J. BIOL. ENVIRON. SCI.,
2012, 6(16), 25-33

Effect of Split Nitrogen Fertilization and Herbicide Application on Soil Weed Seed Bank in Wheat (*Triticum aestivum* L.) and Oilseed Rape (*Brassica napus* L.) Rotation

Sahar Sheibani* **and Hossein Ghadiri**
Department of Crop Production and Plant Breeding, College of Agriculture, Shiraz University, IRAN

ABSTRACT

In order to investigate the effects of nitrogen splitting and herbicide application on soil weed seed bank in a wheat and oilseed rape rotation, a field experiment was conducted in research station of the School of Agriculture, Shiraz University, Iran in 2005-6 and 2006-7. Results suggested that at 304 kg urea ha^{-1} when half of it was applied through sowing stage of wheat and oilseed rape and the other half applied at tillering stage of wheat and the end of rosette stage of oilseed rape grain and biological yield enhanced substantially in wheat and oilseed rape. Presence of weeds in weedy checks plot increased biological yield 57% in wheat, 142% in oilseed rape. On the other hand, it reduced wheat grain yield 53% and oilseed rape grain yield 65% comparing with weed free plots. Results indicate that herbicides application enhanced grain yield 88% in wheat, 63% in oilseed rape. However, it decreased weeds' dry weight 58% in wheat and 78% in oilseed rape when it compared with weedy checks plot. Furthermore, iodosulfuron–methyl–sodium plus mesosulfuron–methyl–sodium in wheat reduced the annual rising of the soil weed seed bank 53% in 0-15cm and 71% in 15-30cm depth, while haloxyfop-(R)-methylester in oilseed rape decreased it 43% in 0-15cm and 40% in 15-30cm depth.

Key Words: Herbicide, nitrogen splitting, weed seed bank.

INTRODUCTION

Weeds are the most serious pests reducing the growth and yield of crop in Iran and control of weeds is a basic requirement and major component of management in most crop production systems. Emerged weeds usually provide the primary indicator of the success of the weed management efforts. Monitoring the seed bank can offer additional information about the long term prognosis for weed management. Seed bank acts as the memory of the weeds population dynamics over several years, reflecting past and present management elements, and it is an indicator of weed problems in the future (Cavers 1995; Dorado *et al.* 1999). Changes of the emerged weed populations relatively represent immediate impacts on changing farming practices, whereas changes in the seed bank may be more representative of long-term trends associated with changes in farming practices (Buhler 1995; Vanasse and Leroux 2000, Legere and Stevenson 2002). Clements *et al*. (1996) noted that changes in farm management systems will influence weed species diversity, witch could be a threat to crop yields when some weed species are superior competitors and there are few management options for farmers. On the other hand, enhanced weed species diversity have several remarkable benefits such as more competition between weed species, more niches for natural enemies of weed, more weed-weed interactions, greater diversity of weed life histories, greater community stability, and reduced incidence of herbicide resistance (Clements *et al*. 1996; Forcella and Durgan 1997; Swanton and Murphy 1996; Dawit and David 1997; Schellhorn and Sork 1997; Zanine *et al*. 1998; Miyazawa *et al*. 2004).

Integrated weed management (IWM) essentially means the integration of several practices, including herbicides, to reduce the negative impact of weeds on crops and the amount of seed produced by the weeds. It involves a system approach such as adopting practices that enhances crop competition with weeds, scouting fields to determine the weed species, size and density, and implementing appropriate crop rotations including growing crops for silage and growing forage legumes in rotation with cereal and oilseed crops (Beckie et al. 2001).

Crop rotation dictates the pattern of disturbances which ultimately leads to weed species composition changes in an agro ecosystem. The selected crop rotation will determine the herbicide use, type of tillage, and timing of tillage events relative to crop and weed emergence, and harvest date relative to crop and weed maturity. Such management practices are the most important determination of weed species composition over a period of several growing season (Ball and Miller 1990). Furthermore, crop rotation can have a significant influence on weed numbers and weed specie shifts. Changes in crop rotation sequences can also influence weeds present because of herbicide selection and certain residual herbicides application. It should be considered that rotation of herbicide "mode of action" is so important to control and prevent of herbicide resistant weeds (Alberta.ca Agriculture and Rural Development 2006 online).

The apparent success in crop rotation systems for weed suppression is based on the use of crop attributes, such as variation in resource competition patterns and allelopathic interference, combined with soil disturbance and mechanical damage to create a less hospitable environment for weeds (Liebman and Dyck 1993). Thus, crop

* Corresponding author: sheibani.sahar@gmail.com

rotations can reduce weed infestations while maintaining or increasing crop yield (Gantzer et al. 1991; Mitchell et al. 1991). Other advantages of crop rotations are to prevent the development of dominant and intractable weed species (Froud-Williams 1988) besides reducing weed seed production (Kegode et al. 1999).

Weed-crop competition is a complex issue and many conflicting results have been reported on the effect of nitrogen (N) fertilizer on crop-weed interaction. Valenti and Wicks (1992) found that increasing N rates application in winter wheat decreased annual grass weed populations and its yield. Conversely, other studies revealed that applications of N favored *Setaria viridis* (Peterson and Nalewaja 1992) and *Avena fatua* (Carlson and Hill 1985) over wheat.

Fertilizer application is an important field management factor. The efficiency of N fertilizer as a top dressing in wheat is influenced by timing, fertilizer rate, and rainfall. Maximum efficiency would be achieved by the latest possible application, as long as the growing plant is still capability to swift N uptake. This would avoid unnecessary vegetative growth and the risk of lodging and also reduce N loss through leaching, denitrification, volatilization, and runoff since an active root system ensures uptake of the N fertilizer applied (Alcoz et al.1993). Both Alcoz et al. (1993) and Stockdale et al. (1997) reported wheat yield enhancement when N fertilizer was applied between the end of tillering and formation of the first node (Stages 4 to 6 on the Feekes scale; Large 1954) compared with application at planting or during heading (Feekes Stage 10). Mossedaq and Smith (1994) suggested that N should immediately apply before the period of peak N demand (i.e., the onset of stem elongation) and speculate that this will result in minimizing N leaching.

The aim of the present study was to determine the effects of N timing and splitting application in combination with two herbicides, iodosulfuron–methyl–sodium plus mesosulfuron–methyl–sodium, and haloxyfop-(R)-methylester on weed management and its seed bank in a wheat and oilseed rape rotation.

MATERIALS AND METHODS

Field study was conducted in 2005-6 and 2006-7 growing seasons at the Experimental Farm of School of Agriculture, Shiraz University, Shiraz, Iran, at Kooshkak (1650 msl, longitude 52˚, 36´, and latitude 30˚, 7´). The meteorological data for this location during the growing seasons for two years were shown in table 1. Wheat was grown in the experimental field in the previous season. Soil texture was clay-loam with pH=7.3, EC=0.28 mmhos/cm, OC=0.7%, N=0.046%, P=16 ppm, K= 270 ppm. After land preparation plowing, disking and ridging the plots were done and winter wheat (CV. Shiraz) was planted 15 cm apart on four rows on raised beds 60 cm apart on 15 Novem ber by Hamedani planter at the rate of 180 kg ha^{-1} in 2005. Oilseed rape (CV. talayeh) was sown in 11 October 2006, at a seeding rate of 7 kg ha^{-1} in 30 cm wide rows.

Table 1. Meteorological data during the growing season.

Month	Average temperature (˚C))		Precipitation (mm)	
	2005-06	2006-07	2005-06	2006-07
November	11.13	12.88	99.00	3.00
December	9.40	3.58	1.50	100.50
January	3.48	1.60	172.00	37.50
February	6.58	5.08	67.00	97.00
March	8.98	8.33	6.50	49.00
April	12.11	12.08	0.00	185.00
May	17.34	19.02	0.00	1.00
June	21.95	23.84	0.00	0.00
July	27.19	27.77	0.00	0.00
August	26.58	25.97	0.00	0.00

No fertilizer was added before planting. Sub plot size was 4×5 m. To measure weed seed bank, Soil samples were collected prior to wheat-sowing and from each plot after wheat and oilseed rape harvesting, to a depth of 0-15 and 15-30 cm. Malon method were used to analyze the soil samples.

The experimental design was a split plot based on RCBD with four replications. Main plots consisted of N timing (T_1=sowing, T_2=tillering, and T_3=stem elongation) in wheat, (T_1=sowing, T_2=end of rosette stage, and T_3=flowering stage) in oilseed rape and splitting (N_0=no N fertilization, N_1= full N fertilization, $N_{½}$= half of the N fertilization). T_1N_0, T_2N_0, T_3N_0 represent no N fertilization at sowing, tillering, and stem elongation stages of wheat and no N fertilization at sowing, end of rosette and flowering stages of oil seed rape. T_1N_0, T_2N_1, T_3N_0

represent no N fertilization at sowing, full N fertilization (304 kg urea ha^{-1}) at tillering, and no N fertilization at stem elongation stage of wheat and no N fertilization at sowing, full N fertilization (304 kg urea ha^{-1}) at the end of rosette and no N fertilization at flowering stages of oil seed rape. $T_1N_{½}$, $T_2N_{½}$, T_3N_0 represent half of the N (152 kg urea ha^{-1}) fertilization at sowing and the other half (152 kg urea ha^{-1}) at tillering and no N fertilization at stem elongation of wheat and half of the N (152 kg urea ha^{-1}) fertilization at sowing and the other half (152 kg urea ha^{-1}) at the end of rosette and no N fertilization at flowering stages of oil seed rape. The sub plots consisted of application of herbicide, iodosulfuron–methyl–sodium plus mesosulfuron–methyl–sodium at 21g ai ha^{-1} with sitogate oil at 0.2% (V/V) in wheat and 108 gr ai ha^{-1} of haloxyfrop-R-methyl in oil seed rape. Weedy and weed free checks were also included. Herbicides were applied as a broadcast application in 300 L of water per ha with a 20-L knapsack sprayer equipped with one flat-fan nozzle 110-02 at a pressure of 3 kPa at 3-4 leaf stages of weeds in both years.

Wheat was hand harvested from the central $1m^2$ of the middle rows in each plot and oilseed rape from the central $2m^2$ of the middle rows in each plot after maturity to measure grain and biological yield. In the five sampling dates with two weeks interval during the growing seasons, weeds were harvested from 0.5 m^2 of each plot. Dry matter were determined by drying the sampled plants of 65˚C to constant weight (data from only one sampling date at 10 weeks after herbicide treatment (WAT) is shown for weed dry weight). All data were subjected to analysis of variance using MSTAT C and SAS statistical software. Main effects and interactions were tested for significance. Means were separated and compared by Duncan multiple range test (DMRT) at the 0.05 level of significance.

RESULTS AND DISCUSSION

Weed seed bank in 0-15cm depth

Analysis of variance indicated that N treatments T_1N_0, T_2N_1, T_3N_0 resulted in greater total seed densities in the 15cm depth in each year (Table 2). Weed seeds number increased 153% after wheat harvesting and 151% after oilseed rape harvesting in N split of T_1N_0, T_2N_1, T_3N_0 in the 15cm depth compared with no N fertilization. By using N treatments T_1N_0, T_2N_1, T_3N_0 more number of weed were able to produce seed witch resulted in soil seed bank increasing. This finding was in agreement with the researchers who reported that based on weed species and densities, adding N can increase the competitive ability of weed more than that of the crop (Gruenhagen and Nalewaja 1996; Carlson and Hill 1985; Peterson and Nalewaja 1992; Ampong-Nyarko and de Datta 1993). Weedy and weed free plots had highest and lowest weeds seed number in 15cm depth in each year respectively (Table 2). Results showed 54% and 63% reduction in weed seed number after wheat and oilseed rape harvesting samples with herbicide function. Herbicide applications indirectly affect the seed bank by reducing the number of seed-producing plants. Integrating of N splitting with herbicides showed plots that received herbicide with N split of $T_1N_{½}$, $T_2N_{½}$, T_3N_0 and T_1N_0, T_2N_0, T_3N_0 had the lower weeds seed number in 0-15cm depth in comparison with N split of T_1N_0, T_2N_1, T_3N_0. It can attributed to the increase of N use efficiency by crops with split usage, so crop competitive ability increased than the weeds, this finding supported the result of the Foster (1996), who reported that higher nutrient levels stimulate the competitive ability of wild oats, green foxtail and barnyard grass. Other weeds competitive ability might be limited by nutrient levels that are adequate for crop growth. Alcoz et al. (1993) also reported that N fertilizer splitting has been suggested as a strategy to improve wheat N use efficiency.

Weed seed bank in 15-30cm depth

The response of weeds' seed density in 15-30cm depth to the integrated of N splitting and herbicide treatments behaved in a very similar way to 0-15cm in each year (Table 2). Herbicide applied caused 73% and 83% reduction in weeds' seed density after wheat and oilseed rape harvesting samples than the weedy check in 15-30cm depth in each year.

Table 2. Number of weeds per m^3 soil as affected by N timing and herbicides.

Number of weed seeds per m^3 soil after wheat harvesting								
Number of weeds per m^3(10^{-4})soil in depth of 0-15 cm					Number of weeds per m^3(10^{-4})soil in depth of 15-30 cm			
2005-2006					2005-2006			
Treatment	Herbicide	Control			Herbicide	Control		
Nitrogen	mesomax+udo soulfuron methyl sodium	Weedy	Weed free	Mean	mesomax+udo soulfuron methyl sodium	Weedy	Weed free	Mean
$T_1N_{½}$, $T_2N_{½}$, T_3N_0	2.2 cd*	7.7 c	1.0 d	3.7 C	3.5 cd*	17.0 a	1.0 e	7.2 A
T_1N_0, T_2N_1, T_3N_0	23.0 b	38.0 a	5.0 cd	22.0 A	5.2 c	10.2 b	3.0 cde	6.2 AB
T_1N_0, T_2N_0, T_3N_0	5.0 cd	19.5 b	1.7 cd	8.7 B	1.2de	9.5 b	1.2 de	4.0 B
Min	10.0 B**	21.7 A	2.6 C		3.3 B**	12.2 A	1.7 C	
Number of weed seeds per m^3 soil after oilseed rape harvesting								
2006-2007					2006-2007			
Nitrogen	haloxyfrop-R-methyl	Weedy	Weed free	Mean	haloxyfrop-R-methyl	Weedy	Weed free	Mean
$T_1N_{½}$, $T_2N_{½}$, T_3N_0	5.5 d*	39.2 b	1.0 d	15.2 B	4.5 c	19.7 b	1.0 c	8.4 AB
T_1N_0, T_2N_1, T_3N_0	36.7 bc	58.0 a	2.7 d	32.2 A	5.0 c	30.25 a	1.0 c	12.0 A
T_1N_0, T_2N_0, T_3N_0	5.0 d	30.7c	2.7 d	12.8 B	2.0 c	16.0 b	0.0 c	6.0B
$T_1N_{½}$, $T_2N_{½}$, T_3N_0	15.7 B**	42.7 A	2.2 C		3.8 B	22.0 A	0.6 C	

*Means within each column followed by same letter are not significantly different at 0.05 probability level according to DMRT.
**Means with same letter are not significantly different at 0.05 probability level according to DMRT.

Annual soil weed seed bank changes

In the soil samples, weeds' seed number differs among sampling depth; such differences were expected considering the type of tillage used to establish the study. In the first soil sample, 18% of total weeds' seed bank was in 0-15cm and 82% was in 15-30cm.

This result was in agreement with Pareja et al. (1985) and Yenish et al. (1992), who reported that in the continuous corn experiments, were moldboard plowed in fall prior to beginning the study, the largest number of weeds' seed was found at the deepest depth, which is a characteristic of moldboard plowing.

Results of the annual soil weed seed bank increasing in the weedy checks in both depths supported this hypothesis that soil weed seed bank enhance annually because weed seed production and its adding to the soil each year (Table 3). No controlling of weeds in weedy checks resulted in the highest annual rising in the soil weed seed bank because of higher number of weeds that produce seeds and add to the soil. As he same time, controlling the weeds in herbicide treatments, iodosulfuron–methyl–sodium plus mesosulfuron–methyl–sodium, in wheat declined the annual rising of the soil weed seed bank 53% in 0-15cm and 71% in 15-30cm depth and haloxyfop-(R)-methylester in oilseed rape decreased it 43% in 0-15cm and 40% in 15-30cm depth. Other researches have reported a steady decline in total seed bank densities in plots receiving continues herbicide applications (Schweizer and zimdahl 1984; Burnside 1986; Vencil and Banks 1994) in these studies weed seed number increasing was rapidly discontinued after herbicide application. The highest rising in soil weed seed bank in weedy checks observed in N splitting of T_1N_0, T_2N_1, T_3N_0 that was conformed the results of the wheat seed and biological yields. The soil weeds seed bank in the N treatments $T_1N_{½}$, $T_2N_{½}$, T_3N_0 was higher in the weedy checks as well, but application of suitable herbicides by considering to the dominant weeds in the filed, crop can reach the highest grain yield as this N treatment was suitable for both weeds and crop. By controlling the weeds and reducing crop and weed competition, wheat and oilseed rape produce the highest yield.

In weedy checks N split of $T_1N_{½}$, $T_2N_{½}$, T_3N_0 had more weeds' seed densities than the T_1N_0, T_2N_1, T_3N_0 when third soil sample compared to the second one. N split of T_1N_0, T_2N_1, T_3N_0 improved weeds' seed germination via breaking the dormancy of large number of weed seeds in second soil samples. Subsequently, because of high weed density, inter weed competition increased and poor seeds produced. Therefore, the amount of seeds entering to the soil seed bank decreased in the second year as a result of the weakness of seeds produced in the previous year. Accordingly the amount of seeds entering to soil seed bank declined in the third soil sample than the second one in N treatment T_1N_0, T_2N_1, T_3N_0.

It is totally accepted that in weed species the usual dormancy hampers the task of predicting time and percentage of weeds' emergence (Benech-Arnold and Sa´ nchez 1995), because in many weeds the number of established seedlings is strongly related to the dormancy level of the seed bank, and the timing of emergence largely depends on the seasonal dynamic variation in seed bank dormancy (Benech-Arnold et al. 2000).

Grain yield

The application of nitrogen splitting showed significant of produced positive impact on wheat and oilseed rape grain yield (Table 4). The best grain yield response was obtained when half of the N (152 kg urea ha^{-1}) fertilization was applied at sowing and the other half was applied at tillering. Grain yield increased 29% in wheat and 39% in oilseed rape with this N treatment as compared to no fertilizer applied. The obtained results are in accordance with Buchholz and Schaeffer (1990) who found that N application between fall and spring growth periods improved winter wheat yields over all-fall and all-spring N applications, particularly under intermediate to higher yield conditions. Research on wheat and canola conducted at Indian Head, Saskatchewan, also showed favorable yield and seed protein content results when N splitting was applied.

Presence of weeds in weedy checks reduced grain yield 53% in wheat and 65% in oilseed rape compared with weed free checks. Whereas, herbicides application enhanced grain yield 88% in wheat and 63% in oilseed rape. These results are supported by (Cheema and Akhtar 2005) and Hashim et al. (2002), who reported that herbicide treatments significantly increased the grain, yield in wheat crop. Appleby et al. (1976), and Hashem et al. (1998), reported that wheat seed yield was reduced up to 92% by competition from weeds. Zaremohazabieh and Ghadiri (2011) also accounted herbicide application had significant effect on corn grain yield. As a result of weeds competition, corn yield reduced approximately 64-77% in weedy checks.

Table 3. Percent of increasing in number of weeds per m^3 soil as affected by N timing and herbicides.

Percent of increasing in number of weeds per m^3 soil after wheat harvesting to before wheat cropping

$m^3(10^{-4})$ soil in depth of 0-15 cm					$m^3(10^{-4})$ soil in depth of 15-30 cm			
2005-2006					**2005-2006**			
Treatment	Herbicide	Control			Herbicide	Control		
Nitrogen	mesomax+udo soulfuron methyl sodium	Weedy	Weed free	Mean	mesomax+udo soulfuron methyl sodium	Weedy	Weed free	Mean
$T_1N_{½}$, $T_2N_{½}$, T_3N_0	45.0% e*	150.0% d	35.0% e	76.7% C	15.0% de*	74.0% a	4.2% e	23.6% A
T_1N_0, T_2N_1, T_3N_0	460.0% b	760.0% a	100.0% de	440.0% A	23.0% cd	34.7% bc	13.0% de	17.3% A
T_1N_0, T_2N_0, T_3N_0	100.0% de	390.0% c	35.0% e	175.0% B	5.5% e	41.2% b	5.2% e	2.9% B
Min	201.7% B**	433.3% A	56.7% C		14.5% B**	50.0% A	7.5 C	

Percent of increasing in number of weeds per m^3 soil after oil seed rape harvesting to after wheat harvesting

2006-2007					**2006-2007**			
Nitrogen	haloxyfrop-R-methyl	Weedy	Weed free	Mean	haloxyfrop-R-methyl	Weedy	Weed free	Mean
$T_1N_{½}$, $T_2N_{½}$, T_3N_0	293.8% b	515.3% a	128.0% c	131.4% A	125.0% b*	109.3% bc	83.2% cd	105.8% B
T_1N_0, T_2N_1, T_3N_0	182.5% bc	152.5% c	59.5% c	126.3% A	99.7% bc	343.8% a	15.0% de	152.8% A
T_1N_0, T_2N_0, T_3N_0	103.3% c	160.8% c	115.0% c	26.0% A	150.0% bc	171.3% b	0.0% e	107.1% B
Min	193.2% B	276.2% A	100.8% C		124.9% B**	208.1% A	32.7% C	

*Means within each column followed by same letter are not significantly different at 0.05 probability level according to DMRT.
**Means with same letter are not significantly different at 0.05 probability level according to DMRT.

Table 4. Wheat and oilseed rape grain and biological yield as affected by N timing and herbicides.

Grain yield (kg ha^{-1})								
	wheat				**Oilseed rape**			
Treatment	Herbicide	Control			Herbicide	Control		
Nitrogen	mesomax+udo soulfuron methyl sodium	Weedy	Weed free	Mean	haloxyfrop-R-methyl	Weedy	Weed free	Mean
$T_1N_{1/2}$, $T_2N_{1/2}$, T_3N_0	1792.0 a*	957.0 c	1758.0 a	1502.0 A	686.0 b	400.0 c	932.0 a	673.0 A
T_1N_0, T_2N_1, T_3N_0	1359.0 b	906.0 c	1698.0 a	1321.0 B	320.0 cd	193.0 d	894.0 a	469.0 B
T_1N_0, T_2N_0, T_3N_0	1350.0 b	528.0 d	1600.0 a	1159.0 C	450.0 c	300.0 cd	700.0 b	483.0 B
Min	1500.0 B**	797.0 C	1685.0 A		485.0 B	298.0 C	842.0 A	
Biological yield (kg ha^{-1})								
$T_1N_{1/2}$, $T_2N_{1/2}$, T_3N_0	4000.0 ab*	4260.0 a	3040.0 cd	3678.0 A	4863.0 b	6200.0 a	175.0 e	3746.0 B
T_1N_0, T_2N_1, T_3N_0	3933.0 ab	4375.0 a	2550.0 de	3619.0 A	5825.0 a	6467.0 a	5750.0 a	6014.0 A
T_1N_0, T_2N_0, T_3N_0	3000.0 cd	3500.0 bc	2150.0 e	2883.0 B	1550.0 d	2375.0 c	300.0 e	1408.0 C
Mean	3644.0 B**	4045.0 A	2582.0 C		4079.0 B	5014.0 A	2075.0 C	

*Means within each column followed by same letter are not significantly different at 0.05 probability level according to DMRT.
**Means with same letter are not significantly different at 0.05 probability level according to DMRT.

Table 5. Weeds' dry weight as affected by N timing and herbicides in wheat and oilseed rape.

weeds' dry weight (g m^{-2})								
	wheat				**Oilseed rape**			
Treatment	Herbicide	Control			Herbicide	Control		
Nitrogen	mesomax+udo soulfuron methyl sodium	Weedy	Weed free	Mean	mesomax+udo soulfuron methyl sodium	Weedy	Weed free	Mean
$T_1N_{1/2}$, $T_2N_{1/2}$, T_3N_0	269.3 de*	943.3 a	0.0 f	405.9 A	176.0 e	872.0 a	0.0 f	351.0 B
T_1N_0, T_2N_1, T_3N_0	371.6 cd	666.7 b	0.0 f	347.8 A	436.8 d	694.9 b	0.0 f	378.9 A
T_1N_0, T_2N_0, T_3N_0	217.0 e	422.5 c	0.0 f	214.8 B	121.6 f	448.0 c	0.0 f	191.5 C
Min	286.0 B**	677.5 A	0.0 C		144.8 B	671.6 A	0.0 C	

*Means within each column followed by same letter are not significantly different at 0.05 probability level according to DMRT.
**Means with same letter are not significantly different at 0.05 probability level according to DMRT.

Biological yield

Wheat and oilseed rape biological yield behaved in a very similar way to grain yield (Table 4). Presence of weeds in weedy checks improved biological yield 57% in wheat and 142% in oilseed rape. The lowest wheat and oilseed rape biological yield were recorded at weedy plots without nitrogen. As shown in (Table 4) N splitting treatments T_1N_0, T_2N_1, T_3N_0, had the highest biological yield in wheat and oilseed rape.

Total weeds dry weight

Aldrich (1984) reported the weeds dry weight measurement is a suitable indicator of their competitive ability. Herbicide application and N splitting affect the weed population in the field. Regarding the results weeds' dry weights shows the lowest amount in the plots without N (Table 5). Iqbal and Wright (1997), reported in wheat, N supply directly correlates with weed competition and their competitive ability. Najafi and Ghadiri (2011) accounted that addition of N increased the competitive ability of corn against weeds and resulted in higher grain yield.

The results showed herbicides reduced weeds biomass 58% and 78% in both wheat and oilseed rape respectively. Hassan (2003) and Khan (2004) regarded chemical control as a highly effective and economical weed control approach. These results are also similar to those of Jarwar et al. (2005), who reported that Puma Super 75EW (1250 ml ha^{-1}) as a chemical weed control caused 86.5 percent weed mortality in wheat crop.

CONCLUSIONS

It is generally accepted that integration of chemical strategy with cultural methods such as fertilizer splitting and crop rotation would be more effective in weed control. All in all, the results of present study indicates that when oilseed rape as a broad leave plant was in rotation with grasses like wheat, it showed tremendous potential to reduce grassy weeds populations and the amount of their seeds entering the soil seed bank.

Spring N application as top dressing prior to stem elongation can increase crop yield compared with all-fall application. As shown in this study when half of the N (152 kg urea ha^{-1}) fertilizer was applied at sowing stage of both wheat and oilseed rape and the other half was applied at tillering stage of wheat and the end of rosette stage of oil seed rape, grain yield increased as compared to when all N fertilizer was applied at tillering stage of wheat and the end of rosette stage of oilseed rape. Otherwise, weed biomass increased significantly when all N fertilizer was used at tillering stage of wheat and the end of rosette stage of oilseed rape. To sum up, chemical weed control must be matched with the split application of nitrogen fertilizer along with crop rotation in order to increase the crop yield more efficiently.

ACKNOWLEDGMENT

This project was funded by a grant from research council of Shiraz University, Shiraz, Iran.

REFERENCES

Alcoz M. M, Hons F. M, Haby V. A (1993). Nitrogen fertilization timing effect on wheat production, nitrogen uptake efficiency, and residual soil nitrogen. Agron. J. 85: 1198-1203.

Aldrich R. J (1984). Weed-crop Ecology-Principles in Weed Management. Breton publishers. North Scitutate, MA., 465 pp.

Amprong-Nyarko K, de Datta S. K (1993). Effects of nitrogen application on growth, nitrogen use efficiency and rice- weed interaction. Weed Res. 33:269-276.

Appleby A. P, Olson P. O, Colbert D. R (1976). Winter wheat yield reduction from interference by Italian ryegrass. Agron. J. 68:463-466.

Ball D. A, Miller S. D (1990). Weed seed population response to tillage and herbicide use in three irrigated cropping systems. Weed Sci. 38:511-517.

Beckie H. J, Hall L. M, Tardif F. J (2001). Herbicide resistance in Canada—where are we today? In: Blackshaw, R.E., Hall, L. M. (Eds.),Integrated Weed Management: Explore the Potential. Expert Committee on Weeds, Sainte-Anne-de-Bellevue, Quebec H9x 3R9, Canada, pp. 1–36.

Benech-Arnold R. L, Sá nchez R. A, Forcella F, Kruk B. C, Ghersa C. M (2000). Environmental control of dormancy in weed seed banks in soil. Field Crops Res. 67: 105–122.

Benech-Arnold R. L, Sánchez R. A (1995). Modeling weeds seed germination. In: Kigel, J., Galili, G. (Eds.), Seed Development and Germination. Marcel Dekker, New York, pp. 545–566.

Buchholz D. D, Schaeffer J. A (1990). Nitrogen rates and timing for winter wheat in Missouri. Missouri Soil Fertility Research Update Rep. No. 90-01. University of Missouri, Columbia.

Buhler D. D (1995). Influence of tillage systems on weed population dynamics and management in corn and soybean in central USA. Crop Sci. 35: 1247-1258.

Burnside O. C, Moomaw R. S, Roeth F. W, Wicks G. A, Wilson R. G (1986). Weed seed demise in soil in weed–free corn production across Nebraska. Weed Sci. 34:248-251.

Carlson H. L, Hill J. E (1985). Wild oat (*Avena fatua*) competition with spring wheat: effects of nitrogen fertilization. Weed Sci.34: 29-33.
Cavers P. B (1995). Seed banks: memory in siol. Can. J. Soil Sci. 75: 11-13.
Cheema M. S, Akhtar M (2005). Efficacy of different post emergence herbicides and their application methods in controlling weeds in wheat. Pak. J. Weed Sci. Res. 11: 23-29.
Clements D. R, Benoit D. L, Murphy S. D, Swanton C. J (1996). Tillage effects on weed seed return and seed bank composition. Weed Sci. 44: 314-322.
Dawit M, David S. E (1997). Weed and seed bank management with integrated methods as influenced by tillage. Weed Sci. 45: 706-715.
Dorado J, Del Monte J. P, Lopez-Fando C (1999). Weed seed bank response to crop rotation and tillage in semiarid agro ecosystems. Weed Sci. 47: 67-73.
Effects of Weeds on Wheat Alberta.ca > Agriculture and Rural Development online This information published to the web on June 21, 2001.Last Reviewed/Revised on June 20, 2006.
Forcella F, Durgan B. R (1997). Weed seed bank emergence across the corn Belt. Weed Sci. 45:67-76.
Foster, K. 1996. Organic Crop Production: Weed Management, Sustainable Production. Farm Facts, Saskatchewan Agriculture and Food Bulletin.
Froud-Williams R. J (1988). Changes in weed flora with different tillage and agronomic management systems. In: Altieri, M.A., Liebman, M. (Eds.), Weed Management in Agro ecosystems: Ecological Approaches. CRC Press, Inc., Boca Raton, FL, pp. 213–236.
Gantzer C. J, Anderson S. H, Thompson A. L, Brown J. R (1991). Evaluation of soil loss after 100 years of soil and crop management. Agron.J. 83:74–77.
Gruenhagen R. D, Nalewaja J. D (1969). Competition between flax and wild buckwheat. Weed Sci.17: 380-384.
Hashem A, Radosevich S. R, Roush M. L (1998). Effect of proximity factors on competition between winter wheat (*Triticum aestivum*) and Italian ray grass (*Lolium multiflorum*). Weed Sci. 46: 181-190.
Hashim S, Marwat K. B, Hassan G (2002). Response of wheat varieties to substituted urea herbicides. Pak. J. Weed Sci. Res. 8(1-2): 49-56.
Hassan G, Faiz B, Marwat K. B, Khan M (2003). Effect of planting methods and tank mixed herbicides on controlling grassy and broad leaf weeds and their effect on wheat cv. Fakhr-e -Sarhad. Pak. J. Weed Sci. Res. 9: 1-11.
Iqbal J, Wright D (1997). Effects of nitrogen supply on competition between wheat and three annual weed species. Weed Res. 37:391-400.
Jarwar A. D, Arain M. A, Rajput L. S (2005). Chemical weed control in wheat. Pak. J. Weed Sci. Res. 11(1-2): 11-15.
Kegode G. O, Forcella F, Clay S (1999). Influence of crop rotation, tillage, and management inputs on weed seed production. Weed Sci. 47: 175–183.
Khan I., Hassan G, Khan M. A., Khan M. I (2004). Efficacy of some new herbicides on both grassy and broad leaf weeds in wheat -II. Pak. J. Weed Sci. Res. 10(1-2): 33-38.
Large E. C (1954). Growth stages in cereals: Illustration of the feekes scale. Plant Pathol. 3:128-129.
Legere A, Stevenson F. C (2002). Residual effects of crops rotation and weed management on a wheat test crop and weeds. Weed Sci. 50:101-111.
Liebman M, Dyck E (1993). Crop rotation and intercropping strategies for weed management. Ecol. Appl. 3: 92–122.
Malone C. R (1967). A rapid method for enumeration of viable seeds in the soil. Weeds.15:381-382.
Mitchell C. C, Westerman R. L, Brown J. R, Peck T. R (1991). Overview of long term agronomic research. Agron. J. 83: 24–29.
Miyazawa K, Tsuji H, Yamagata M, Nakano H, Nakamato T (2004). Response of weed flora to combinations of reduced tillage, biocide application and fertilization practices in a 3-year crop rotation. Weed Biol. Manag. 4:24-34.
Mossedaq F, Smith D. H (1994). Timing nitrogen application to enhance spring-wheat yields in a Mediterranean climate. Agron. J. 86:221–226.
Najafi B, Ghadiri H (2011). Weed control and grain yield response to nitrogen management and herbicides. J. Biol. Environ. Sci (In press).
Parejae M. R, Staniforth D. W, Pareja G. P (1985). Distribution of weed seed among soil structural units. Weed Sci. 33:182-189.
Peterson D. E, Nalewaja J. D (1992). Environment influences green foxtail (*Setaria viridis*) competition with wheat (*Triticum aestivum*).Weed Thecnol. 6:606-610.
Schellhorn N. A, Sork V. L (1997). The impact of weed diversity on insect population dynamics and crop yield in collards, Brassica oleracea (Brassicaceae). Oecologia. 111: 223-240.
Schweizer E. E, Zimdahl R. L (1984). Weed seed decline in irrigated soil after six years of continuous corn (*Zea mays*) and herbicides. Weed Sci. 32:76-83.
Stockdale E. A, Gaunt J. L, Vos J (1997). Soil–plant nitrogen dynamics: What concepts are required? Eur. J. Agron. 7:145–159.
Swanton C. J, Murphy S. D (1996). Weed science beyond the weeds: the role of integrated weed management (IWM) in agro ecosystems health. Weed Sci. 44:437-445.
Valenti S. A, Wicks G. A (1992). Influence of nitrogen rates and wheat (*Triticum aestivum*) cultivars on weed control. Weed Sci**.** 40:115-121.
Vanasse A, Lerpous G. D (2000). Floristic diversity, size and vertical distribution of the weed seed bank in ridge and conventional tillage systems. Weed Sci. 48:454-460.
Vencill W. K, Banks P. A (1994). Effects of tillage systems and weed management on weed populations in grain sorghum (*Sorghum bicolor*). Weed Science. 42: 541-542..
Yenish J. P, Doll J. D, Buhler D. D (1992). Effects of tillage on vertical distribution and viability of weed seed in soil. Weed Sci. 40:429-433.
Zanin G, Berti A, Riello L (1998). Incorporation of weed spatial variability in to the weed control decision-making process. Weed Res.38:101-118.
Zaremohazabieh S, Ghadiri H (2011). Effects of rimsulfuron, foramsulfuron and conventional herbicides on weed control and maize yield at three planting dates. J. Biol. Environ. Sci. 5 (14): 47-56.