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Effect of Sowing Rates and Weed Control Methods on Winter Wheat under Mediterranean Environment

Munir, A. Turk and Abdel Rahman, M. Tawaha
Department of Crop Production, Faculty of Agriculture,
Jordan University of Science and Technology (JUST), P. O. Box 3030, Irbid, 22110 Jordan

Abstract: Field experiments were conducted during the two growing seasons of 1999/2000 and 2000/ 2001 in northern Jordan to detect the influence of varying seeding rates and weed control methods on yield, yield components, and phenological traits of irrigated winter wheat. Seeding rate of 140 kg ha^{-1} produced the maximum grain yield ha^{-1}. At this density, it also exhibited the lowest spikes plant^{-1}, grains spike^{-1} and thousand grains weight. Whereas at the density of 100 kg ha^{-1}, a minimum yield of 1882.5 kg ha^{-1} was obtained owing the lesser number of plant per unit area. Weed control methods hand significant effect on yield, yield components, and phenological traits. Hand weeding provided the better weed control 2,4-D application at stage 22-28 (2-8 tillers detectable) also produced significantly higher grain yield as compared to unsprayed control. The only weed control treatments, that reduced wheat yield was 2,4-D applied at stage 43 (mid boot stage, flag leaf sheath just visible swollen).

Key words: Winter wheat, 2,4-D, seeding rates, weed control, hand weeding , BBCH.

Introduction

Wheat is grown under rainfed conditions in the north of Jordan, where limited precipitation restricts the yield. Due to the erratic and low rainfall, supplemental irrigation is potential solution to increase wheat production. Supplemental irrigation is addition for irrigation water to a certain crop in addition to the rainfall amount during the growing season distributed a cording to the plant needs in order to give the plant its water requirements to increase and sustain the productivity per unit area. Wheat production under a particular set of environmental conditions is influenced by various agronomic factors (Gontia and Joshi, 2000). Among these, seeding rate and weed control which are the deciding factors for canopy architecture, light interception and consequently for modifications of yield components and finally yield (Turk and Tawaha, 2001). Successful management of annual weeds in winter wheat with herbicides often depends on the relative competitiveness of the crop with weeds early in the spring and on proper timing of the herbicide application. The ability of winter wheat to compete with annual weeds in the spring in part depends on wheat plant population, planting date, winter survival, soil moisture and soil fertility (Ross and Harper, 1972; Kirkland, 1993; Jaradat, 1988; McDonald, 1990). High seeding rates may result in an earlier competitive advantage over weeds compared with lower seeding rates (Ross and Harper, 1972; Kirkland, 1993). In Jordan, most of the wheat and barley plantings are done by hand - broadcasting followed by one pass of a disc harrow, which incorporates seeds to variable depths. This compensates for such losses, farmers generally apply seed at higher rates when broadcasting compared to those used with a drill. In many cases, only the roughest approximations of weight and land areas are used. However, the little research done using different seeding rates has been with a drill and has suggested that there was no difference between 80 and 120-kg seed ha^{-1} (Jaradat, 1988). Higher seeding rates, accelerate phenological traits, such as days to flag extension, heading, grain filling and maturity (Fukai *et al.*, 1990; Dofing and Knight, 1992; Henson and Lukach, 1992), and are associated with higher tiller and spike numbers m^{-2}, but lower tillers and spikes number plant^{-1} (Mcloed, 1982; Fukai *et al.*, 1990; McDonald, 1990; Dofing and Knight, 1992). Grains number spike^{-1} was found to decrease at higher seeding rates (Mcloed, 1982; Dofing and Knight, 1992). Phenoxy herbicides have been used for broadleaf weed control in wheat since late 1940s, however, their misapplication can reduce yield (Klingman and Ashton, 1982; Swan, 1975). Wheat is susceptible to phenoxy herbicide injury from emergence to the four-leaf stage and from jointing to the soft dough stage of growth (Coupland, 1950; Friesen, 1950; Martin *et al.*, 1989; Martin *et al.*, 1990). Phenoxy herbicide application at these stages can reduce plant height, delay maturity, and reduce grain yield (Klingman and Ashton, 1982). Plants treated with 2,4-D often exhibit malformed leaves, stems, and roots, 2,4-D affects plant metabolism by stimulating nucleic and protein synthesis which affects the activity of enzymes, respiration, and cell division (EPA, 1988). Often cells in the phloem of treated plants are crushed or plugged, interfering with normal food transport (Mullison, 1987) which can leave parts of the plant malnourished or possibly lead to death. Weed problems in rainfed wheat should not be the same as in irrigated wheat, and weed response to commonly used rainfed wheat herbicide is well known. There is, however little information on irrigated wheat tolerance of herbicides. The objective of this research was to study the influence of various seeding rates and weed control methods on yield components and productivity of irrigated winter wheat.

Materials and Methods

Field experiments were conducted in 1999/2000 and 2000/ 2001 growing seasons, at the semi arid region in the North of Jordan under irrigation. The location has a Mediterranean type climate of mild rainy winters and dry hot summers. The experimental field received granular fertilizers DAP (diammonium phosphate 18 % N and 46 % P_2O_5) at rate of 100-kg ha^{-1}, which was applied and mixed with soil prior to planting. Split plot designs with three replications were used in both years. The seeding rates (100, 120 and 140 kg ha^{-1}) were randomly assigned to the main plots in each replicate. Weed control methods were randomly assigned to each rate plot, representing the sub plot treatments. The test crop was a winter wheat cv. H. 27. Each sub plot consisted of four rows, 30 cm apart and 2 m in length. The seeds were sown by hand on Nov. 7, 1999 and Nov. 8, 2000. The alleys between replicates were 1m wide. The dominant broad leaf weed species were, *Cardaria draba* L., *Diplotaxis erucoides* L., *Molucclla laevis* L. *and Brasica nigra* L. Weed control treatments were weed check (untreated), hand – weeding (practiced monthly during the growing season) and 2, 4-D (2, 4- Dichlorophenoxy acetic acid) ester which was applied at a rate of 480 g ha^{-1} (a. I), at two growth stages. The herbicides were applied with a mounted sprayer equipped with a fan-type nozzle. Plots were evaluated visually on a 0 to 100 scale where 0 = no injury and 100 = plant death to estimate wheat injury 21 days after the treatment. The wheat growth stages were identified using the BBCH code. The wheat growth stages and herbicide application dates were stage 22-28 (2-8 tillers detectable), Jan. 20, 1999, and Jan. 24, 2000, and stage 43 (mid boot stage, flag leaf sheath just visible swollen), Feb. 15, 1999 and Feb. 27, 2000. Measurements recorded each year include grain yield (kg ha^{-1}), grain weight plant^{-1}, 1000 grains weight (g), grains spike^{-1}, spike length (cm), spikes plant^{-1}, and plant height (cm). Before harvest, weed number and fresh above ground biomass were determined in four 0.25 of 0.25 of m^{-2} random quadrates per plot. The weed control efficiency (WCE) was calculated by the following formula of Singh *et al.* (2000).

$$WCE = \frac{\text{Dry matter of weeds in unweeded plot} - \text{Dry matter of weed in treatment}}{\text{Dry matter of weeds in unweeded plot}} \times 100$$

Wheat plants were harvested at mature stage during June 27, and June 26, in 1999 and 2000 growing seasons, respectively. From the three central rows of each plot, the plants of one m^2 quadrate were clipped at 10 cm above the soil surface by hand sickle. The MSTAT-C program was used for statistical analysis. Data for each trait were analyzed for a randomized complete block design (RCBD) with split –plot arrangement according to the procedure outlined by Steel and Torrie (1980). Comparisons between means were made using least significant differences (LSD) at 0.05 probability level.

Results and Discussion

No significant interaction between seasons was detected, probably due to irrigation being used. The main source of yield variation in the Mediterranean region is variation in rainfall.

Therefore, the present results are the means across two growing seasons. Interaction effects of seeding rates and weed control methods were, also, not significant in respect of different variables. Stage 22-28 (2-8 tillers detectable) and stage 43 (mid boot stage, flag leaf sheath just visible swollen) were susceptible to 2, 4-D visible injury (Table 1). Mid boot treatment (stage 43) caused more visible injury than stage 22-28 treatment. The results are in accordance with those of Martin *et al.* (1990).

Seeding rate: Seeding rate had a significant effect on all variables measured in both seasons. Grain weight plant^{-1}, 1000-grains weight, plant height, grains number spike^{-1}, spike length and fertile tillers plant^{-1} were negatively related to seeding rate.

As for grain weight per plant, it tended to decrease with the increase in seeding rate (Table 2). The lowest seeding rate of 100 kg ha^{-1} produced the maximum grains weight plant^{-1} (4.9 g) and vice versa. This might be attributed to a higher spikes plant $^{-1}$ (5.1), longer spikes (7.0 cm), more grains spike^{-1} (54.8) and heavier thousand grains weight (40.3 g). Reduction in wheat grain weights have been associated with increasing seeding rates by Dofing and Knight (1992). The highest (5.1) and the lowest (3.8) number of spikes plant $^{-1}$ were recorded under 100 and 140 kg ha^{-1}, respectively. The decrease in spikes number plant^{-1} in 140 kg ha^{-1} was attributed to an increased competition among plants for growth factors, which finally reduced the number of effective tillers. Reduction of tillering by increasing seeding rate has been reported previously (McDonald, 1990).

On the other hand, plants density (spikes m^{-2}) and grain yield were directly related to seeding rate. Grain yields increased as seeding rates increased, with highest yields being obtained at 140kg ha^{-1}. The yield increase observed with increase in seeding rate is a function of more spikes being produced as a result of more plants being established. The influence of seeding rate on grain yield was through the increased production of spikes per unit area (Table 2). However, not through the increased production of fertile tillers per plant. This explains why maintaining adequate plant populations is important for maximizing grain yield, given the low number of spikes produced, on average, per plant. High seeding rates promoted phenological development, in which flag leaf extension and heading occurred 5 days earlier in the high seeding rate (140kg ha^{-1}) than in the low (100kg ha^{-1}) (data not presented). Finlay *et al.* (1971) also found that plant from a low seeding rate headed significantly latter than those from higher seeding rates. No significant differences in number of weeds m^{-2} were recorded between various seeding rates. On the other hand, differences in weed fresh weights were significantly among the various seeding rates (Table 3). In particular, increasing seeding rate decreased the weights of weed (71.5g m^{-2}) obtained at seeding rate 140 kg ha^{-1}. However decreasing the seeding rate to 100kg ha^{-1} increased the weight of weed (150.5g m^{-2}).

Weed control methods: Weed control methods had significant effect on yield, yield components, and phenological traits. Hand weeding provided the better weed control as it gave higher wheat yield. 2,4-D application at stage 22-28 (2-8 tillers detectable) also produced significantly higher grain yields as compared to unsprayed control. The increase in grain yield with hand weeding or with 2,4-D application at stage 22-28 (2-8 tillers detectable) was mainly due to their effective control of weeds by reducing dry matter of weeds and weed intensity which resulted in more spikes m^{-2}, spikes plant^{-1}, and grains spike^{-1} and finally higher grain yield. The only weed control method, that reduced the wheat yield was 2,4-D applied at stage 43 (mid boot stage, flag leaf sheath just visible swollen). Yield reduction in response to 2,4-D

Table 1: Irrigated winter wheat injury as affected by seeding rates and weed control methods

Weed control methods	Seeding rate (kg ha^{-1})		
	100	120	140
Control	0	0	0
Hand weeding	0	0	0
2,4-D at stage 22-28	3	6	10
2,4-D at stage 43	16	22	29

*Data statistically not analyzed

Table 2: Yield and yield components for irrigated winter wheat as affected by seeding rates and weed control methods.

Treatments	Grain yield (kg ha^{-1})	Grain weight plant^{-1} (g)	1000 grain weight (g)	Grains spike^{-1}	Spikes m^{-2}	Spikes plant^{-1}
Seeding rate (kg ha^{-1})						
100	1882.5 c	4.9 a	40.3a	54.8 a	428.0 c	5.1 a
120	1959.3 b	4.6 b	37.3 b	52.0 b	446.0 b	4.2 b
140	2190.5 a	4.2 c	35.8 c	48.0 c	498.0 a	3.8 c
LSD(0.05)	70.0	0.3	1.3	2.5	17.0	0.4
Weed control methods						
Control	1976.3 c	4.4 c	37.3 ab	49.3 bc	428.0 cd	4.2 b
Hand weeding	2123.0 a	5.2 a	37.7 ab	59.3 a	428.0 a	4.7 a
2,4-D at stage 22-28	2050.0 b	4.8 b	38.0 a	49.7 b	465.0 b	4.5 ab
2,4-D at stage 43	1893.3 d	3.8 d	38.0 a	47.3 c	431.0 c	3.7 c
LSD (0.05)	68.0	0.5	1.3	3.0	14.0	0.3
Interaction	NS	NS	NS	NS	NS	NS

Means in each column followed by same letters are not significantly different according to LSD ($P \leq 0.05$). NS = Non Significant

Table 3: Phenological traits, number and weight of weeds for irrigated winter wheat as affected by seeding rates and weed control methods.

Treatments	Plant height (cm)	Spike length (cm)	Weight of weeds (g)	Number of weeds	*Weed control efficiency (%)
Seeding rate (kg ha^{-1})					
100	78.0 a	7.0 a	150.5 a	18.8 a	-
120	73.5 b	6.3 b	102.0 b	15.8 b	-
140	69.3 c	5.6 c	71.5 c	14.3 bc	-
LSD(0.05)	4.1	0.6	18.1	3.0	-
Weed control methods					
Control	72.7 bc	6.2 bc	318.3 a	26.0 a	-
Hand weeding	79.0 a	6.9 a	13.0 d	1.3 d	95.9
2,4-D at stage 22-28	74.3 b	6.5 b	46.7 c	16.3 c	85.3
2,4-D at stage 43	68.3 c	5.6 c	58.3 b	21.3 b	81.7
LSD (0.05)	3.0	0.4	11.0	4.0	-
Interaction	NS	NS	NS	NS	-

Means in each column followed by same letters are not significantly different according to LSD ($P \leq 0.05$). * Data statistically not analyzed.
NS = Non Significant

application at stage 43 was closely related to reduction in spikes m^{-2} and spike length.

Similar effect of herbicide treatment was also reported by Martin *et al.* (1989), who found that herbicide treatment applied after growth stage 40 (booting) generally injure winter wheat. Differences in weed number and fresh weights were significant among various weed control methods (Table 3). Hand weeding proved significantly superior than control treatment. It reduced the weed number and fresh weight of weeds than control treatments. In addition, hand - weeded treatment was more effective than 2,4-D applications in suppressing weed growth. On the basis of average of two years, the weed control efficiency ranged from 81.7 to 95.9 Maximum weed control efficiency of 95.9 was recorded with the hand weeding, whereas it was 85.3 in respect to 2,4- D application at 22-28 (2-8 tillers detectable)-growth stage. Minimum weed control efficiency was recorded with the application of 2,4 -D applied at 43-growth stage during both growing seasons.

Under the conditions that prevailed in this study. The highest yields were generally achieved with the highest seeding rates and hand weeding treatment. The lowest yields generally achieved with the lowest seeding rates and 2, 4-D application at stage 43 (mid boot stage, flag leaf sheath just visible swollen). Higher rather than lower seeding rates are recommended because they allow for greater crop competition against weeds. Hand weeding, which is practiced by traditional farmers, proved to be superior when compared with 2,4-D, irrespective of stage of application.

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