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Short communication

Paddy straw mulch effect on microclimate, growth and yield of wheat under zero till sowing in North-West India

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Wheat (*Triticum aestivum* L.) is an important cereal grain crop grown in India. In Punjab, wheat is cultivated on an area of 35.12 lakh hectares with annual production of 178.30 lakh tonnes and average productivity of 5.07 t ha^{-1} (Anon., 2019). Area of rice-wheat cropping system is 13.5 m ha in Indo Gangetic Plains, of which 10 m ha are in India (Mahajan and Gupta, 2009). Most of the rice fields in Punjab is harvested by combine harvesters, followed by in situ burning of the residues prior to sowing of wheat. Incorporation of residues is unattractive among the farmers due to the cost and time constraints. Sowing of wheat crop without seed bed preparation i.e. zero tillage is gaining importance in the Indo-Gangetic Plains. This technology assists in achieving sustainable productivity, reducing inputs, maximizing yields, enhancing profitability and conserving natural resources. Use of rice residues as mulch is the best possible solution to avoid burning which contributes towards environmental pollution in the IGP region. Crop residues retention on the soil surface have positive benefits on soil-water conservation, reduces evapo-transpiration by decreasing evaporation (Ram *et al.,* 2013), maintenance of canopy temperature at the grain-filling stage which save wheat crop from the terminal heat effects (Gupta *et al.,* 2010). So, retention of surface crop residue assists in achieving sustainable productivity. Manipulation of the agronomic techniques viz. use of paddy straw as crop mulch in zero till wheat helps in countering the effect of climate change (Dhaliwal *et al.,* 2019). So the present investigation was planned to study the effect of establishment methods with and without paddy straw mulch, seed rate and weed management on micro climatic factors, growth and yield of zero till wheat in north-west India.

The experiment was carried during *rabi* season of 2016-17 and 2017-18 at Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana. Standing stubbles (6 t ha^{-1}) of paddy variety PR 121 were chopped with Paddy Straw Chopper cum Spreader only in with paddy straw residue plots. Wheat variety PBW 677 was sown with PAU Happy Seeder attached with press wheels in residue plots and with zero-till drill in without residue plots after harvesting the paddy crop from the ground. The crop was sown in rows 20 cm apart on 8^{th} November, 2016 and 30^{th} October, 2017, respectively. The experiment was laid in split plot design with four replicates. The treatments in main plots consisted of two establishment methods viz. zero till (ZT) wheat with paddy straw residue and without paddy straw residue, two levels of wheat seed rate (100 and 150 kg ha^{-1}) and in sub plots; four levels of weed control (weedy check, weed free, clodinafop + metribuzin @ 206.3 and 275 g ha^{-1}). Herbicide was applied when weeds were at 3-4 leaf stage as per the treatment.

The observations on soil temperature were measured at 10 cm soil depth at 8:00 am and 2:00 pm using soil thermometer. The photosynthetically active radiation (PAR) interception was measured periodically between 12:00 to 2:00 pm, on sunny day by using LI-COR-LINE Quantum Sensor Photometer. The incoming and outgoing solar radiations on top of the canopy and radiation penetration at the ground surface below the crop canopy were measured. The observations were taken at random from two places in each plot. The per cent interception was calculated as under:

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

Table 1: Effect of establishment methods, seed rate and weed control treatments on PAR and plant height of zero till wheat

Treatments	PAR (%)								Crop parameters	
	30 DAS		60 DAS		90 DAS		At harvest		Plant height (cm)	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Establishment methods (A)										
Without residue	43.54	44.54	65.05	67.35	82.31	85.61	73.60	74.88	100.62	101.92
With residue	45.81	46.81	69.00	71.60	85.69	89.29	76.98	78.25	105.88	107.58
Seed rate (B)										
100 kg ha^{-1}	44.60	45.60	67.07	69.52	84.11	87.56	75.40	76.68	103.10	104.60
150 kg ha^{-1}	44.75	45.75	66.98	69.43	83.89	87.34	75.18	76.46	103.41	104.91
Weed control (C)										
Weedy check	44.72	45.72	65.26	67.71	82.18	85.63	73.46	74.72	97.56	99.06
Weed free	44.64	45.64	68.73	71.18	86.34	89.79	77.65	78.95	109.19	110.69
Clod + metri 275 g ha^{-1}	44.73	45.73	67.64	70.09	84.66	88.11	75.95	77.23	104.11	105.65
Clod+metri 206.3 g ha^{-1}	44.63	45.63	66.47	68.92	82.83	86.28	74.09	75.37	102.14	103.60
LSD (p=0.05)	A=0.99 B=NS C=NS	A=1.75 B=NS C=NS	A=0.65 B=NS C=NS	A=0.92 B=NS C=NS	A=1.65 B=NS C=NS	A=1.93 B=NS C=NS	A=0.94 B=NS C=NS	A=1.0 B=NS C=NS	A=1.19 B=NS C=1.75	A=1.62 B=NS C=2.02

Clod+metri-Clodinafop + metribuzin

Table 2: Effect of establishment methods, seed rate and weed control treatments on growth, yield attributes and grain yield of zero till wheat

Treatments	Plant dry matter (g m^{-2})		Plant tillers (No. m^{-2}) at 90 DAS		Spike length (cm)		Grain yield (t ha^{-1})		Straw yield (t ha^{-1})	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Establishment methods (A)										
Without residue	1021.54	1043.88	370	374	10.37	10.28	4.92	4.88	7.22	7.23
With residue	1173.88	1178.43	402	405	11.39	11.32	5.07	5.22	7.68	7.76
Seed rate (B)										
100 kg ha^{-1}	1055.65	1063.56	385	389	10.84	10.77	4.95	4.98	7.32	7.37
150 kg ha^{-1}	1176.59	1189.48	387	390	10.93	10.83	5.04	5.12	7.58	7.62
Weed control (C)										
Weedy check	921.46	944.67	368	372	10.30	10.21	4.02	4.11	5.55	5.46
Weed free	1178.67	1182.89	401	405	11.38	11.27	5.45	5.48	8.38	8.46
Clod + metri 275 g ha^{-1}	1098.78	1112.76	389	392	11.04	10.98	5.34	5.41	8.05	8.15
Clod + metri 206.3 g ha^{-1}	1026.45	1047.57	386	389	10.81	10.75	5.16	5.20	7.81	7.91
LSD (p=0.05)	A=38.31 B=38.31 C=46.34	A=34.67 B=34.67 C=42.56	A=8 B=NS C=9	A=9 B=NS C=10	A=0.49 B=NS C=0.51	A=0.36 B=NS C=0.45	A=0.10 B=NS C=0.11	A=0.12 B= 0.12 C=0.10	A=0.15 B=0.15 C=0.23	A=0.11 B= 0.11 C=0.12
	Interaction A×B=NS; B×C=NS; A×C=NS; A×B×C=NS						Interaction: A×C=S		All Interactions:NS	

Clod+metri-Clodinafop + metribuzin

Where,

PAR(I) = Total PAR incoming above the canopy (W m^{-2})

PAR(T) = PAR transmitted to ground (W m^{-2})

PAR(R) = PAR reflected from the canopy (W m^{-2})

For dry matter accumulation of crop, plant biomass was taken from two spots of 50 cm row length randomly. Samples were oven dried at 60±2°C till constant weight. Ten spikes were selected at random from each plot. Data on grain yield were recorded from net plot. The data on crop were analyzed by the analysis of variance (ANOVA) for split plot design.

Influence on microclimatic characters

Soil temperature is an important parameter which helps to check the effect of crop residue on crop growth. It was observed from the data that in morning time (8 am), soil temperature (17.68 and 17.96 °C) was significantly higher in ZT wheat with residue than without residue plots (16.24 and 16.54 °C), but in the afternoon (2 pm) it was reverse. This retention of paddy straw mulch balances soil temperature by increasing temperature in the morning and decreasing temperature in the afternoon. So increment in soil temperature in morning hours in residue plots provided good conditions for the emergence of wheat plants when the temperature is low in winters (Brar *et al*., 2020). Increased soil temperature under mulch has been attributed to the reduction in outgoing heat radiation from the soil during cold hours (morning) while lower soil temperature under mulch has mostly been attributed to the reduced solar energy reaching the soil during afternoon.

Zero till wheat sown with residue intercepted significantly more PAR as compared to crop sown without residue at 30, 60, 90 DAS and at harvest. Intercepted PAR was higher by 5.2 and 5.1% at 30 DAS, 6.1 and 6.3% at 60 DAS, 4.1 and 4.3% at 90 DAS and 4.6 and 4.5% at harvest, respectively during 2016-17 and 2017-18 in ZT with residue as compared to without residue (Table 1). This might be due to more tillers per unit area (Table 2) recorded in residue plots and ultimately more interception of PAR. Dadhwal, (2011) also reported more PAR interception under paddy straw residue plots.

Influence on crop parameters

Plants were taller by 5.2 and 5.6 per cent in wheat sown in residue plots as compared to without residue plots in first and second year, respectively (Table 1). The improvement in plant height with weed control treatments might be attributed to the better utilization of resources due to weed free environment that ultimately encourages the shoot growth. Among the establishment methods, crop with residue recorded significantly more crop dry matter and number of tillers as compared to without residue, during both years (Table 2). This can be attributed to more interception of light and plant height in crop sown with residue by providing favourable growth conditions to the crop (Dadhwal, 2011). Higher seed rate plots accumulated significantly more dry matter than recommended seed rate. Among the establishment methods, maximum grain yield (5.07 and 5.22 t ha^{-1}) was recorded from ZT crop sown in paddy residues which was significantly higher than the crop sown without paddy straw residue (4.92 and 4.88 t ha^{-1}) during 2016-17 and 2017-18, respectively (Table 2). Zero till with residue gave 3.17 and 7.13 per cent higher grain yield as compared to zero till without residue during 2016-17 and 2017-18 sown crops, respectively. Accumulation of more vegetative biomass at anthesis due to longer vegetative phase as well as longer grain filling period led to 7.13 per cent increase in grain yield in 2017-18 in paddy straw mulch plots. Higher seed rate of 150 kg ha^{-1} had higher grain yield (5.04 and 5.12 t ha^{-1}) that was significantly higher (1.89 and 2.85%) than recommended seed rate of 100 kg ha^{-1} (4.95 and 4.98 t ha^{-1}) during 2016-17 and 2017-18, respectively (Table 2). Increased yield attributes might be due to greater sink and good growth in reproductive phase. Further there might be a positive impact of paddy straw residue mulch on soil water balance due to reduced soil evaporation and better soil water retention that ultimately increased wheat yields. An increase in temperature up to 0.5°C reduced the duration of crop by seven days, resulting in yield loss of 0.5 t ha^{-1} in North India was reported by Parry *et al.,* (1992). High temperature after flowering stage accelerates leaf senescence, thereby reduces grain filling stage and thus decreases grain yield.

CONCLUSION

This two years' study concluded that zero till (ZT) sown wheat with residue recorded significantly higher grain yield as compared to ZT wheat without residue and similar to weed free conditions. The modification of microclimate of zero till wheat with paddy straw residue (Happy seeder sown wheat) is helpful in achieving good growth and development of the wheat crop sown at optimum time in north-west India.

Conflict of Interest Statement: The author(s) declare(s) that there is no conflict of interest.

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