ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Agronomy 2 (2): 101-108, 20003
ISSN 1680-8207

The Response of Awnless Six Row Barley (*Hordeum vulgare* L.) To Nitrogen Fertilizer Application and Weed Control Methods in the Absence of Moisture Stress

M.A. Turk, A.M. Tawaha, N. Samarah and N. Allataifeh
Department of Plant Science, Faculty of agricultural and Environmental Sciences, McGill University, Macdonald Campous, 21,111 Lakeshore, Ste-Anne-de-Bellevue, Quebec, Canada H9x 3v9

Abstract: Field experiments were conducted to detect the influence of varying N rates and weed control methods and 2, 4-D ester which was applied at two growth stages on yield, yield components, and phenological traits of barley. Among N rates significantly highest grain yield (2112.5 kg ha^{-1}) was obtained under 120 kg N ha^{-1} owing to the highest numbers of spikes m^{-2} (537.5), spike length (7.5 cm), and number of grains per spike (56.3) though it had the lowest 1000 seed weight. Hand weeding provided the better weed control method and this was reflected in higher barley yield. Application of 2,4-D at stage 22-28 also produced significantly higher grain yield as compared to unsprayed control. The only weed control treatments, that reduced barley yield when 2,4-D was applied at mid boot stage.

Key words: Barley, 2,4-D, N rates, hand weeding, BBCH

Introduction

Barley (***Hordeum vulgare*** L.) is the most widely grown cereal crop in Jordan and other West Asian countries. The barley-based farming system exists in wide areas along the dry margins (200-300 mm rainfall per year) of cultivation in Syria, Jordan and Iraq (Jaradat and Haddad, 1994). It is grown mainly as feed for livestock. Due to the erratic and low rainfall, supplemental irrigation is potential solution to increase barley production. Supplemental irrigation is addition for irrigation water to a certain crop in addition to the rainfall amount during the growing season distributed according to the plant needs in order to give the plant its water requirements to increase and sustain productivity per unit area. Barley production under a particular set of environmental conditions is influenced by various agronomic factors. Among these, N 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, 1998; Turk and Tawaha, 2001; Tawaha ***et al.***, 2002). Very little of the rainfed barley crop currently receive fertilizer. Farmers realized that rainfall is the main limiting factor, and fertilizer is likely to be ineffective if not counterproductive. On the contrary, many researchers have shown that barley responded to relatively high fertilizer levels, whether under irrigated or dry farming conditions. Stanberry and Lowery (1965) showed that barley production was increased with the addition of up to 135 kg ha^{-1} of N, when they used 1010 mm water, but under limited moisture (470 mm) the response was only up to 65 kg ha^{-1} of N. On the other hand, Luebs and Laag (1967) pointed out that the yield of barley was reduced when a high amount of nitrogen was used under high water tension. Dwiredi ***et al.*** (1989) showed that increasing nitrogen up to 80-kg ha^{-1} increased the number of tillers, spike length, and grain yield. Successful management of annual weeds in barley 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 barley to compete with annual weeds in the spring in part depends on barley plant population, planting date, winter survival, soil moisture, and soil fertility (Ross and Harper, 1972; Kirkland, 1993; Jaradat, 1988; Mcdonald, 1990, Tawaha ***et al.***, 2002). Weeds are prime users of soil moisture. Winter annual weeds are of most concern in rainfed farming areas of Jordan because their growth requirements, physiology and seed production are similar to those of wheat and barley. Both broad leaved and grassy weeds cause losses in soil moisture and, consequently, crop yields (Klingman and Ashton, 1982). Although it was estimated that weeds problem could reduce wheat yield by 30-80% (Duwayri and Saghir, 1983), very limited research has been done on weed control, especially in the rainfed areas of the country.

Until 20 years ago, weed control in Jordanian rainfed Agriculture was limited to mechanical and cultural methods. With the advent of herbicides, however, chemical weed control became possible and resulted in better weed control and increased crop yields (Tamimi, 1981; Duwayri and Saghir, 1983). Hand weeding used to be one of the mechanical methods for weed control, however, this practice was abandoned because it was no longer economical. Chemical weed control of broadleaved weeds in Jordan dates back to the early 1970s. The herbicide 2,4-D was the first to be introduced into Jordan rainfed areas for the control of broadleaved weeds (Goetze, 1976; Qasim, 1982). In Jordan 2,4-D used for the control of broad leaf weed in cereal has not changed however, and growers still use 2,4-D and other similar products. Early research with winter wheat cultivars identified the safest rate and time for application of this herbicide as at the 2 leaf stage (Olsen ***et al.***, 1951; Klingman, 1953; Robinson and Fenster, 1973). Crop safety of 2,4-D on the newer cultivars grown in Jordan has not been evaluated and growers have reported injury to barley crops when recommended herbicides have been used. Growers like to apply the 2,4-D in the mid boot stage to control emerged spring annual weeds. Some growers would also like to apply the 2,4-D in the 3 leaf stage to control emerged winter annual weeds. This would prevent these weeds from becoming a serious problem which may happen if the 2,4-D is applied in the mid boot.

Phenoxy herbicides have been used for broadleaf weed control in wheat since the late 1940, 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 grains yield due to inhibitance of cell division and growth in the meristematic regions (Klingman and Ashton, 1982). Plants treated with 2,4-D often exhibit malformed leaves, stems, and roots as 2,4-D affects plant metabolism by stimulating nucleic and protein syntheses which affects the activity of enzymes, respiration, and cell division (Anonymous, 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 barley should be the same as in wheat, and weed response to commonly used wheat herbicide is well known. There is, however little information on barley tolerance of herbicides. The objective of this research was to study the influence of various N rates and 2,4-D application on yield components and productivity of irrigated barley.

Materials and Methods

Field experiments were conducted in the 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 overall climatic conditions of the site are typical Mediterranean weather with average monthly temperature ranging from 3°C in January to 34°C in August (Jaradat, 1988). Respective values for nitrate-N were 2.7 and 2.1 ppm. According to criteria for dry land soils in the region (Ryan and Matar, 1990) soils were deficient in N and barley is likely to respond to fertilizer application. As a standard procedure for such trials, and inline with farmer's practice, the site was tilled with a disc harrow. As P was not a variable, triple super phosphate was added at 40 Kg P_2O_5 ha^{-1}. Nitrogen was applied as urea (46% N) half at the time of sowing and the other half was applied at onset of stem elongation (appearance of terminal spike). Split plot designs with three replications were used in both years. The N rates (40, 80, and 120 kg N 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 six-row awnless barley cv. JF// Barssoy/Ri. Each sub plot consisted four rows, 30 cm apart and 2 m in length. The seed were sown by hand on the 5th Nov. 1999 and 5th Nov. 2000.The alleys between replicates were 1 m 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 B 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 by a fan-type nozzle. Plots were evaluated visually on a 0 to 100 scale where 0 = no injury and 100 = plant death to estimate barley injury 21 days after the treatment. The barley growth stages were identified using the BBCH (BASF- Bayer- Ciba-Geigy-Hoechst) code. The barley growth stages and herbicide application dates were stage 22-28 (2-8 tillers detectable), Jan. 21, 1999, and Jan. 23, 2000, and stage 43 (mid boot stage, flag leaf sheath just visible swollen), Feb. 16, 1999 and Feb. 20, 2000. Measurements recorded each year include grain yield (kg ha^{-1}), grain weight $plant^{-1}$, 1000 grain 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 using the following formula, as reported by Singh ***et al.*** (2000).

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

Barley plants were harvested at maturity stage during 26 and 27th June in 1999 and 2000 growing seasons, respectively. From the three central rows of each plots, 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 Bplot arrangement according to 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

Non 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 presented results are means across the two growing seasons. Interaction effects of N 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).

Nitrogen Effect

Nitrogen application had a significant effect on all variables measured.

Grain yield, grain weight spike^{-1}, grain number spike^{-1}, spike length, spikes plant^{-1}, spikes m^{-2} and plant height were increased by N application, while the 1000 grain weight was decreased. Among various N levels, 120 kg N ha^{-1}, significantly out yielded (5.4 g plant^{-1} and 2112.5 kg ha^{-1}) other levels (40 and 80 kg N ha^{-1}), owing to the highest number of spikes plant^{-1} (4.8), spike length (7.5 cm) and grains spike^{-1} (56.3) though it had the lowest thousand grain weight (34.6 g) (Table 2 and 3). Several researchers have found that an increase in nitrogen

Table 1: Barley injury as affected by N rates and weed control methods in the absence of moisture stress

	N rate Kg ha^{-1}		
Weed control methods	40	80	120
Control	0	0	0
Hand weeding	0	0	0
2,4-D at stage 22-28	2	3	3
2,4-D at stage 43	25	26	26

*Data statistically not analyzed

Table 2: Yield and yield components for awnless six row barley as affected by N rates and weed control methods in the absence of moisture stress

N rate (kg ha^{-1})	Grain yield (kg ha^{-1})	Grain weight plant^{-1} (g)	100 grain weight (g)	Grains spike^{-1}	Spike m^{-2}	Spikes plant^{-1}
40	1800.0	4.3	41.1	47.8	425.0	3.7
80	1943.8	4.9	37.3	52.5	502.5	4.1
120	2112.5	5.4	34.6	56.3	537.5	4.8
LSD(0.05)	69.0	0.5	1.9	2.1	32.0	0.4
Weed control methods						
Control	1950.0	5.0	37.8	51.7	490.0	4.4
Hand weeding	2066.7	5.9	40.2	59.3	523.3	4.8
2,4-D at stage 22-28	1988.3	5.1	38.5	52.7	486.7	4.4
2,4-D at stage 43	1803.3	3.5	34.1	45.0	453.3	3.3
LSD (0.05)	37.0	0.6	1.6	2.0	15	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# 0.05). NS= non-significant

Table 3: Phenological traits, number and weight of weeds for awnless six row barley as affected by N rates and weed control methods in the absence of moisture stress

N rate (kg ha^{-1})	Plant height (cm)	Spike length (cm)	Weight of weeds (g)	Number of Weeds	*Weeds control efficiency (%)
40	64.3	6.4	84.0	29.5	-
80	70.3	7.0	100.4	33.5	-
120	75.5	7.5	114.2	37.5	-
LSD(0.05)	4.7	0.4	9.8	3.0	-
Weed control methods					
Control	70.0	6.9	286.7	34.3	-
Hand weeding	75.7	7.6	1.5	1.0	99.0
2,4-D at stage 22-28	69.0	6.9	53.3	43.7	81.4
2,4-D at stage 43	65.3	6.3	56.7	55.0	80.0
LSD (0.05)	3.3	0.5	5.0	5.0	
Interaction	NS	NS	NS	NS	-

Means in each column followed by same letters are not significantly different according to LSD (P# 0.05). * Data statistically not analyzed, NS= non-significant

application generally increases the grain number spike^{-1} (Turk and AL-Jamali, 1998), spike length (Abd EL-Latif and Salamah, 1982), fertile tillers plant^{-1} (Turk and AL-Jamali, 1998), spike number m^{-2} (Lauer and Partridge, 1990), plant height (Abd EL-Latif and Salamah, 1982), and reduces the 1000 grain weight (Needham and Boyed, 1976).

Nitrogen had a significant effect on grain yield (Table 2). The increase in yield was directly related to more spikes being produced per plant, longer spikes and higher number of grains per spike (Table 2).

Nitrogen fertilizer prolonged the vegetative growing period of irrigated barley and consequently delayed its date of heading. Such a delay was intensified as higher rates of N were applied. The addition of 120 kg N ha^{-1} delayed the information of the first head by 7 days over the control (Data not shown). These results are in agreement with previous findings (Tisdale and Nelson, 1975). The heavier weight of weed was recorded when fertilizer was applied in higher rates, while the main effect of N rate was non significant for number of weeds plants.

Weed control methods

Weed control methods had significant effect on yield, yield components, and phenological traits. Hand weeding provided the better weed control method and this was reflected in higher barley 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 the 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 barley yield when 2,4-D was applied at stage 43 (mid boot stage, flag leaf sheath just visible swollen). Yield reductions in response to 2,4-D application at stage 43 were closely related to reductions in spike 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 barley. Differences in weed number and fresh weights were significant among the various weed control methods (Table 3). Hand weeding proved significantly superior to 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 80.0 to 99.0 Maximum weed control efficiency of 99.0 was recorded with the hand weeding, whereas it was 81.4 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 N rates and hand weeding treatment. The lowest yields generally achieved with the lowest N rates and 2, 4-D application at stage 43 (mid boot stage, flag leaf sheath just visible swollen). Hand weeding, which is practiced by traditional farmers, proved to be superior when compared to 2,4-D, irrespective to stage of application

References

Abd EL-Latif, L.I. and G.D. Salamah, 1982. Response of barley to levels of nitrogen and phosphorus under sandi soil conditions. Annual Agric. Sci. Moshtoho, 18: 37-45.

Anonymous, 1988. Pesticide fate sheet Number, 942. September 1988.

Coupland, R.T., 1950. Effect of 2,4-D on spring wheat. Res. Rep. North Cent. Weed Control Conf., 8: 58.

Duwayri, M. and A.R. Saghir, 1983. Effect of herbicides on weeds and winter cereals in Jordan. Dirasat, 10: 115-128.

Dwiredi, D.P., H. Pal and M. Kumar, 1989. Response of barley varieties to nitrogen under irrigated conditions. Ind. J. Agron., 42: 189-195.

Friesen, H.A., 1950. Effect on 2,4-D on spring wheat. Res. Rep. North Cent. Weed Control Conf., 7: 73.

Goetze, N., 1976. Jordan Wheat Research and Production. Final Report. USAID/ OSU, pp: 206

Jaradat, A.A., 1988. An Assessment of Research Needs and Priorities for Rainfed Agriculture in Jordan. Al-Hurria, Press. Irbid, Jordan, pp: 17-64

Jaradat, A.A. and N.I. Haddad, 1994. Analysis and interpretation of Mashreq project finding (1990-1992). Special report: Increased productivity of barley, pasture and sheep (RAB/ 98/ 026). ICARDA, West Asia Regional Program, Amman, Jordan.

Kirkland, K.J., 1993. Weed management in spring barley (***Hordeum vulgare***) in the absence of herbicide. J. Sust. Agric., 3: 95-104.

Klingman, G.L., 1953. Effect of varying rates of 2,4-D and 2,4,5-T at different stages on growth of winter wheat. Agron. J., 45: 606-610.

Klingman, G.L. and F.M. Ashton, 1982. AWeed science: Principles and Practices@. John Wiley and Sons, Inc., New York.

Lauear, J.G. and J.R. Partridge, 1990. Planting date and nitrogen rate effect on spring malting barley. Agron. J., 82: 1083-1086.

Luebs, R.E. and A.E. Laag, 1967. Nitrogen effect on leaf area, yield and nitrogen uptake of barley under moisture stress. Agron. J., 59: 219-22.

Martin, M.H., S.D. Miller and H.P. Alley, 1989. Winter wheat response to herbicide applied at three growth stages. Weed Technol., 3: 90-94.

Martin, M.H., S.D. Miller and H.P. Alley, 1990. Spring wheat response to herbicide applied at three growth stages. Agron. J., 82: 95-97.

Mcdonald, G.K., 1990. The growth and yield of uniculum and tillered barley over a range of seeding rates. Aust. J. Agric. Res., 41: 449-461.

Mullison, W.R., 1987. Environmental fate of Phenoxy herbicides. A In Fate of Pesticides in the Environment. Biggar. James W. and James N. Seiber. Eds. Agricultural Experimental Station, Division of Agricultural and Natural Resources, University of California, Publication, 3320-1987.

Needham, P. and D.A. Boyed, 1976. Nitrogen requirements of cereals. 2. Multi-level nitrogen test with spring barley in southwestern England. J. Agric. Sci., 87: 163-170.

Olsen, P.J., S. Zalik, W.J. Breakley and D.A. Brown, 1951. Sensitivity of wheat and barley at different stages of growth to treatment with 2,4-D. Agron. J., 43: 77-83.

Qasim, J.R., 1982. The Competitive and Allelopathic Effects and Chemical Control of Syrian Sage (***Salvia syriaca*** L.) in Wheat. M.Sc. Thesis, University of Jordan, Amman, Jordan.

Ryan, J. and A. Matar, 1990. Soil test Calibration in West Asia and North Africa. Proceedings of the third Regional Workshop. 3-9 September Regional Workshop. 3-9. September 1988, ICARDA. Aleppo, Syria.

Robinson, L.R. and C.R. Fenester, 1973. Winter wheat response to herbicide applied postemergence. Agron. J., 65: 749-751.

Ross, M.A. and J.L. Harper, 1972. Occupation of biological space during seedling establishment. J. Ecol., 60: 77-88.

Singh, T.L., S. Brar and U.S. Walla, 2000. Comparative efficiency of herbicides for weed control in chickpea (***Cicer arietinum*** L.). Crop. Res., 19: 1-5.

Stanberry, C.O. and M.L. Lowery, 1965. Barley production under various nitrogen and moisture levels. Agron. J., 57: 31-34.

Steel, R.G.D. and J.H. Torrie, 1980. A Principles and Procedures of Statistics. @ Mc Graw-Hill Book Company, U.S.A.

Swan, D.G., 1975. Necessity for proper timing of applications of 2,4-D to winter wheat. Down Earth, 13: 23-25.

Tamimi, S., 1981. A brief review of research on rainfed agriculture. FAO. Baghdad, Iraq.

Tawaha, A.M., M.A. Turk and G.A. Maghaireh, 2002. Response of barley to herbicide versus mechanical weed control under semi-arid conditions. Agron and Crop Sci., 18: 106-112.

Tisdale, S.L. and Nelson, 1975. Soil fertility and Fertilizers. 3rd Ed. Macmillan, New York, USA.

Turk, M.A. and A.F. AL-Jamali, 1998. Effect of varying nitrogen supplies at different stage on yield and yield components of barley in semi-arid conditions. Crop. Res., 15: 11-20.

Turk, M.A., 1998. Effect of nitrogen and phosphorus levels on barley cultivars grown in semi-arid conditions. Agron and Crop Sci., 18: 257-262.

Turk, M.A. and A.M. Tawaha, 2001. Wheat response to 2,4-D application at two growths stages Acta Agron., 49: 387-391.