Northern State and elsewhere in the Sudan. They reduce yield directly, through interference or, indirectly, through hindering cultural and harvest practices and indirectly interfere with the use of land and water resources and adversely affect human welfare (Nasr Eldin, 2009; Hamada *et al.*, 2009; Mukhtar and Elamin, 2011). In Northern State unrestricted weed growth reduced wheat grain yield by 43%-80% (Osama, 1999 and Khalid, 2005).

Traditional method of weed control in the Northern State was late voluntarily hand removal of weeds as fodder for livestock. Hand weeding is a labour intensive, expensive and time consuming. Moreover, labour has become scarce. The yield losses are mainly due to delayed weeding, or insufficient weed control (Mohamed and Abdalla, 1997; Osama, 1999 and Bedry and Elamin, 2011).

In developing countries manual weeding is the most common method of weed control, but in many instances the available labour is unable to remove weeds from vast areas of land during critical periods, thus, the use of herbicides is a necessity (Abdel Rasoul, 1998 and Elamin, 1991). Herbicides constitute a highly efficient method for controlling weeds, increasing yields and reducing labour in crop production (Mukhtar, 2006).

This study was carried out to determine the magnitude of yield losses due to weed interference and the herbicidal efficacy of 2, 4-D, Clodinafop-propargyl and their tank mixtures in wheat.

Materials and Methods

A field experiment was conducted during two consecutive winter seasons (2009/2010 and 2010/2011) at Elkarwat scheme, Dongola Locality, Northern State, Sudan. The area is located within latitude 16° and 22° N, and longitude 20° and 32° E (Mukhtar, 2006). Dongola Locality is a true desert, is characterized by extremely high temperatures and radiation in summer, low temperature in winter, scarce rainfall and high wind speed. The mean maximum and minimum temperatures are 36.8 and 19.5°C, respectively. The climate is hyper arid with a vapour pressure of 10.8 mb and a relative humidity of less than 20% (Osman, 2004).

The soil in the experimental site is a silty clay, with 30% sand, 40.33% silt and 45.67% clay (Damirgi and Al-agidi, 1982 and Osman *et al.*, 2005).

The herbicides treatments were; 2,4-D, as Safaya 720 EC, at 5.8, 6.8 and 7.8 kg. a.i/fed. (1 fed = 0.42 ha); clodinafop-propargyl as Topic 80% EC at 0.3 and 0.4 kg. a.i/fed., and 2,4-D at 5.8 and 6.8 kg. a.i/fed., in tank mixture with Clodinafop-propargyl at 0.3 and 0.4 kg. a.i/fed. Treatments were arranged in a randomized complete block design (RCBD), with four replications. In each season, the experimental site was ploughed, disc harrowed, leveled and divided into 1.8 × 3 m plots. Each plot was made of six rows. Wheat, cultivar Wadi Elneel was planted by hand in rows on flat at a seed rate of 90 kg/ha, on 30 November for both winter seasons, inter-row spacing was 30 cm. Nitrogen fertilizer, as urea, was applied at a rate of 40 kg/fed. ((½ dose at 2 weeks after sowing and ½ dose at 6 weeks after sowing). Weeded and unweeded checks were included for comparison. In the weeded treatment, weeds were removed frequently by repeated hand weeding to keep the crop free from weeds up to harvest. However, in the unweeded treatment weeds were left to grow, unrestrictedly, with the crop until harvest. Irrigation water was applied at 10-15 days interval depending on temperature and other environmental conditions. The herbicides 2,4D, Clodinafop-propargyl and their tank mixtures were applied post-emergence three weeks after sowing, with a knapsack sprayer calibrated to deliver 254 l/fed. All other cultural practices were as recommended by the Agricultural Research Corporation. Visual observations of phytotoxicity of the herbicides treatments on the crop were assessed periodically.

The effect of treatments on weeds was assessed by counting the individual weed species at 4 weeks after herbicides application. This was done by randomly placing 1x1 m quadrate in each plot. Weeds inside each quadrate were identified and individual weed species counted. The percentage control of grassy and broad-leaved weeds, as compared with the unweeded control, for each treatment was calculated. At eight weeks after sowing ten plants were randomly selected from the four inner rows in each plot. Plant height, number of leaves/plant, number of tillers/plant and leaf area index were measured. At harvest spikes from ten randomly selected plants in each treatment were cut, air dried and used for determination of yield characters including, number of spikes/plant, number of grains/spike and 1000grain weight (g). An area of 2.5 × 1.2 m. was harvested from each plot, air dried, threshed, weighed and grain yield was calculated.

The procedure described by Gomsez and Gomez (1984) was used to estimate the combined Analysis of variance (ANOVA), was performed using the statistical analysis system (SAS) computer package for SAS Institute Inc., 1990, to detect significant effects among the treatments and populations. Mean squares for treatments or populations were calculated. Simple statistics including mean, standard deviation, standard error and coefficient of variation (C. V. %) were also calculated.

Results and Discussion

Visual observations revealed that the herbicides 2, 4-D, and Clodinafop-propargyl, at all rates and their tank mixtures showed no phytotoxicity symptoms on the crop. The treated plants displayed vigorous growth indicating that the herbicides used were selective on wheat.

The weed flora in the experimental site consisted of grassy and broad-leaved weeds. The dominant weed species were: *Tribulus terrestris* L., *Malva palviflora* L., *Sonchus oleraceous* L., *Amaranthus graecizans* L., *Chenopodium album* L., *Cynodon dactylon* (L.) Pers., *Echinochloa colona* (L.) Link., *Avena fatua*, *Trigonella hamosa*, *Sinapis arvensis* L., *Convolvulus arvensis* L. and *Sorghum arundinaceum* (Dew.) Stapf. Weeds compete with wheat for water, nutrients, space and light (Mukhtar, 2012). 2,4-D, at all rates, gave consistent and effective control of broad-leaved weeds throughout the season, but its activity against gramineous weeds was poor (Table 1). Similar results were reported by Le Roy (1971) and Hassan, *et al*. (2008) who reported that 2,4-D gave poor control of grasses and was highly effective on broad-leaved weeds during the whole season. These findings are in line with the result of Khalid (2004 and 2005) who showed that the post- emergence treatment of 2,4-D in wheat gave effective control of broad-leaved weeds, but was poor against grassy weeds clodinafop-propargyl, at both rates gave good control of poaceous weeds, but its activity against broad-leaved weeds was poor (Table 1). Similar results were reported by Mohamed (1996); Kamal (2009) and Khalid (2009) who reported that the application of clodinafop-propargyl resulted in effective grass weeds control.

All herbicides tank mixtures gave consistent and effective weed control of grasses and broad-leaved weeds throughout the season (Table 1).The highest grass and broad-leaved weeds control was achieved by the herbicides tank mixtures (Table 1). These results are in agreement with the those of Khalid (2004) who mentioned that post-emergence treatment of 2, 4-D in tank mixture with clodinafop-propargyl in wheat gave effective and satisfactory control of broad-leaved and poaceous weeds.

A significant weed biomass reduction was achieved with all herbicides treatments and their tank mixtures compared to the weedy check (Table 1). The highest weed biomass reduction was achieved by the intermediate rate of 2, 4-D in tank mixture with the two rates of clodinafop-propargyl (Table 1). Similar results were reported by Mukhtar *et al*. (2008), who indicated that the herbicides Dual gold and atrazine and their tank mixtures significantly reduced weed biomass compared to full season weedy treatment. Also the same result was found by Osama (1999) who reported that the herbicides 2, 4-D and clodinafop-propargyl and their tank mixtures significantly reduced weed biomass compared to weedy check.

A significant increase due to herbicides was also found in1000 grains weight (g), plant height (cm) and leaf area index (Tables 2 & 3).

Combined analysis of both winter seasons indicated that unrestricted weed growth significantly reduced wheat grain yield by 68.94% compared to the weed free treatment (Table 3). This reduction in wheat total grain yield was due effects of weeds on various yield components (Table3). Similar findings were found by Khalid (2004).

All herbicides treatments (except the two rates of clodinafop-propargyl) and the weed free full season treatment increased wheat grain yield, compared to unweeded control treatment (Table 3).

The combined analysis of both winter seasons indicated that, within all herbicides the highest grain yield was achieved by 2, 4-Dat 6.8 kg. a.i/fed., in tank mixture with clodinafop-propargyl at 0.4 kg. a.i/fed., and gave grain yield comparable to weed free control treatment (Table 3). These results indicate that early removal of weeds by herbicides enabled the crop to maximize the use of available resources and thus secure good establishment and growth. The increase in grain yield affected by herbicides is in agreement with the findings of Khalid (2005) who reported that, 2, 4-D alone or in tank mixture with clodinafop-propargyl gave effective control of weeds, improved wheat growth and resulted in high grain yield compared to the unweeded treatment. Similar findings were also reported by Kamal (2009) who indicated that, 2, 4-D as post-emergence treatment for control of weeds in wheat gave high grain yield and its yield components compared to the weedy full season treatment. These results also are in line with the findings of Khalid (2009) who showed that the use of clodinafop-propargyl in wheat gave satisfactory control of weeds and resulted in high grain yield and its yield components compared to the weedy full season treatment. Based on these results, it can be concluded that, the effectiveness of the herbicide 2, 4-D at 6.8 kg. a.i/fed., in tank mixture with clodinafop-propargyl at 0.4 kg. a.i/fed., against weeds and its high selectivity in wheat, make these herbicides tank mixture possible candidates for control of weeds in wheat in the Northern State.

Table 1: Effect of herbicides on weeds in wheat at 4 weeks after application (seasons 2009/2010 and 2010/2011 combined)

Treatments	Herbicide rate (kg. a.i./fed)	Percentage grass weed control	Percentage broad-leaved weed control	Weed biomass (g / m^2)
2, 4-D	5.8	17.92	83.41	9.13b
2, 4-D	6.8	18.17	91.29	8.79b
2, 4-D	7.8	26.36	94.17	8.76b
Topic	0.3	75.82	21.83	12.72b
Topic	0.4	78.75	25.68	11.91b
2, 4-D + Topic	5.8 + 0.3	77.72	95.72	7.32b
2, 4-D + Topic	5.8 + 0.4	90.17	97.61	7.00b
2, 4-D + Topic	6.8 + 0.3	92.90	98.68	6.71c
2, 4-D + Topic	6.8 + 0.4	94.84	98.83	5.81c
Weed free full season	-	100	100	0.00
Weedy full season	-	0.00	0.00	74.37a
Sig	-	*	*	*
C.V%	-	3.54	4.02	2.8
S.E	-	0.95	1.33	0.29

-Means with the same letters in the same column are not significantly different at 0.05 level of probability according to DMRT.

* = Significant at 0.05 probability level

Table 2: Effect of herbicides on wheat growth attributes (seasons 2009/2010 and 2010/2011 combined)

Treatments	Herbicide rate kg. a.i./fed.	Plant height (cm)	Number of leaves/plant	Leaf area index	Number of tillers/plant
2, 4-D	5.8	40.95f	4.95d	0.26a	10.92e
2, 4-D	6.8	41.40f	5.73d	0.30a	13.12de
2, 4-D	7.8	44.89e	5.54d	0.31a	15.18d
Topic	0.3	38.44g	3.83e	0.28a	7.00f
Topic	0.4	41.50f	3.92e	0.28a	7.22f
2, 4-D + Topic	5.8 + 0.3	49.19d	7.13c	0.31a	18.72c
2, 4-D + Topic	5.8 + 0.4	52.21c	7.33c	0.34a	18.92bc
2, 4-D + Topic	6.8 + 0.3	56.40 b	8.53b	0.33a	19.00bc
2, 4-D + Topic	6.8 + 0.4	57.00b	8.92b	0.35a	21.11ab
Weed free full season	-	64.54a	10.06a	0.37a	24.22a
Weedy full season	-	29.27h	3.44e	0.17b	6.13f
Sig	-	*	*	*	*
C.V%	-	1.84	9.21	19.72	10.95
S.E	-	.0.58	0.21	0.06	0.84

-Means with the same letters in the same column are not significantly different at 0.05 level of probability according to DMRT.

* = Significant at 0.05 probability level

Table 3: Effect of herbicides on wheat grain yield and yield components (seasons 2009/2010 and 2010/2011 combined)

Treatments	Herbicide rate (kg a.i./fed)	Number of spikes/plant	Number of grains/spike	1000 grains weight (g)	Grain yield (t /ha)
2, 4-D	5.8	5.11de	40.63f	39.34c	2.48f
2, 4-D	6.8	6.01d	44.63e	33.98cd	2.73e
2, 4-D	7.8	8.02d	46.39de	32.95 cd	3.00d
Topic	0.3	2.98e	35.60g	29.08d	1.90g
Topic	0.4	3.12e	38.38g	29.26d	1.95g
2, 4-D + Topic	5.8 + 0.3	12.00c	47.17d	37.31c	3.24c
2, 4-D + Topic	5.8 + 0.4	12.01c	48.75d	38.01c	3.64b
2, 4-D + Topic	6.8 + 0.3	14.24b	52.78c	41.11b	3.71b
2, 4-D + Topic	6.8 + 0.4	15.06b	54.94b	52.42a	4.46a
Weed free full season	-	17.42a	61.00a	54.72a	4.70a
Weedy full season	-	2.97e	36.90g	21.30e	1.46g
Sig	-	*	*	*	*
C.V%	-	5.23	2.17	1.80	0.45
S.E	-	0.25	0.52	0.36	0.01

-Means with the same letters in the same column are not significantly different at 0.05 level of probability according to DMRT.
* = Significant at 0.05 probability level

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المكافحة الكيميائية للحشائش فى القمح (*Triticum aestivum* L.) بمحلية دنقلا الولاية الشمالية-السودان

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المستخلص

تشكل الحشائش معوقاً حيوياً رئيسياً للحد من إنتاج القمح (*Triticum aestivum* L.) فى السودان. أجريت تجربة مبيدات حشائش خلال موسمين شتويين متعاقبين للعامين 2010/2009 و 2011/2010 بمشروع الكروات، محلية دنقلا، الولاية الشمالية، السودان لتحديد نسبة الفقد الناجمة من منافسة الحشائش ولتقييم فعالية مبيد 2,4-D كلودينافوب-بروباجايل وخليطهما فى القمح. ضمنت معاملة نظيفة من الحشائش وأخرى موبوءة بها للمقارنة. جميع جرعات 2,4-D أعطت مكافحة فعالة للحشائش عريضة الأوراق خلال موسم النمو، لكن فعاليته على الحشائش

النجيلية كانت ضعيفة. كلودينافوب-بروباجايل بجرعتيه أعطى مكافحة جيدة للحشائش النجيليـــة، لكـــن فعاليتـــه ضـــد الحشائش عريضة الأوراق كانت ضعيفة. مخاليط مبيدات الحشائش أعطت مكافحة فعالة للحشائش النجيليـــة وعريضـــة الأوراق خلال الموسم. كانت أعلى مكافحة للحشائش النجيلية وعريضة الأوراق قد أنجزت بمخاليط مبيدات الحشائش. كل مبيدات الحشائش ومخاليطها حققت مكافحة معنوية للحشائش وأدت إلى نقص فى الوزن الجاف مقارنـــة بالمعاملـــة الموبوءة بالحشائش. خليط 2,4-D بمعدل 6.8 كجم مادة فعالة للفدان مع (كلودينـــافوب بروبارقيـــل) Clodinafop-propargyl بمعدل 0.3 و 0.4 كجم مادة فعالة للفدان حقق أكبر نقص للوزن الكلى للحشائش. التحليـــل المشـــترك للموسمين الشتويين أشار إلى أن النمو للحشائش طول الموسم قلل معنوياً إنتاجية حبوب القمح بحوالى 68.94% مقارنة بالمعاملة النظيفة من الحشائش. أوضحت النتائج أن من بين معاملات مبيدات الحشائش التى حققت أعلى إنتاجية للحبوب هى خليط 2,4-D بمعدل 6.8 كجم مادة فعالة للفدان مع Clodinafop-propargyl بمعدل 0.4 كجم مادة فعالة للفدان و التي أعطت إنتاجية حبوب مشابهة للمعاملة النظيفة من الحشائش.