Pak. J. Agri. Sci., Vol. 46(4), 2009
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

WEED DENSITY AND GRAIN YIELD OF WHEAT AS AFFECTED BY SPATIAL ARRANGEMENTS AND WEEDING TECHNIQUES UNDER RAINFED CONDITIONS OF POTHOWAR

Syed Haider Abbas[1], Muhammad Saleem[1]*, Muhammad Maqsood[2], M. Yaqub Mujahid[1], Mahmood-ul-Hassan[3] and Rashid Saleem[4]
[1]Wheat Programme, National Agricultural Research Centre, Islamabad
[2]Deptartment of Agronomy, University of Agriculture, Faisalabad
[3]Mutation Breeding Division, Nuclear Institute for Agriculture & Biology, Faisalabad
[4]Crop Sciences Institute, National Agricultural Research Centre, Islamabad
*Corresponding author's e-mail: drsaleemyousaf@gmail.com, mhj407jb@yahoo.com

A field trial was conducted at the Experimental Farms of Pir Meher Ali Shah Agriculture University, Rawalpindi during Rabi season, 2004 to study the effect of spatial arrangements and weeding techniques on weeds and yield of wheat. The experiment was laid out in randomized complete block design with two factors under split plot arrangement having three replications. The spatial arrangements were comprised of 15 cm, 22.5 cm and 30 cm apart rows and there were six weeding techniques viz. weeding check was included for comparison, hand weeding (weed free), chemical control (by application of Buctril Super @ 750 ml ha^{-1}), bar-harrow 2–way, hoe and barharow 1-way. Hand weeding and chemical control with different spatial combinations showed significant effects on weed density, weed mortality percentage, weed biomass and grain yield. Spatial arrangement of 15 cm significantly decreased the weed biomass and enhanced grain yield. The interaction between weeding techniques with spatial arrangements was found significant for weed biomass and grain yield. The highest wheat crop yields of 5448 and 5970 kg ha^{-1} were achieved by using hand weeding and chemical control weeding techniques along with 15 cm spatial arrangement. These treatments caused significant increase of 133.93 % and 113.47% respectively over weedy check with 30 cm spacing.
Keywords: Weeding technique, spatial arrangement, weed density, grain yield, wheat, weed biomass, hoeing and chemical control

INTRODUCTION

Wheat (*Triticum aestivum* L**.**) is a staple food in Pakistan and plays a vital role in its economy. It is grown on area of 8.414 million hectares with a total production of 21.75 million tonnes in Pakistan with an average yield of 2585 kg ha^{-1}. It contributes 12.7 percent to the value added in agriculture and 2.6 percent to GDP in Pakistan (GOP, 2007-08). The average yield of wheat of certain wheat growing countries is higher as compared to Pakistan. Among the several factors responsible for low yield in Pakistan; weed competition and improper spatial arrangements are important and research on these limiting factors will certainly lead to high crop yields.

Weeds compete with wheat crop for nutrients, water, sunlight, space and weaken the main crop, which ultimately lead to low crop yield. The introduction of high yielding short stature wheat varieties having high fertilizer requirements has resulted in tremendous increase in weed flora in wheat because of poor shading ability of dwarf wheat varieties over weeds to suppress them effectively. Shading is a major mean by which crop plants suppress weeds. In row crops, much of the cost of intertillage, seedbed preparation and seed cleaning operations is due to weed infestation. Weeds decrease yield by 15-50 percent and in serious cases, the loss may lead to complete failure of crop. Generally there is a negative linear relationship between above-ground weed biomass and crop yield at harvest, so weed suppression is translated directly into yield (Weiner *et al.*, 2001). Control of weeds is, therefore, essential for obtaining higher yields and better quality of produce. Many types of weed species have been found to infest the wheat crop. Approximately 28-weed species are commonly found to infest the wheat crop in Punjab (Anjum *et al.*, 2007).

Spatial arrangement is another important management factor affecting the agronomic characteristics of wheat. Narrow row spacing leads to higher leaf photosynthesis and suppresses weed growth compared with the wider spacing (Dwyer *et al.,* 1991). The biomass of the target weed and target weed plus naturally-occurring weeds decreases with decreasing row spacing (Olsen *et al.*, 2002).

The cultural weed control method is more effectively used in wheat growing areas, due to the reason that it is an environment friendly weed control measure and it uses various agricultural practices to eradicate weeds. This method may be used with stirring soil through weeding and inter-culturing practices by using hoe, pick axe and spade etc.

Wheat grown on large areas needs harrowing operation to control weeds, which is an economical mechanical practice. Bar harrowing is one of the important practices under mechanical weed control, which may be done by Bar harrow implement that is run using tractors after first or second rainfall. Bar harrow opens root zone of wheat during early growth stages of the crop, which would result in better root establishment. It is to be noted that Bar harrow could only be used when crop is grown by drilling method. By this means, wheat crop may be kept clean from annual weeds such as lamb's quarter, white sweet clover, nettle leaf weed, wild onion, shepherds clock, vetch weed etc.

Mechanical methods of weed control range in complexity from hand hoeing to tillage operation with multi-component machines such as cultivators and bed conditioners. The most commonly used mechanical methods are hand hoeing, tillage and mowing (Ross and Lambi, 1999).

The major area of expansion in weed control technology since world war two has been the development of herbicides. Herbicides are applicable in conditions, where no tillage practices are carried out. The chemical weed control is one of the improved methods to control weeds for having more crop yields (Malik *et al.*, 2001). In wheat, the most easy and cheap method is the use of weedicides, which takes less time and is an effective measure to control weeds on a large scale.

Several weeding techniques such as mechanical, cultural, biological, chemical or ecological are in practice. Control of weeds by a single method usually does not give positive results and may also not be socio-economically acceptable. An integrated weed control practice involves specific control measures to be directed not only against one weed species, but also for all the species affecting one crop in a particular area.

Therefore, the study was designed to evaluate the effects of integrated weed control techniques and spatial arrangements on weed biomass and wheat yield under rainfed conditions.

MATERIALS AND METHODS

To evaluate the effects of different weeding techniques and spatial arrangement on wheat, wheat cultivar GA-2002 was planted as a test crop at the Experimental Farm of University of Arid Agriculture, Rawalpindi during Rabi season, 2004. The experiment was laid out in randomized complete block design (RCBD) with two factors under split plot arrangement. The plot size was 3×4 m^2 with three replications. The spatial arrangement treatments were comprised of 15 cm, 22.5 cm and 30 cm apart rows, whereas weed control treatments viz. weedy check, hand weeding (weed free), Buctril Super @ 750 ml ha^{-1} was sprayed with knap sack hand sprayer fitted with holocone type nozzle, Bar-harrow 2–way, hoe and Barharow 1-way. Recommended seed rate @ 125 kg per hectare was used. Nitrogen, phosphorus and potassium were applied at the time of sowing @ 110, 85 and 60 kg ha^{-1}, respectively. All the other agronomic practices were applied uniformly to all the treatments.

Weed population was recorded using a quadrate of one meter square, taking two samples from each plot and then, the average was computed. The surviving weeds were counted using a quadrate of $1m^2$, taking two samples at random from each plot 15 days after the treatment applications, the average was taken and then the mortality percentage was calculated species wise for each treatment. Weed biomass was taken at harvest and was placed in oven at 70°C for 48 hours and dry weight was recorded. At maturity, each plot was harvested and after threshing, the total yield per plot was recorded and calculated on per hectare yield. Statistical analysis was done to evaluate the different weeding techniques in combination with spatial arrangements applying the analysis of variance technique (Steel and Torrie, 1984) by using the MSTATC statistical computer software package.

RESULTS AND DISCUSSION

Weed density

Weed density before the application of treatments

Varying spatial arrangements affected weed population. The highest weed density was recorded in 30 cm apart rows (24.167) followed by 22.5 cm (21.17) spatial arrangement (Table 1). In wider spatial arrangement, weed density was the highest because weeds were not effectively suppressed by crop plants and got chance to grow freely; whereas, the lowest weed density was observed in 15 cm apart rows (18). Narrow spacing had the lowest weed density. These findings are in agreement with those of Dwyer *et al.* (1991), who also reported that narrow spacing suppressed weed density and growth.

Weed density after the application of treatments

The lowest number of weeds was recorded in hand weeding (Table 1), which was followed by chemical control with 15 cm spatial arrangement (2). These findings agree with the results of Pandey and Singh, 1994 who concluded that hand weeding was better than herbicide treatment for weed control. Whereas the highest weed density was recorded in weedy plots (control) with spacings of 30 cm and 22.5 cm (38) followed by 15 cm spacing (36) (Fig. 1). In control, as no weed control measure was applied, so weeds had the maximum opportunity to thrive in the highest number because of the absence of any of the competing agents and factors and hence, weeds utilized all the resources up to the optimum level. It is evident from the data that complete hand weeding combined with row spacing significantly reduced weed density. These findings are in confirmity to the findings of Deshmukh and Atale (1995), who reported that hand weeding was efficient in controlling weeds when it was compared with weedy check. Similarly, narrow spatial arrangement significantly reduced weed number by suppressing weed population. There was a linear relationship between spatial arrangement and weed density (Fig. 2). Narrow spacing resulted in less weed density, whereas, wider spatial arrangement caused higher weed density. The results of study are in line with those of Marwat (2002.) who reported less weed number in narrow spaced rows.

Table 1. Weed density (m^{-2}) in wheat before and after the application of treatments

Treatments	Weed Density in wheat before and the application of Treatments			Weed Density in wheat after the application of Treatments		
	S_1	S_2	S_3	S_1	S_2	S_3
Weedy check	12	23	18	36	38	38
Hand weeding	24	30	32	00	00	00
Chemical control	13	12	17	03	05	06
Bar harrow (2- way)	25	22	31	10	11	12
Hoeing	14	21	24	06	11	10
Bar harrow (1- way)	20	19	23	09	13	14

S_1=15 cm, S_2=22.5 cm and S_3=30 cm

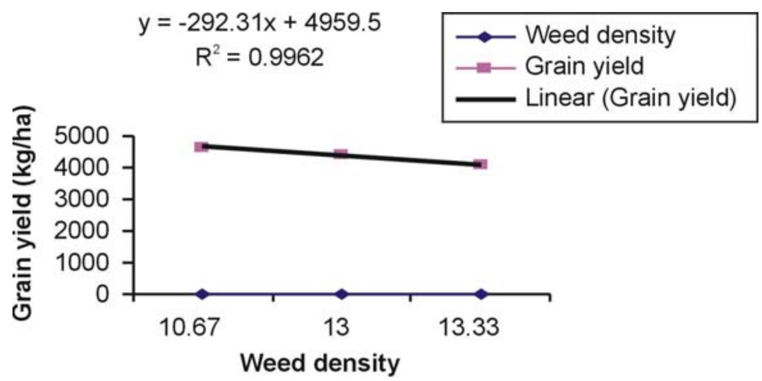

Fig. 1. Relationship between weed density and grain yield

Weed mortality percentage

Examination of data (Table 2) revealed that the effects of different weeding techniques and spatial arrangements on weed mortality percentage were significant. In case of *Convolvulus arvensis* weed, the maximum mortality percentage (100%) was observed in hand weeding in combination with all spatial arrangements followed by barharrow 2-way with 15 cm row spacing (80.55%). Maximum mortality percentage of *Medicago polymorpha* weed (100%) was recorded in hand weeding in combination with all spatial arrangements, followed by chemical control with 15 cm spacing (71.66%), whereas minimum mortality was found in weedy check with all spatial arrangements. Maximum mortality percentage of *Fumaria indica* weed was caused by hand weeding with all spacings (100%), followed by chemical control with 15 cm spatial arrangement (100%). Minimum mortality percentage

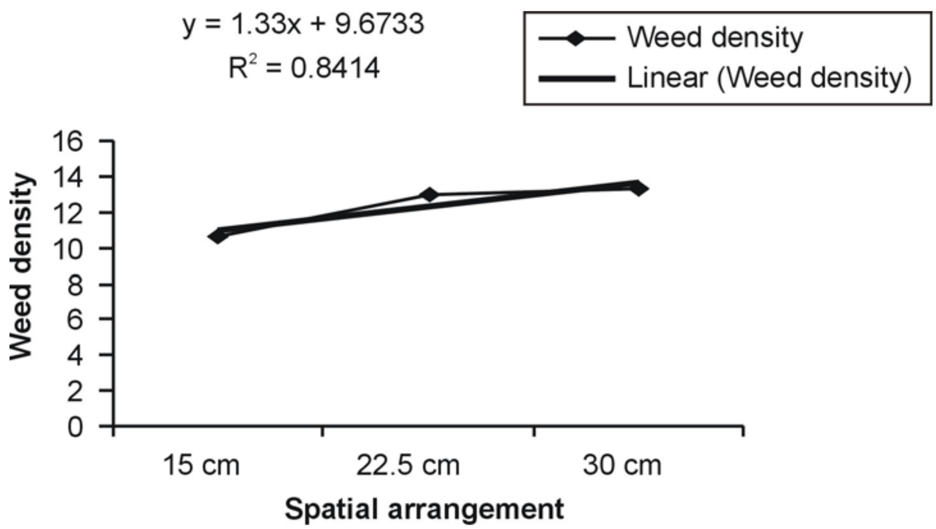

Fig. 2. Relationship between spatial arrangement and weed density

Table 2. Weed mortality percentage as influenced by weeding techniques and spatial arrangement

Treatments	S_1					S_2					S_3				
	CL	M	F	CH	E	CL	M	F	CH	E	CL	M	F	CH	E
Weedy check	00	00	00	--	--	00	00	00	--	00	00	00	00	--	00
Hand weeding	100	100	100	--	--	100	100	100	100	--	100	100	100	100	--
Chemical control	100	71	100	--	33	67	44	67	33	--	58	68	48	50	17
Bar harrow (2–way)	80	45	29	00	50	58	39	52	--	--	50	56	43	50	17
Hoeing	63	52	50	--	33	72	44	30	33	00	50	58	50	33	33
Bar harrow (1-way)	27	43	25	--	17	50	35	52	--	50	56	47	63	33.	17

Where
CL (*Convolvulus arvensis*) M (*Medicago polymorpha*) F (*Fumaria indica*) CH (*Chenopodium album*) E (*Euphorbia helioscopia*)
S_1=15 cm, S_2=22.5 cm and S_3=30 cm

was recorded in weedy plots (control) with all spacings. In case of *Chenopodium album*, hand weeding resulted in maximum mortality percentage with 22.5 and 30 cm spacing (100%), followed by chemical control with 30 cm row spacing (50%). Maximum mortality percentage of *Euphorbia helioscopia* was attained with barharrow 2- way along with 6 inches spatial arrangement (50%), followed by barharrow 1-way with the spacing of 22.5 cm (16.66%); while minimum mortality percentage was observed in weedy check (control) with 22.5 and 30 cm spacing (0%). Hence, it may be concluded that hand weeding with all spatial arrangements significantly reduced weed population which was followed by chemical control in combination with different spacings.

Weed biomass (g m^{-2})

Varying weeding techniques affected weed biomass significantly (Table 3). Among the treatments, the lowest weed biomass (00) was recorded in plots with hand weeding treatment, followed by chemical treatment (16.36), while the highest weed biomass (50.43) was observed in weedy plots (control), followed by barharrow 2–way (30.20). Different spatial arrangements affected weed biomass at harvest. The highest weed biomass (33.25) was recorded in 30 cm row spacing, followed by 22.5 cm spacing (25.14), and these treatments were statistically at part with each other, whereas the lowest biomass (16.85) was attained in 15 cm spacing. The interaction between weeding techniques and spatial arrangements was found significant. The lowest weed biomass was recorded in chemical control with 15 cm spatial arrangement (8.283) followed by hoe treatments with 15 cm line spacing (13.41). These findings are in consistence with the findings of Alford *et al.* (2004), who concluded that the growing of crops in narrow rows reduced weed biomass. Narrow planting rows suppressed weed growth compared to wider row spacing (Dwyer *et al.*, 1991).

Grain yield (kg ha^{-1})

Weeding techniques differed significantly (Table 4) regarding grain yield. Among various treatments, chemical control produced the highest grain yield,

Table 3. Weed biomass (g m^{-2}) as influenced by weeding techniques and spatial arrangement

Treatments	S_1	S_2	S_3	Means
Weedy check	33.43 c	56.86 a	61.00 a	50.43 a*
Hand weeding	00.00 h	00.00 h	00.00 h	00.00 e
Chemical control	08.28 g	17.95 ef	22.85 de	16.36 d
Bar harrow (2- way)	24.53 d	26.13 d	39.95 b	30.20 b
Hoeing	13.41 fg	26.45 d	36.24 bc	25.36 c
Bar harrow (1-way)	21.43 de	23.47 de	39.47 b	28.12 bc
Means	16.85 C	25.14 B	33.25 A*	

*Any two means not sharing same letter are significantly different from each other at 5 % probability level

Table 4. Grain yield (kg ha^{-1}) as influenced by weeding techniques and spatial arrangement

Treatments	S_1	S_2	S_3	Means
Weedy check	2694.66 g	2749.33 g	2551.66 g	2665.22 d*
Hand weeding	5448.00bc	4329.66 ef	4034.66 f	4604.11 b
Chemical control	5970.33 a	5613.00 ab	5308.00 Bc	5630.44 a
Bar harrow(2-way)	4974.66 cd	4765.00 de	4224.00 ef	4654.55 b
Hoeing	4441.00 def	4470.33 def	3932.66 f	4281.33 c
Bar harrow (1-way)	4412.00 ef	4446.66 def	4382.00 ef	4413.55 bc
Means	4656.77 A*	4395.66 B	4072.16 C	

*Any two means not sharing same letter are significantly different from each other at 5% probability level

(5630.44 kg ha^{-1}) followed by barharrow 2-way (4654.55 kg ha^{-1}). While the lowest grain yield (2665.22 kg ha^{-1}) was recorded in weedy plots (control). These findings match with the work of Akhtar *et al.* (1997) and Malik *et al.* (2001) who reported that chemical control of weeds resulted in having more grain yield. These results are also in agreement with those of Chilot *et al.* (1993) who determined that the application of herbicide gave a yield advantage of 27% in wheat.

Similarly, spatial arrangements also had significant effect on grain yield (kg ha^{-1}). The highest grain yield (4656.77 kg ha^{-1}) was recorded in 15 cm row spacing, while the lowest (4072.16 kg ha^{-1}) was recorded in 30 cm spacing. These findings are in parallel to the results of Marwat *et al.* (2002), who concluded that narrow spatial arrangement produced the highest grain yield. However, these results are in contradiction to the findings of Champion *et al.* (1998) who determined that spacing did not influence weed suppression and grain yield was reduced in 15 cm rows.

The effect of interaction between weeding techniques and spatial arrangements was found significant. The highest grain yield (5970.33 kg ha^{-1}) was recorded for chemical control with 15 cm spacing. After chemical control, hand weeding technique along with 15 cm spatial arrangement produced higher grain yield of 5448 kg ha^{-1} as compared to all the other treatment combinations. While the lowest grains yield (2551.66 kg ha^{-1}) was recorded in weedy plots with 30 cm spacing. These conclusions are in consistency with the work of Marwat *et al.* (2002), who reported that the interaction of herbicides with row spacing was significant for grain yield. A negative linear relationship was found between weed density and grain yield (Fig. 1). Decrease in weed density by using suitable weeding technique and adopting appropriate spatial arrangement, resulted in higher grain yields. This finding is in agreement with the conclusion of Weiner *et al.* (2001) who also determined a negative linear relationship between above-ground weed biomass and crop yield at harvest, so weed suppression translated directly into yield.

SUMMARY AND CONCLUSION

Varying weeding techniques significantly affected grain yield since weed suppression translated directly into higher crop yield. Hand weeding and chemical control combinations with all spatial arrangements produced significant effects on weed density, weed mortality percentage and weed biomass. Different spatial arrangements also had significant effect on grain yield. 15 cm spatial arrangement decreased weed density. The interaction between weeding techniques with spatial arrangement was found significant only for grain yield. It may, therefore, be concluded that higher wheat crop yields can be achieved by using hand weeding and chemical control weeding techniques along with 15 cm spatial arrangement under rainfed conditions of Pothowar.

REFERENCES

Akhtar, M.S., M.A. Malik, M.A. Shehzad, M. Musa and M. Nasim. 1997. Effect of new post-emergence herbicides on weed control in wheat under rainfed conditions. Agric. Res. 35(3): 155-160.

Alford, C.M., S.D. Miller and J.T. Cecil. 2004. Using row spacing to increase crop competition with weeds. Proceedings of 4th International Crop Sci. Cong., 26 Sept.-1st Oct., 2004, Brisbane, Australia. http://www.cropscience.org.au/icsc2004/poster/2/4/412_alfordcm.htm.

Champion, G.T., R.J.F. Williams and J.M. Holland. 1998. Interactions between wheat (*Triticum aestivum* L.) cultivar, row spacing and density and the effect on weed suppression and crop yield. Association of Applied Biologist.

Chilot, Y., B. Hailu and F. Rezene. 1993. Economics of alternative weed control practices in wheat, barley and faba bean at wolmera red soil zone. Proc. 8th annual conference of the Ethiopian Weed Sci. Committee. Addis Abeba (Ethiopia). EWSC: 32-33.

Deshmukh, S. and H.B. Atale. 1995. Effect of 2, 4-D isoproturon and isoguard plus on weed control in irrigated late sown wheat. Indian J. Agron. 40(2): 296-297.

Dwyer, L.M., M. Tollenaar and D.W. Stewart. 1991. Changes in plant density dependence of leaf photosynthesis of maize (*Zea mays* L.) hybrids, 1959 to 1988. Can. J. Plant. Sci. 71: 1-11.

GOP. 2007-08. Economic Survey of Pakistan. Economic Advisory Wing, Finance Division, Islamabad.

Malik, M.A., F. Hassan, I. Aziz and M.H. Khan. 2001. Comparitive study of different weed management techniques in wheat (*Triticum aestivum* L.) under rainfed conditions. Pak. J. Arid Agric. 4(1-2): 19-23.

Marwat, I.M., H.K. Ahmad, H.H. Khan and A. Khan. 2002. Effect of weed management practices on economic traits in wheat. Pak. J. Bio. Sci. 2(11): 722-724.

Marwat, I.M. 2002. Effect of weed management practices on different traits of wheat. Pak. J. Biol. Sci. 2(11): 719-721.

Olsen, J.M., L. Kristensen, H.W. Griepentrog and J. Weiner. 2002. Effects of crop density, spatial uniformity and weed species on competition with spring wheat (*Triticum aestivum* L.). 5th EWRS Workshop on Physical Weed Control 45 Pisa, Italy, 11-13 March, 2002.

Ross, M.A. and C.A. Lambi. 1999. Applied Weed Science. 2nd ed. Prentice Hall Company Inc., USA. pp.58-59.

Saeed, M.A., M. Hussain, S.A. Bajwa and A.R. Rao. 1991. Frequency and density of weeds in wheat (*Triticum aestivum* L.). Pak. J. Weed Sci. Res. 4(1): 43.

Steel, R.G.D. and J.H. Torrie. 1984. Principles and Procedures of Statistics, 2nd ed. McGraw Hill Book Company Inc., New York. 754p.

Weiner, J., H.W. Griepentrog and L. Kristensen. 2001. Suppression of weeds by spring wheat (*Tritcum aestivum* L.) increases with crop density and spatial uniformity. J. App. Eco. 38: 784-790.