Pak. J. Bot., 39(4): 1189-1195, 2007.

EFFECT OF PLANTING GEOMETRY AND MULCHING ON MOISTURE CONSERVATION, WEED CONTROL AND WHEAT GROWTH UNDER RAINFED CONDITIONS

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Abstract

The investigation to evaluate the effect of planting geometry and mulching on soil moisture, weed control and growth parameters of wheat under rainfed conditions was carried out at the University of Arid Agriculture, Rawalpindi during rabi 2001-2002. The experiment comprised of three types of planting geometries i.e., 25 cm apart single rows, 40 and 55 cm apart double and triple row strips, respectively. Wheat straw mulch i.e., 1, 2, 3 and 4 t ha^{-1} was compared against control. The results obtained indicated that mulching treatments had significantly increased soil moisture contents at tillering (6-21 %), booting (4-16 %) and grain (2-24 %) formation stage when mulch rate increased from 1 to 4 t ha^{-1} compared to control treatment. Similarly, the increase in mulch rate from 1 to 4 t ha^{-1} wheat straw when compared with control, progressively increased the emergence count (24-42 %), number of tillers (26-52 %), plant height (10 -37 %) and reduced the weed biomass (3-17 %). This indicated that emergence counts, plant height, number of tillers were directly proportional to the mulching material while weed biomass was inversely proportional to it. The planting geometry and interaction between mulching and planting geometry had non-significant effect on moisture contents through out the crop growth period except at tillering stage where maximum moisture contents recorded 16.80 % when 4 tones wheat straw mulch was applied in combination with 40 cm apart double row strip planting.

Introduction

Wheat (*triticum aestivum*) plays a vital role in meeting the food requirement of both urban and rural population in Pakistan but its yield is low in rainfed areas because of unavailability of moisture at the time of sowing which adversely affect the emergence and plant establishment. The problem is further accentuated due to the heavy infestation of weeds which not only deplete soil moisture but also compete for light, nutrients and space with the main crop, resulting in poor performance of the crop. Weeds are one of the most serious pests, reducing the growth and yield of wheat (Young *et al*., 1994). In rainfed area moisture availability is one of the most important limiting factors, which directly affects the plant growth and grain yield in these areas.

Straw mulch helps to retain soil moisture reduce, temperature, conserve soil, control weeds and increase soil fertility (Dushouyu *at al.*, 1995). Mulches increase the soil moisture in the root zone and significantly decrease soil temperature. This provides a more stable environment for seedling establishment and growth than unmulched soil (Osuiji, 1990). Moreover, mulches increase infiltration and storage of water in the rhizoshpere, improve structure and macro-porosity of soil along with reducing runoff and evaporation losses (Acharya & Kapur, 1993).

Narrow row spacing results in higher leaf photosynthesis and suppresses weed growth due to smothering effect compared with wider row spacing (Dwyer *et al*., 1991). Adjusting planting geometry to narrow row spacing has higher radiation use efficiency during grain filling which further contributes to higher dry matter yield (Tollenear & Aguilera, 1992). Therefore, it seems that planting geometry and mulches could be used as a management tool for maximizing crop growth and yield through moisture conservation and weed control particularly under rainfed conditions.

Keeping in view the importance of planting geometry and mulches, the present study was conducted to compare the effect of different rates of straw mulch on soil moisture conservation, weed control and its subsequent effect on growth of wheat crop.

Materials and Methods

A field experiment was conducted at the Research Farm of the University of Arid Agriculture, Rawalpindi to evaluate the effect of planting geometry and mulching on growth of wheat under rainfed conditions. During November 2001, wheat variety Inqbal-91 was sown in randomized complete block design with a split plot arrangement keeping planting geometry in main plots and mulch treatments in subplots. The crop was planted in 3 m x 5 m plots with single row hand drill @ 125 kg ha^{-1}. Uniform doses of NP i.e., 85:65 kg ha^{-1} were applied to all the plots before sowing. Planting geometry arrangements comprised of: a) 25 cm apart single rows, b) 40 cm apart double rows strips, c) 55 cm apart triple rows strips. To keep the uniform plant population, twelve rows plot^{-1} were sown and planting geometry was adjusted according to the plot size keeping 15 cm distance between rows within strips except single rows planting. Threshed wheat straw was used as mulch between the rows /strips in subplots @ 0, 1, 2, 3 and 4 tonnes ha^{-1}.

The observation regarding soil moisture content was determined at sowing time from a composite soil sample and then at tillering, booting and grain formation by taking soil samples at the depth of 0-15 cm from each plot. The moisture percentage was calculated dividing the difference of fresh and dry weight by oven dry weight and then multiplied by 100. Emergence count was recorded form one m long four rows after one week of emergence. Number of tillers was recorded from one m long four rows at tillering stage five (Large, 1954), Plant height of 10 randomly selected plants was taken then values were averaged, Weed biomass were recorded by weighing above ground parts of all weeds and then converted into kg ha^{-1} from each plot at ripening stage II (Large, 1954).

The data collected was analyzed statistically by using analysis of variance technique and Duncan's New Multiple Range Test and 5% probability level was used to compare the differences among the treatment means (James *et al*., 1997). Mean rainfall and temperature during the crop growth period from November 2001 to April 2002 are presented in Fig. 1.

The data regarding the effect of planting geometry and mulching on soil moisture contents at tillering, booting and grain formation stages of wheat are presented in Tables 1, 2 and 3. At the time of sowing a composite soil sample was taken from whole plot and the moisture content was found to be 5.6%. The low soil moisture content is attributed to low rainfall during this period.

The data regarding soil moisture content at tillering stage revealed that mulching treatments and interaction between mulching and planting geometry significantly affected the moisture content (Table 1).

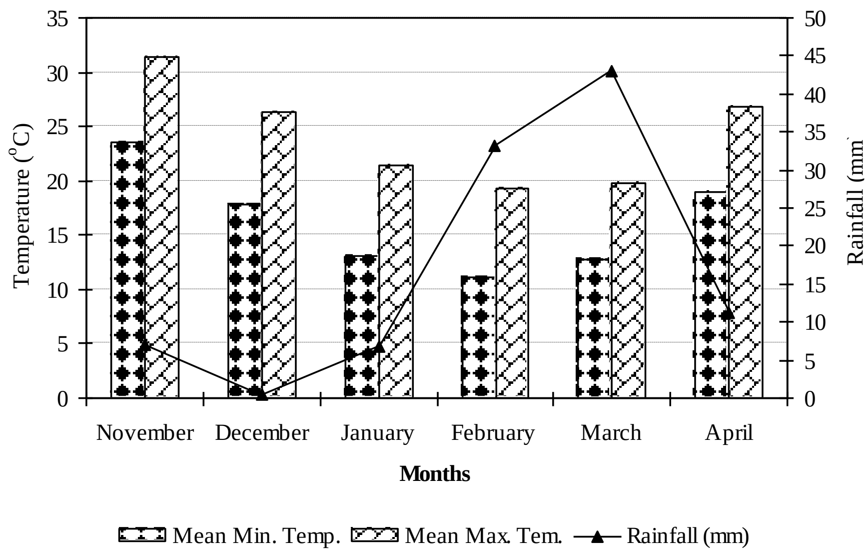

Fig. 1. Mean rainfall (mm) and temperature (°C) during the crop growth period.

Table 1. Effect of planting geometry and mulching on % moisture content at tillering stage of wheat.

Treatments	G_1	G_2	G_3	Mean
T_1 = Control	13.62 e	13.81 e	13.58 e	13.67 D
T_2 = 1 tonne	14.61 d	14.40 d	14.44 d	14.48 C
T_3 = 2 tonnes	15.06 c	14.61 d	15.19 c	14.95 C
T_4 = 3 tonnes	15.52 c	15.33 c	15.52 c	15.46 B
T_5 = 4 tonnes	16.27 b	16.80 a	16.64 ab	16.57 A
Mean	15.01	14.99	15.07	

Any two means not sharing a letter common in a row or column differ significantly at 0.05 probability level.

Table 2. Effect of planting geometry and mulching on % moisture content at booting stage of wheat.

Treatments	G_1	G_2	G_3	Mean
T_1 = Control	6.27 NS	6.53	6.49	6.43 d
T_2 = 1 tonne	6.83	6.68	6.66	6.73 d
T_3 = 2 tonnes	6.83	6.86	6.59	6.76 c
T_4 = 3 tonnes	7.18	7.43	7.02	7.21 b
T_5 = 4 tonnes	7.43	7.56	7.36	7.45 a
Mean	6.91NS	7.01	6.82	

Any two means not sharing a letter common in a row or column differ significantly at 0.05 probability level.

Table 3. Effect of planting geometry and mulching on % moisture content at grain formation stage of wheat.

Treatments	G_1	G_2	G_3	Mean
T_1 = Control	10.49 NS	10.52	10.20	10.40 d
T_2 = 1 Tonne	10.57	10.41	10.95	10.64 d
T_3 = 2 Tonne	11.48	11.21	11.51	11.40 c
T_4 = 3 Tonne	12.31	12.30	12.39	12.33 b
T_5 = 4 Tonne	13.07	12.67	12.90	12.88 a
Mean	11.58	11.42	11.59	

Any two means not sharing a letter common in a row or column differ significantly at 0.05 probability level.

Results and Discussion

Mulching generally increase soil moisture content recorded at tillering stage in case of all planting geometries as compared to control. Mulch application @ 4 t ha^{-1} in combination with double row and triple row spacing conserved maximum moisture in the soil which was followed by same mulch rate in combination with single row planting. Combination of mulching @ 3 t ha^{-1} with 25 cm apart single rows and 55 cm apart triple rows were at par with each other. The lowest rate of mulching showed similar result in all planting geometries although it helped to retain more moisture in soil than control.

The data recorded for soil moisture contents at booting stage revealed that mulching treatments had significantly affected the soil moisture contents at booting stage whereas planting geometry and the interaction between mulching and planting geometry had non significant effect on soil moisture contents (Table 2).

Maximum soil moisture was conserved with 4 t ha^{-1} mulch followed by 3 t ha^{-1} mulch application which was significantly different from rest of treatments as the moisture contents decreased with the decreasing rate of mulch application. Minimum soil moisture was recorded in control, which was at par with 1 t ha^{-1} mulch.

The data regarding soil moisture content at grain formation stage presented in Table 3 revealed that mulch significantly affected the soil moisture contents whereas planting geometry and interaction between planting geometry and mulching had non-significant effect on soil moisture contents.

Maximum soil moisture was conserved where 4 t ha^{-1} of mulch was applied which was followed by 3 and 2 t ha^{-1} of mulch. Minimum soil moisture contents were observed in control, which was at par with one t ha^{-1}. This indicates that with the increase of rate of mulch, moisture contents are increased and *vice versa*. Higher rates of straw mulch conserved more moisture. It is evident that mulches have double ha^{-1} actions. One by controlling weeds and other by providing soil cover, both these effects reduced water loss through decreased transpiration and evaporation, respectively. The results are in accordance with findings of Ahmad & Hanif (1998), Chaudhry & Faizullah (1989), Tariq *et al*., (2001), Baten *et al*., (1995), Misra, (1996) and Shafiq *et al*., (1994) who observed the reduction in evapotranspiration and increase soil moisture conservation by use of mulches.

Soil moisture values showed a lot of fluctuations which were mainly because of variation in the weather parameters like rainfall, temperature and relative humidity. When the soil samples were collected after rain their values was high with the exception of few sample where almost all the mulch treatments showed the high moisture contents in the soil as compared to control. It was further revealed that higher rates of mulch conserved more soil moisture by providing better cover to the non-cropped area.

Mulch application had significant effect on emergence count but planting geometry and interaction between planning geometry and mulching had non-significant effect (Table 4). Mulch application @ of 3 and 4 t ha^{-1} produced higher emergence count than control which was followed by 1 and 2 t ha^{-1} mulch. Lowest emergence count was observed in control.

Increase in emergence count with high rates of mulches is attributed to soil moisture conservation (Chaudhry & Faizullah, 1989). Mulch cover reduces evaporation losses from soil surfaces thus increasing moisture availability for germinating seeds. This contributed to better crop stand and this effect is reflected in the number of total tiller per unit area (Table 6).

Table 4. Effect of planting geometry and mulching on emergence count of wheat.

Treatments	G_1	G_2	G_3	Mean
T_1 = Control	80.00 NS	90.00	92.33	87.44 c
T_2 = 1 tonne	113.00	105.33	109.33	109.22 b
T_3 = 2 tonne	111.000	110.33	105.00	108.77 b
T_4 = 3 tonne	124.33	118.33	126.33	123.00 a
T_5 = 4 tonne	126.00	119.33	127.66	124.33 a
Mean	110.86 NS	108.66	112.13	

Any two means not sharing a letter common in a row or column differ significantly at 0.05 probability level.

Table 5. Effect of planting geometry and mulching on number of tillers (m^{-2}) of wheat.

Treatments	G_1	G_2	G_3	Mean
T_1 = Control	174.33	132.66	135.33	147.44 b
T_2 = 1 tonne	247.00	170.00	196.33	204.44 a
T_3 = 2 tonnes	220.00	184.00	216.00	206.66 a
T_4 = 3 tonnes	236.66	217.66	219.00	224.44 a
T_5 = 4 tonnes	241.00	215.00	215.66	223.88 a
Mean	223.80 a	183.86 b	196.46 b	

Any two means not sharing a letter common in a row or column differ significantly at 0.05 probability level.

Table 6. Effect of planting geometry and mulching on plant height (cm) of wheat.

Treatments	G_1	G_2	G_3	Mean
T_1 = Control	69.87 NS	69.76	69.71	69.78 d
T_2 = 1 Tonne	69.88	69.83	69.83	69.85 c
T_3 = 2 Tonnes	69.86	69.86	69.83	69.85 c
T_4 = 3 Tonnes	69.95	69.91	69.87	69.91 b
T_5 = 4 Tonnes	70.10	70.04	69.97	70.04 a
Mean	69.93	69.88	69.84	

Planting geometry and wheat straw mulching had significant effect on number of tillers but interaction between planting geometry and mulching had non-significant effect on tillering (Table 5).

The result showed that application of mulch significantly increased the number of tillers as compared to control. The mulch application @ 1, 2, 3 and 4 t ha^{-1} produced statistically same number of tillers m^{-2} but different from control. Agarwal & Rajat (1977) have also shown that straw application increased the production in barley. Tillers m^{-2} was increased in mulched plots than unmulched plots which was attributed to increase in soil moisture contents and reduction in evaporation from soil due to application of mulch (Shafiq *et al*., 1994)

Maximum number of tillers m^{-2} was observed in 25 cm apart single row planting geometry but different from 40 cm and 55 cm apart double and triple rows planting geometry which were at par with each other. It seems that closer row spacing of 15 cm in case of double and triple row strips planting increased competition between plant adjacent rows thus suppressing tillering. Similar results were reported by Qasim (1993) who found that maximum numbers of tillers were produced in single row system of planting followed by double row strip planting.

Mulch spreading had significant effect on plant height, but planting geometry and interaction between mulching and planting geometry had non-significant effects on plant height (Table 6).

Table 7. Effect of planting geometry and mulching on total weed biomass (kg ha^{-1}) of wheat.

Treatments	G_1	G_2	G_3	Mean
T_1 = Control	916.44 NS	924.00	917.00	916.44 a
T_2 = 1 tonne	884.55	889.00	878.33	884.55 b
T_3 = 2 tonnes	856.33	856.66	855.00	856.33 c
T_4 = 3 tonnes	816.00	817.33	814.66	816.00 d
T_5 = 4 tonnes	783.00	767.33	791.00	783.00 e
Mean	850.86	851.20	851.73	

Any two means not sharing a letter common in a row or column differ significantly at 0.05 probability level.

The mulch applications @ 1 and 2 t ha^{-1} produced taller plants than control but were at par with each other. The mulch @ 4 t ha^{-1} produced tallest plants than all other treatments. Shortest plants were recorded in control plots. The plant height was increased by the application of different rates of mulches compared with control. The increase in plant height is attributed to moisture conservation and weed suppression due to the application of mulches (Ullah *et al*., 1998).

Total weed biomass showed that mulch treatments had significantly affected the total weed biomass whereas planting geometry and mulching had non-significant effect on total weed biomass (Table 7).

Mulch application @ 4 t ha-1 produced minimum total weed biomass which was statistically different from all treatment, Maximum total weed biomass was observed in control which was followed by 3, 2 and 1 t ha-1 mulch application respectively. It was evident from the data that higher rates of mulch application controlled weeds more effectively as compared to control. A trend of gradual decrease in weed biomass with increased in mulch rate was observed.

Conclusion

From the investigations it is clear that mulch under rainfed conditions helped to enhance the moisture contents of soil and its availability to crop plants as in this study it increased moisture contents from 2 to 24% with the increasing rate of wheat straw. However, the economic feasibility of wheat straw application is need to be investigated. It is therefore, proposed that alternative options / mulching materials for wheat straw needs also to be investigated for timely availability and at economical rates which could be as beneficial as the wheat straw mulch and should be free from any allelopathic effects.

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(Received for publication 15 June 2007)