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COMPARATIVE STUDY OF DIFFERENT ORGANIC MULCHES FOR INCREASES WHEAT PRODUCTIVITY IN DISTRICT FAISALABAD, PUNJAB, PAKISTAN

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ABSTRACT

Weeds are major threat to global wheat production and cause serious threat to food security. Organic mulches have potential to reduce weeds growth and conserve the soil moisture thus ensures the better crop growth and yield. Therefore, present study was conducted to compare the performance of different organic mulches in improving wheat growth and productivity. The study was comprised of different organic mulches; M_1= No mulch (control) M_2= maize straw mulch, M_3= wheat straw mulch, M_4= sorghum straw mulch and M_5= rice straw mulch and three nitrogen levels N_1 = 90 kg, N_2 = 120 kg and N_3= 150 kg/ha. The results indicated that both organic mulches and N rates had significant impact on growth, and yield traits. The maximum leaf area index (LAI), crop growth rate (CGR), productive tillers (307 m^{-2}), grains/spike (46.22), 1000 grain weight (42.33 g) biological yield (13.76 t/ha) and grain yield 4.75 t/ha was obtained with sorghum straw mulch and minimum productive tillers (255.33 m-^{2}), grains/spike (36.22), biological yield (11.46 t/ha) and grain yield (3.59 t/ha) was recorded in no mulch (control). Among nitrogen levels maximum productive tillers (290.6 m^{-2}), grains/spike (42.80), 1000 grain weight (40.65 g), biological yield (13.44 t/ha) and grain yield (4.32 t/ha) was obtained with 150 kg/ha N and minimum productive tillers (274 m^{-2}), grains/spike (38.13), 1000 grain weight (36.94 g) biological yield (11.98 t/ha) and grain yield (3.90 t/ha) was obtained with 90 N kg/ha. Thus, farmers can use sorghum straw mulch and N (150 kg ha^{-1}) to improve the wheat productivity. However, farmers must be educated by government institute and adoptive research farms in order to understand and adaption of this approach.

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INTRODUCTION

Wheat is the world's most valuable and domesticated crop, and it is first grown crops in world. It is essential foodstuff for the European, African and Asian countries for last 8000 years. It is also staple food in Pakistan and grown in both irrigated as well as in barani areas of Pakistan. In Pakistan wheat is grown on 8,825 thousand ha with production of 24.946 million tonnes (Government of Pakistan, 2020). Wheat crop provides more energy and protein than any other cereal. Moreover, it is an important source of protein, carbohydrate and nutrients for humans (Anjum *et al.*, 2005; Chattha, Hassan, Khan, Chattha, Mahmood*, et al.*, 2017; Chattha, Chattha*, et al.*, 2017; Hassan, Aamer, Nawaz*, et al.*, 2021; Hassan, Chattha, Ullah*, et al.*, 2019). There are many constraints responsible for lower production of wheat, but most important reasons are non-availability of the certified seed, weeds infestation, un-availability of the irrigation water, prolonged drought periods and irrational uses of fertilizer (Zain *et al.*, 2017; Muhsin *et al.*, 2021). Different biotic and a-biotic factors are also responsible for reduction in yield potential of crops (Abbas *et al.*, 2007; Hassan, Aamer*, et al.*, 2020; Hassan, Chattha, Khan*, et al.*, 2020; Hassan, Aamer, Umer Chattha*, et al.*, 2021). Among major nutrients, nitrogen (N) plays important role in growth and establishment of crop. The production of amino acids in plants is also linked to the availability of N and it also important for photosynthetic process in plants (Shehzad *et al.*, 2012). The economic and biological yield of wheat is much affected by the N and its deficiency causes stunted growth and significant reduction in the final production (Mohsin *et al.*, 2012). Nitrogen is a key element and plays an imperious role in chlorophyll formation (Aslam *et al.*, 2015; Chattha, Hassan, Khan, Chattha, Ashraf*, et al.*, 2017). All biochemical changes that occur in plants are governed mainly by N which makes him essential nutrient for growth and development of wheat (Kutman *et al.*, 2010). Excessive amount of N may cause lodging in the crop and its deficiency caused stunted growth. Therefore, appropriate rate of N is mandatory to get the desirable production (Mckenzie, 2002).

Weeds are also another major threat to global wheat production as they compete with wheat for nutrients, light and space as well. Globally, weeds cause $96 billion loss annually to the farmers and overall economy of world, therefore they should be properly managed in order to ensure food security and prevent such huge losses. Organic mulching is a technique in which soil surface is covered by different organic materials such as leaves crop stubble and residues in order to avoid the evaporation losses from soil surface. The mulching practice has been widely used all over the world to control the evaporation losses and for controlling the weeds. Organic mulching is widely used in areas facing water shortage, owing to fact it reduced the water loss by covering the soil surface and maintaining the soil temperature (Yang *et al.*, 2006). Organic mulch also increased the rate of infiltration, bulk density, water holding capacity, organic matter and soil nutrient status which in turn improved the overall soil health and crop productivity (Yang *et al.*, 2006; Khurshid *et al.*, 2006; Pakdel *et al.*, 2013). Organic mulch substantially controlled the weeds by inhibiting weeds germination and reducing their density and biomass (Jodaugienė *et al.*, 2006). We hypothesized that organic mulches would improve the growth and productivity of wheat crop. Therefore, this study was performed to compare the effect of different organic mulches on weeds biomass and growth and productivity of wheat crop grown in semi-arid region.

METHODOLOGY

Experiment site

The experiment was performed at Agronomy Farm, University of Agriculture, Faisalabad during 2018-19. The study site has semi-arid climate (Hassan *et al.*, 2018; Hassan, Chattha, Barbanti*, et al.*, 2019) with hot and humid summer and dry winter (Hassan, Chattha, Barbanti*, et al.*, 2020). Prior to sowing of wheat crop, soil samples from different parts of experiment field were collected with soil auger and subjected to determine the different soil properties following the procedure of Chapman and Pratt (1962). The experimental soil has the sandy loam texture with following properties; pH 8.03, organic matter 0.74%, total nitrogen 0.081% and available phosphorus and potassium 13 and 172 mg kg^{-1}.

Experimental details

The experiment was performed in randomized complete block design (RCBD) with split plot arrangement having three replications. The study was comprised of different organic mulches; no mulch, maize straw mulch, wheat straw mulch, sorghum straw mulch and rice straw mulch and different rates of N; 90, 120 and 150 kg ha^{-1}. Organic mulches for the experiment were collected from Agronomy Research Farm and were applied in the field after germination of the crop in chopped form at the rate of 5 t/ha.

Crop husbandry

Soil was cultivated following planking to prepare the seedbed for sowing of wheat crop. The fertilizer was applied at 80:60 (PK) kg/ha. Wheat variety Ujala-2016 seed was sown on 25th November 2018 with the help of hand drill by maintaining the row-to-row distance of 22.5 cm with seed rate of 125 kg/ha. The sources of fertilizers were triple-super phosphate (TSP) (46% P) and sulphate of potash (50% K). Complete dose of PK was applied at the time of seedbed preparation. The source of N was urea (46%N), and 50% N was applied at sowing and rest of N was applied with first and second irrigations according to treatments. In total five irrigations were applied from sowing to harvesting. First irrigation of 4-acre inches was applied and remaining four irrigations were applied at rate of 3-acre inches.

Observations

An area of 1 m^2 was marked in each plot and narrow and broad leaves were counted to determine their number and later on uprooted and weighed to determine the total weeds biomass. For the determination of leaf area index after an interval of 45 days, two rows (1 meter long), were harvested from each experimental plot at ground level. A sub-sample of leaves (5 g) was taken from the harvested samples and leaf area was measured by leaf area meter and LAI was measured by methods of Watson (1947). Moreover, sample taken for determining leaf area was oven dried and crop growth rate was determined by method of Hunt (1978).

Ten plants in each plot were marked and plant height was measured and averaged. Similarly, an area of 1 m2 was marked in each plot and productive tillers were counted. Moreover, ten spikes were taken, and spikelets were counted and averaged, after those grains from each spike was separated and counted and averaged was worked out. Additionally, a sub-sample of 1000 grains were taken for determining the 1000 grain weight. The complete plots were harvested and weighed to determine biological yield and later threshed for determination of grain yield and converted into t ha^{-1}.

Statistical analysis

The collected data on different traits was analyzed by Fisher's analysis of variance technique and LSD test at 5% level of significance was used for comparison of treatment means (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Weeds density and biomass

Result showed that organic mulches had significant impact on the narrow and abroad leaf weeds, overall weed density and weed biomass. However, N application has no impact on the on the narrow and abroad leaf weeds, overall weed density and weed biomass (Table 2). The maximum narrow (7.66 m^2) and broad leave weeds (15.55 m^2) was noticed in control (no mulch) after that rice straw mulch and minimum narrow (5.0 m2) and broad leaves (8.88 m^2) were recorded in sorghum straw mulch. Likewise, maximum weeds density and weeds biomass was also recorded in control, whereas minimum weeds density and weeds biomass was recorded in sorghum straw mulch. Organic mulch significantly reduced the weeds biomass and weeds density. Mulches cover the soil surface which reduced the entry of light that inhibited the weeds germination and growth. Additionally, mulches also produced allelo-chemical which inhibited the overall weeds density and weeds biomass (Singh, 2008).

Growth traits

Organic mulches and nitrogen levels had a significant ($P \leq 0.05$) impact on leaf area index (LAI) and crop growth rate (CGR) of wheat. It was observed that LAI and CGR was increased progressively and reached to maximum value 90 days of sowing (DAS) then gradually decreased as crop reached towards maturity. In case of organic mulches maximum LAI and CGR was observed in sorghum mulch after that wheat mulch and minimum LAI and CGR was observed in no mulch. Among N levels maximum LAI and CGR were recorded in 150 kg/ha N and minimum recorded with an application 90 kg/ha (Figure 1). The application of organic mulches reduces water losses which ensures the water availability to crop and therefore resulted in better growth and yield. Additionally, mulch also produced allelo-chemicals which reduce the weeds growth thus increased the inputs availability to crop which in turn increased the growth traits including the LAI and CGR (Solangi *et al*., 2018). The maximum CGR was also noticed in sorghum straw mulch which can be due maximum LAI. The maximum LAI ensured maximum light harvesting which favored the more assimilates production and thus resulted in higher CGR in sorghum mulch as compared to other mulches. The application of N also significantly improved both LAI and CGR. Application of nitrogen boosted the early crop growth and increased the leaf growth (leaf number, length and width) which ensures maximum light harvesting and carbon assimilation thus resulted in more assimilates production consequently leads to higher CGR (Liaqat *et al.*, 2003; Hussain *et al.*, 2014). The organic mulches and N levels also had a significant impact on the plant height (Table 1). The taller plants with maximum height were recorded in sorghum mulch after that wheat mulch and lowest plant height was noticed in control (Table 2). In case of N levels maximum plant height (102 cm) was noticed in 150 kg N ha^{-1}, and minimum plant height (99.53 cm) was noticed in 90 kg N ha^{-1} (Table 2). Mulch application reduce weeds growth and ensured better water and nutrients availability which induced better assimilates production thus resulted in substantial improvement in plant height (Solangi *et al.*, 2018) compared to control. The increase in plant height by N application can be due increase in inter-nodal distance and increased assimilates production (Liaqat *et al.*, 2003).

Table 1. Effect of different organic mulches and nitrogen levels on weeds density and weed biomass grown in wheat.

Organic mulches (OM)	Narrow leaves weeds (m2)	Broad leaves weeds (m2)	Weeds density (m2)	Weeds biomass (g)
No mulch (M1)	7.66 A	15.55 A	15.77 A	16.04 A
Maize straw mulch (M2)	6.88 B	13.33C	10.22 B	12.6 B
Wheat Straw mulch (M3)	6.11C	11.00 D	8.22 CD	26.13 D
Sorghum straw mulch (M4)	5.00 D	8.88 E	7.44 D	6.16 E
Rice straw mulch (M5)	7.11 AB	14.66 B	9.11 BC	9.67 C
LSD≤0.05P	0.58	0.46	1.14	10.07
Nitrogen levels (NL)				
N1: 90 kg ha-1	6.73	12.79	10.33	10.72
N1: 120 kg ha-1	6.53	12.60	10.06	10.68
N1: 150 kg ha-1	6.40	12.66	10.06	10.55
LSD≤0.05P	NS	NS	NS	NS
OM × NL				
M1 × N1	7.66	15.66	16.66	16.06
M1 × N2	7.66	15.33	15.33	16.00
M1 × N3	7.66	15.66	15.33	16.06
M2 × N1	6.66	13.33	10.33	12.8
M2 × N2	7.00	13.66	10.33	12.73
M2 × N3	7.00	13.00	10.00	12.26
M3 × N1	6.66	11.33	8.00	8.80
M3 × N2	6.00	11.00	8.33	8.73
M3 × N3	5.66	10.66	8.33	8.60
M4 × N1	5.33	9.33	7.66	6.30
M4 × N2	5.00	8.33	7.33	6.13
M4 × N3	4.66	9.00	7.33	6.06
M5 × N1	7.33	14.33	9.00	9.63
M5 × N2	7.00	14.66	9.00	9.83
M5 × N3	7.00	15.00	9.33	9.56
LSD≤0.05P	NS	NS	NS	NS

Means sharing different letters differed at 0.05 P level.

Table 2. Effect or different organic mulches and nitrogen levels on yield traits of wheat crop.

Organic mulches (OM)	Plant height (cm)	Productive tillers (m^{-2})	Spikelets/spike	Grains/spike
No mulch (M1)	95.44 D	255.33 C	12.88 D	36.22 D
Maize straw mulch (M2)	98.44 C	279.66 B	14.00 BC	39.33 C
Wheat Straw mulch (M3)	103.11B	303.66 A	14.33 B	42.11 B
Sorghum straw mulch (M4)	107.44 A	307.00 A	15.33 A	46.22 A

Rice straw mulch (M5)	97.22 CD	265.33 C	13.66 C	38.11 C
LSD≤0.05P	2.12	10.07	0.56	1.40
Nitrogen levels (NL)				
N1: 90 kg ha-1	99.53 B	274 C	13.33 C	38.13 C
N1: 120 kg ha-1	99.46 B	282 B	13.80 B	40.26 B
N1: 150 kg ha-1	102.0 A	290.6 A	15.00 A	42.8A
LSD≤0.05P	1.83	6.04	0.64	1.43
OM × NL				
M1 × N1	94.00 f	247	12.33	34.66
M1 × N2	99.66 ef	257	12.66	35.33
M1 × N3	95.66 ef	262	13.66	38.66
M2 × N1	94.00 f	272	13.33	37.33
M2 × N2	96.66 ef	281	13.66	39.33
M2 × N3	104.66 bc	286	15.00	41.33
M3 × N1	109.66 a	294	13.66	39.66
M3 × N2	101.0 cd	304	14.00	42.66
M3 × N3	98.66 de	313	15.33	44.00
M4 × N1	103.66 bc	296	14.33	43.66
M4 × N2	105.66 b	306	15.33	45.33
M4 × N3	113.0 a	319	16.33	49.66
M5 × N1	96.33 ef	261	13.00	35.33
M5 × N2	97.33 def	262	13.33	38.66
M5 × N3	98.00 de	273	14.66	40.33
LSD≤0.05P	4.09	NS	NS	NS

Means sharing different letters differed at 0.05 P level.

Table 3. Effect or different organic mulches and nitrogen levels on yield and yield trait of wheat crop.

Organic mulches (OM)	1000 grain weight (g)	Biological yield (t ha^{-1})	Grain yield (t ha^{-1})	Harvest index (%)
No mulch (M1)	36.08 C	11.46 D	3.59 D	31.36 B
Maize straw mulch (M2)	37.6BC	12.93 B	3.96 C	30.61 B
Wheat Straw mulch (M3)	39.37 B	13.03 B	4.30 B	33.25A
Sorghum straw mulch (M4)	42.33 A	13.76 A	4.75 A	34.61 A
Rice straw mulch (M5)	36.97 C	12.64 C	3.89C	30.76 B
LSD≤0.05P	1.84	0.24	0.18	1.51
Nitrogen levels (NL)				
N1: 90 kg ha-1	36.94 B	11.98 C	3.92 C	32.77 A
N1: 120 kg ha-1	37.82 B	12.88 B	4.05 B	31.50 B
N1: 150 kg ha-1	40.65 A	13.44 A	4.32 A	32.08 AB
LSD≤0.05P	1.16	0.17	0.12	1.03
OM × NL				
M1 × N1	35.70 g	11.20	3.44	30.71 cd
M1 × N2	35.60 g	11.00	3.58	32.57 bc
M1 × N3	36.96 fg	12.20	3.75	30.81 cd
M2 × N1	35.63 g	12.60	3.80	30.15 d
M2 × N2	37.36 efg	12.90	3.94	30.55 cd
M2 × N3	39.80 cde	13.30	4.14	31.15 cd
M3 × N1	37.36 efg	11.50	4.14	36.01 a
M3 × N2	38.00 defg	13.60	4.23	31.14 cd
M3 × N3	42.73ab	14.00	4.56	32.6 bc

M4 × N1	40.43 bcd	12.30	4.48	36.48 a
M4 × N2	41.46 bc	14.30	4.67	32.66 bc
M4 × N3	45.10 a	14.70	5.10	34.7 ab
M5 × N1	35.60 g	12.33	3.76	30.54 cd
M5 × N2	36.66 fg	12.60	3.85	30.61 cd
M5 × N3	38.66 cdef	13.00	4.05	31.14 cd
LSD≤0.05P	2.61	NS	NS	2.40

Means sharing different letters differed at 0.05 P level.

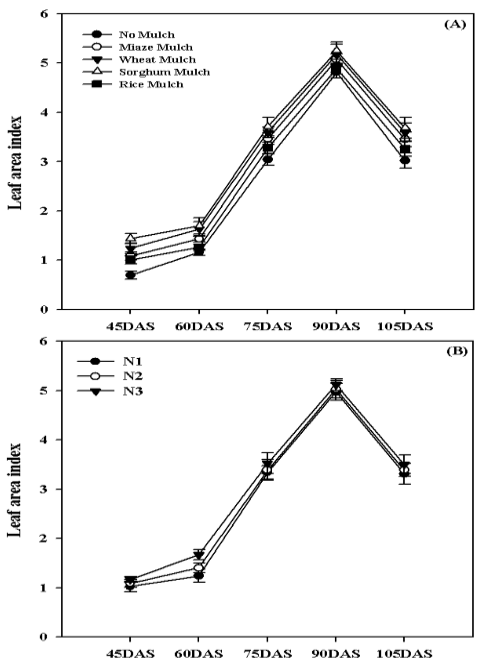

Figure 1: Effect of different organic mulches (A) and nitrogen levels (B) on leaf area index of wheat crop. N1: 90 kg ha^{-1}, N2: 120 kg ha^{-1} and N3: 120 kg ha^{-1}.

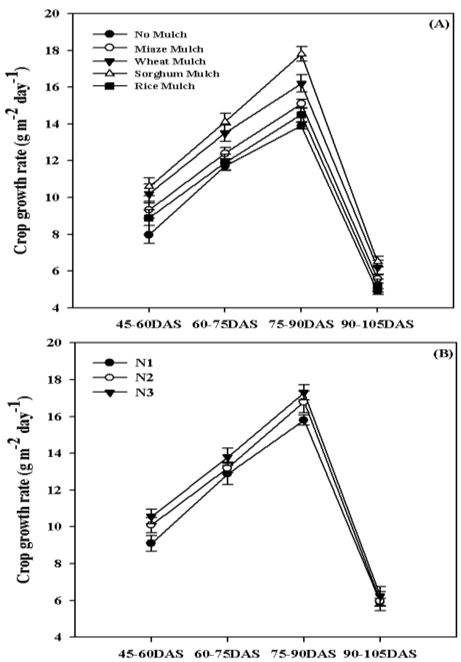

Figure 1: Effect of different organic mulches (A) and nitrogen levels (B) on crop growth rate of wheat crop. N1: 90 kg ha-1, N2: 120 kg ha^{-1} and N3: 120 kg ha^{-1}.

Yield and yield traits

The variable organic mulches and N levels had a significant impact on the yield traits of wheat crop (Table 2, 3). The maximum productive tillers, spikelets and grains/spike were noticed with application of sorghum straw mulch, after that wheat mulch and minimum productive tillers, spikelets and grains/spike were noticed in control (Table 2). In case of N levels maximum productive tillers, spikelets and grains/spike were noted in 150 kg N ha^{-1} after that 120 kg N ha^{-1} and minimum productive tillers, spikelets and grains/spike were noted in 90 kg N ha^{-1} (Table 3). Sorghum and wheat significantly increased productive tillers, spikelets and grains compared to other mulches which can be attributed to maintenance of optimum moisture conditions, nutrients availability, higher LAI and CGR and substantial reduction in weeds biomass and density (Hussain *et al.*, 2014). Increasing N level proved beneficial in boosting productive tillers owing to reduction in rate of tiller's mortality (Ali *et al.*, 2018). Additionally, N increased the yield traits by favoring the better assimilates production, higher LAI and CGR (Hussain *et al.*, 2014).

Different organic mulches and N levels significantly affected the 1000 grain weight (GW) (Table 3). The maximum 1000 GW (42.33 g) was recorded in sorghum mulch, followed by wheat mulch and minimum 1000 GW (36.08 g) was noticed in control (Table 3). Similarly, among the N levels maximum 1000 GW was noticed with application of 150 kg N ha^{-1} and minimum 1000 GW was recorded 90 kg N ha^{-1} (Table 3). Sorghum mulch produced maximum grain weight as compared to the control mulch which could be due to more conversion of soil moisture, higher weeds suppression and higher assimilates production (Teame *et al.*, 2017). Nitrogen plays a significant role in increasing the grain weight which is in confirmation with findings of Yousaf *et al.* (2014). Likewise, the maximum biological yield (13.76 t ha^{-1}), grain yield (4.75 t ha^{-1}) and harvest index (34.61%) were recorded in sorghum straw mulch after that wheat mulch and minimum biological yield (11.46 t ha^{-1}), grain yield (3.59 t ha^{-1}) and harvest index (31.35%) were noticed without mulch application (Table 3).

In case of N levels maximum biological grain yield and harvest index was recorded in 150 N kg ha^{-1} and minimum biological and grain yield and harvest index was recorded in N 90 kg ha^{-1} (Table 3). All the mulches significantly improved biological yield over the control, but sorghum and wheat straw produced maximum biological yield. Mulch application conserves water and suppressed weeds growth and ensured the better LAI and CGR and which is reflected in terms of higher biological yield (Depar *et al.*, 2014). Biological yield is highly affected by the availability of the nitrogen and increase in availability of nitrogen increased the biological yield (Yousaf *et al.*, 2014). All the applied mulches showed positive results in term of grain yield but sorghum mulch produced more grain yield then the rest of others due to more LAI, CGR, tillers, grains/spike, 1000 GW and suppression of weeds growth (Hussain *et al.*, 2014). Nitrogen is the essential element of plant growth and N application increased the grain yield by increasing LAI, CGR, tillers, grains/spike, 1000 GW (Ali *et al.*, 2009).

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, application or organic mulches and N application significantly affected the crop growth, yield and weeds biomass. However, sorghum straw mulch performed appreciable well and resulted in maximum suppression in weeds biomass and density and increase in wheat growth and yield. Moreover, 150 kg N ha^{-1} substantially increased wheat growth and yield compared to other levels. Therefore, it is recommended sorghum straw mulch and application of 150 kg N ha^{-1} can be promoted among farmers to enhance the wheat growth and productivity. However, more studies are direly needed in different cropping system and ecological conditions in order to make it recommendation for farmers at larger scale.

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