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Effect of mulching, row direction and spacing on microclimate and wheat yield at Ludhiana

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ABSTRACT

The field experiments were conducted in *rabi* seasons of 2014-15 and 2015-16 at research farm, Ludhiana, Punjab. Wheat variety (WH 1105) was sown in two row directions *viz*, east-west (E-W) and north-south (N-S) with three row spacing as S_1 (15 cm), S_2 (22.5 cm) and S_3 (30 cm), and two mulching levels *viz*., M_o (No mulch) and M_1 (mulch at the rate of 5t ha^{-1}). PAR interception, canopy temperature, soil temperature and soil moisture were recorded periodically during the crop season in all the treatments. The results revealed that the intercepted photosynthetically active radiation (PAR) was 4-5 per cent higher in E-W than N-S row direction which contributed 1.67 q ha^{-1} higher grain yield. Better utilization of solar radiation was observed in 15.0 cm row spacing and the canopy temperature was 0.5°C higher in unmulched crop as compared to mulched crop during both years. Straw mulching @ 5t ha^{-1} improved soil moisture and regulated soil temperature. Mean soil temperature was higher (1.0 °C) under mulched crop as compared to unmulched crop. The soil moisture was 4-5 per cent higher under mulched crop as compared to unmulched crop which ultimately resulted in higher soil temperature during early growth stages. Significantly higher grain yield was recorded in mulched crop as compared to unmulched.

Keyword: Wheat, rice straw mulch; soil temperature; soil moisture; photosynthetically active radiation; canopy temperature

Wheat is the most important *rabi* cereal crop of north-western India. Punjab produces 21.8 per cent wheat of country with an acreage of 13.6 per cent. Significant increase in wheat yield may be achieved through improved planting geometry and appropriate tillage practices. Pathan *et al.,* (2006) reported that higher crop yield resulted from more intercepted photosynthetically active radiation (PAR) oriented in east–west direction. Similarly, crop yield increased from more intercepted photosynthetically active radiation of wheat sown in east–west direction The sowing of crop at closer spacing leads to higher leaf area index, crop growth rate and increased photosynthesis leading to increase in water use efficiency and grain yield. The planting geometry with uniform spatial distribution results in better utilization of land and environmental resources by the crop (Chen *et al.*, 2008).

Wheat straw mulching is a possible option for improving water retention in the soil there by reducing evaporation. Crop residues placed on soil surface shade soil, serve as a water vapour barrier against evaporation losses, slow down surface runoff, and ultimately increase the infiltration of water (Mulumba and Lal, 2008). Mulches have been found to increase the soil moisture, leaf area index (LAI), PAR interception and there by seed yield of mustard (Saikia *et al.* 2014). Saha *et al.* (2010) reported that the black plastic mulch resulted increase in soil temperatures, decrease in canopy temperatures, that resulted in less incidence of leaf curl disease in tomato.

In Punjab, about 20 million tons of rice straw is produced every year which is usually burnt in open fields. Due to burning of rice straw, pollution level in Punjab during October November becomes very high with low visibility. Secondly, ground water table in Punjab is depleting in most of the districts. To address these major problems of the state, the experiments were planned.

MATERIAL AND METHODS

The field experiments were conducted during *rabi* seasons of 2014-15 and 2015-16 at the research farm, Department of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana. The area is characterized by semi-arid, sub-tropical climate with

Table 1: PAR interception (%), canopy temperature (°C), soil temperature (°C) and soil moisture (v/v) (%) of wheat under different row direction, row spacing and mulch application during 2014-15 and 2015-16 (Mean of two years)

Treatments	PAR interception (%)	Canopy temperature(°C)	Soil temperature(°C)	Soil moisture (v/v) (%)
Row direction				
North-South	79.1	19.3	14.8	19.2
East-West	75.2	18.6	14.2	23.3
Row spacing				
15.0 cm	78.9	18.3	14.8	22.3
22.5 cm	76.7	19.1	14.2	21.4
30.0 cm	74.4	19.7	14.8	18.1
Mulch application				
No mulch	72.9	19.0	14.7	18.4
Mulch	75.6	18.5	15.7	20.7

sandy loam soil. Wheat variety (WH1105) was sown on 15th November in split-split plot design with treatments as row direction in main plots, row spacing in sub-plots, and mulching in sub-sub plots with three replications. The crop was sown in two row directions viz, east-west (E-W) and north-south (N-S) with three row spacing i.e. S_1 (15 cm), S_2 (22.5 cm) and S_3 (30 cm) and two mulch treatments viz. M_o (No mulch) and M_1 (mulch). The rice straw mulch applied at 5 t ha^{-1} after emergence of a crop (7-10 days after sowing). The soil temperature at 10 cm depth was recorded at 7.30 am and 2.30 pm twice a week. Canopy temperature was measured at 5 days interval with the help of Infrared Thermometer (FLUKE 574, Fluke Corporation) at 2.30 p.m. from fully developed canopy till its physiological maturity. Photosynthetically active radiation (PAR) was recorded with Line Quantum Sensor at 15 days interval. Intercepted PAR was calculated by using the following formula (Kumar *et al.*, 2008)

$$\text{PAR interception (\%)} = \frac{\text{PAR (I)} - [\text{PAR (T)} + \text{PAR (R)}]}{\text{PAR (I)}} \times 100$$

Where:

PAR(I) : Incident PAR

PAR(T) : Transmitted PAR

PAR(R) : Reflected PAR

For determining soil moisture, soil samples were collected from each plot at fortnightly interval as well as before and after each irrigation treatment from sowing to harvesting from 0-15, 15-30, 30-60, 60-90 and 90-120 cm soil depth. The samples were dried in oven at a temperature of 105°C. The moisture on percent volume basis was calculated by Standard Gravimetric Method as follow given by Dastane (1967)

Soil water content (%) = Soil water content (weight basis) x Bulk density x Depth of soil (cm)/100

RESULTS AND DISCUSSION

Photosynthetically active radiation (PAR)

The PAR interception varied with leaf area index (LAI) and maximum PAR interception was recorded at maximum LAI. On an average, PAR interception was higher (79.1%) in E-W row direction as compared to N-S row direction (75.2%) (Table 1). Pathan *et al.,* (2006) also reported that the light interception by wheat crop canopy was higher in E-W row orientation than N-S row orientation.

On an average PAR interception was higher (78.9 %) under 15 cm row spacing as compared to 22.5 cm row spacing (76.7 %) and in 30 cm row spacing (74.4 %) during both years of study (Table 1). PAR interception was higher (75.6%) in mulched crop as compared to unmulched crop (72.9%). Saikia *et al.,* (2014) also observed higher PAR interception by mustard under mulch as compared to non-mulch treatment.

Canopy temperature

Canopy temperature was higher (0.7 °C) in N-S row direction as compared to E-W row direction during both the years of study (Table 1). Sharma and Angiras (1996) also reported the higher canopy temperature in N-S row direction.

Table 2: Yield and yield attributing characters of wheat under different row direction, row spacing and mulch application during 2014-15 and 2015-16 (Mean of two years)

Treatments	Number of effective tiller per meter square	Ear length per ear (cm)	Number of spikelets per ear	1000 grain weight (g)	Straw yield (q ha^{-1})	Grain yield (q ha^{-1})
Row direction						
North-South	389	10.0	238	35.2	77.13	40.47
East-West	402	10.9	251	37.7	80.11	42.14
CD (p=0.05)	NS	NS	NS	NS	NS	1.03
Row spacing						
15.0 cm	420	10.5	263	36.8	82.96	42.91
22.5 cm	392	10.7	245	36.7	81.68	41.96
30.0 cm	375	10.7	225	35.9	71.22	39.05
CD (p=0.05)	22.9	NS	NS	NS	4.37	1.73
Mulch application						
No mulch	373	10.1	239	36.1	77.04	40.47
Mulch	418	10.8	249	36.9	80.19	42.15
CD (p=0.05)	15.4	0.26	NS	NS	NS	0.89

Canopy temperature was higher under 30 cm row spacing followed by 22.5cm and 15 cm (Table 1). This might be due to higher leaf area index observed under 15 cm row spacing resulting in higher transpiration, thus canopy temperature remained lower due to higher transpiration as compared to wider row spacing. The canopy temperature was 0.5-1.0°C lower (during mid February to march) under mulched crop as compared to unmulched crop during both years. Saha *et al.* (2010) also reported decrease in canopy temperature in tomato under black plastic mulch.

Soil temperature

Mean soil temperature was higher under N-S row direction as compared to E-W row direction. However, the differences were negligible during the both years of pooled analysis (Table 1). Among the different row spacings, mean soil temperature was higher in 30 cm row spacing followed by 22.5 cm and 15 cm during both years of pooled analysis. Mean soil temperature was 1.0°C higher in mulched crop as compared to un mulched crop. Chakraborty *et al.,* (2008) also observed significantly lower soil temperature under rice straw mulch than unmulched crop.

Soil moisture

Soil moisture can be conserved by reducing evaporation through dense canopy cover with close spacing and by covering soil surface with mulch. Soil moisture recorded higher under E-W row direction as compared to N-S row direction. Among different row spacing soil moisture was higher in 15 cm followed by 22.5 cm and 30 cm row spacing treatments. Soil moisture was higher in mulched crop as compared to un-mulched crop during both the years. Saikia *et al.,* (2014) also observed higher (8.6 to 30%) soil moisture under mulching in mustard crop.

Yield and yield attributing characters

The number of effective tillers was statistically at par in E-W and N-S row direction. Significantly higher number of tillers (420 tilllers m^{-2}) was recorded in 15 cm row spacing as compared to 22.5 cm row spacing (392 tilllers m^{-2}) and 30 cm (375 tilllers m^{-2}) row spacing (Table 2). Kalpana *et al.,* (2014) also observed that the number of effective tillers was higher in 15 cm row spacing followed by 17.5 cm and 22.5 cm row spacing. Numbers of effective tillers were significantly higher (10.7 %) in mulched crop as compared to non-mulched crop during both the years of study.

Ear length recorded was statistically at par in both the row directions. The ear length was higher in 22.5 cm row spacing followed by 15 cm and 30 cm. However, the differences were statistically non-significant. Significantly higher ear length 10.8 cm was in mulched crop as compared to non-mulched crop (10.1 cm). The number of spikelets per ear was higher in E-W row direction as compared to N-S.

Among row spacing number of spikelets recorded was higher in 22.5 cm row spacing and under mulch application. It was higher in mulched crop as compared to unmulched crop, but all the differences were non-significant. The 1000 grain weight were statistically at par in all the treatments.

Significantly higher grain yield (42.14 q ha^{-1}) was recorded in E-W row spacing as compared to N-W row spacing (40.47 q ha^{-1}) (Table 2). This might be due to less shade effect created by crop plants in the E-W row direction which results in higher PAR interception than N-S row direction (Table 1). The higher straw yield was recorded in E-W row direction which was at par with N-S directions.

Among the row spacings, the significantly higher wheat grain and straw yield was recorded in 15 cm row spacing as compared to 30 cm row spacing. The higher grain and straw yield recorded in 15 cm spacing might be due to higher PAR interception as compared to wide spacing during both the years of study (Table 1).

CONCLUSION

PAR interception was 4.7 to 5.0 per cent higher in E-W row direction as compared to N-S row direction due to this 1.67 q ha^{-1} higher grain yield was recorded in E-W row direction. Higher grain yield and straw yield were recorded in closer row spacing of 15 cm as compared to 30 cm row spacing. Higher canopy temperature was recorded under N-S row direction as compared to E-W row direction. Soil moisture was 4.2 per cent higher in mulched crop as compared to no mulching crop which indicates that rice straw mulching is helpful to conserve moisture in the field. To get higher productivity wheat crop should be sown in E-W row direction at 15 cm row spacing with rice straw mulch application @5t ha^{-1}.

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