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INFLUENCE OF TILLAGE PRACTICES AND MULCH APPLICATION ON WHEAT GROWTH AND YIELD

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ABSTRACT

The study was carried out in the field during the *rabi* seasons of 2020-21 and 2021-22 under irrigated conditions on loam soil to assess the growth attributes of wheat as impacted by tillage practices and residue mulch application. The treatments comprised of two tillage methods viz., T_1: conventional tillage and T_2: Minimum tillage, five residue mulch application viz., M_1: No residue, M_2: soybean residue, M_3: maize residue, M_4: groundnut residue and M_5: glyricidia mulch and control (weed free check). The study was organized using a split plot design with 10 treatment combinations, incorporating a randomized complete block design for comparison between control and treatments. The findings showed that conventional tillage exhibited notably higher growth parameter viz., plant height (31.0, 70.5 and 83.6 cm), number of tillers/m^2 (220.9, 372.4 and 427.4), plant dry weight (9.9, 25.1 and 104.5 g) at 30, 60 DAS and at harvest, respectively, SPAD value (45.5, 47.3 and 38.6 at 30, 60 and 90 DAS, respectively) and grain yield (33.01 q/ha) as compared to minimum tillage. Among residue mulch, application of glyricidia mulch showed increased plant height (31.9, 71.4 and 84.8 cm), number of tillers/m^2 (231.9, 375.1 and 436.5), plant dry weight (11.3, 25.8 and 105.9 g) at 30, 60 DAS and at harvest, respectively, SPAD value (46.1, 47.8 and 39.8 at 30, 60 and 90 DAS, respectively) and grain yield (35.02 q/ha) compared to no residue, groundnut, soybean and maize residue. The combination of conventional tillage with glyricidia residue registered higher plant height, plant dry weight, number of tillers/m^2, SPAD value and grain yield compared to other treatment combinations.
Keywords : Glyricidia mulch, Growth parameter, Residue mulch, SPAD value, Tillage

Introduction

Wheat is the most widely consumed staple food among all grain crops globally, wheat is grown across an area of 221.88 Mha, yielding a production of 780.25 Mt and an average productivity of 3.52 t/ha (Kamboj, 2023). In India, wheat covers 31.13 Mha, with a production of 109.59 Mt and a productivity of 3521 kg/ha (Kamboj, 2023). Uttar Pradesh leads in both area (9.85 Mha) and production (35.51 Mt), followed by Madhya Pradesh with 6.08 Mha and 18.18 Mt. Punjab boasts the highest productivity at 4868 kg/ha, closely followed by Haryana at 4834 kg/ha (Kamboj, 2023). In Karnataka, wheat is grown on 1.71 lakh ha, producing 2.12 lakh tonnes annually, with a productivity of 1244 kg/ha (Anonymous, 2023).

Traditionally wheat is grown after clean intensive tillage to create a friable seedbed that leads to a long turnround period resulting in delayed wheat planting, loss of nutrients, greenhouse gas emission and environmental pollution (Timalsina *et al*. 2021). The major reasons for the poor yield of wheat are delay in sowing, deterioration of soil physical structure due to intensive tillage and depleted soil fertility (Tripathi *et al.*, 2003). Furthermore, labour scarcity and high cost of inputs (fuel, fertilizer, and machinery) make wheat production less profitable. There are several improved management practices developed under the frameworks of conservation agriculture like, zero or minimum tillage in wheat, residue management that improves the water and nutrient use efficiency, maximizes the yields, increase profitability, conserve the natural resource base and reduce the risk due to environmental and economic factors (Ladha *et al.*, 2016).

Tillage improves the soil's capacity to support plant development. Soil tillage has a pivotal role in agriculture as it influences soil properties (physical, chemical and biological), the soil environment and crop growth. As continuous soil tillage profoundly affects soil properties, it is crucial to implement proper tillage methods that prevent soil structure deterioration while preserving crop yield and ecosystem stability (Zamir *et al.*, 2013). Conservation tillage refers to techniques for managing soil that reduce disturbance to soil structure, significantly saves the time in seedbed preparation, increases soil organic matter and reduced operation costs. In these studies, the mulch enhanced the wheat grain yield in comparison with un-mulched wheat. Mulch increased the soil moisture in the root zone and significantly decreased soil temperature, which provides suitable environment for seedling establishment and growth of wheat. Thus, the current research aimed to assess how tillage methods and mulching types influence the growth and yield of wheat.

Materials and Methods

Experimental site and weather conditions

Field study on impact of tillage method and mulch application on growth factors of wheat in Karnataka's Northern transition zone was carried out at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad, Karnataka during *rabi* season of 2020-21 and 2021-22 under irrigated conditions. The rainfall measured during the course of the experiment from November 2020 to March 2021 was 41.2 mm distributed in 5 rainy days. The higher rainfall received in the month of January (27.2 mm) and no and lower rainfall received in December (0 mm) and March (0.4 mm). However, rainfall received during 2021-22 was 232.4 mm, which was distributed in 16 rainy days. The higher rainfall received in November (156.2 mm) and there was a lack of rainfall in January and February. Maximum average temperatures fluctuated between 26.1 to 36.3ºC during 2020-21 and 27.2 to 35.4ºC during 2021-22. The mean minimum temperature varied from 14.6 to 22.6ºC during 2020-21 and 13.2 to 21.4 ºC during 2021-22. The experimental site soil has a loamy texture having a pH of 7.4, electrical conductivity of 0.25 ds/m and low in organic carbon content with low in available N (158.41 kg/ha), high in available P (32.15 kg/ha) and medium available K (291.52 kg/ha).

Experiment details

The treatment detail of the experiment are two tillage practices viz., T_1: conventional tillage, T_2: minimum tillage in main plot and five residue mulches viz., M_1: No residue, M_2: soybean residue, M_3: maize residue, M_4: groundnut residue and M_5: glyricidia mulch in subplots and control (weed free check) were taken. The experiment was arranged using a split plot design with 10 treatment combinations, including a randomized complete block design to compare control with treatment combinations. Wheat (UAS 334) was sown with a seed rate of 125 kg/ha in the second fortnight of November 2020 and harvested on second fortnight of march 2021 during first year and in second year it was sown on first fortnight of November 2021 and harvested on second fortnight of March 2022. The suggested fertilizer dosage was applied at a rate of 120:60:40:20:20 N, P_2O_5, K_2O, $ZnSO_4$ and $FeSO_4$ kg ha^{-1} in the form of urea, di-ammonium phosphate, muriate of potash, zinc sulphate and ferrous sulphate, respectively.

Morphological data

The height of five randomly chosen plants in each treatment was assessed, starting from the plant's base to the base of the longest fully opened leaf at 30 and 60 days after sowing (DAS), and from the plant's base to the bottom of the panicle at the time of harvest. The measurements were recorded and measured in centimetres (cm). Similarly, number of tillers per square meter in each treatment was noted at 30 and 60 DAS, as well as at harvest. Destructive plant samples were gathered to evaluate the production of plant dry matter at 30, 60 DAS and at harvest. Plant samples were collected from the second row on either side of the plot, covering a row length of 0.5 meters each time. After sampling, the plant material was first air dried and subsequently oven dried at 70 (ºC) until reaching a constant weight. This procedure was executed to establish the total biomass production, with the findings presented in grams per meter of row length. The relative chlorophyll content of the leaves was determined by Konica Minolta SPAD-502 plus (Soil plant analysis development) meter. The SPAD measurements were taken from youngest fully opened flag leaf third from the top of the plant. This leaf exhibits a significant correlation with the nitrogen levels in wheat. Five leaves were chosen at random from the plants in each treatment and the relative chlorophyll content was assessed by clamping the sensor head onto the leaf blade. The SPAD values were noted at 30, 60, and 90 DAS throughout the crop growth period. The data was not recorded at harvesting stage as the crop doesn't bear any green leaves. Grain yield per treatment was measured at the time of harvest. Once threshing was completed, the grains were divided, cleaned and weighed.

Data analysis

The data gathered throughout the study were compiled and analysed for statistical significance as per the analysis of variance for split plot design. Randomized complete block design was followed to compare the control treatments with treatment combinations. Fisher's analysis of variance (ANOVA) technique, as outlined by Gomez and Gomez (1984) was adopted for the purpose. The values of least significant difference (LSD) were worked out at P = 0.05, wherever F tests were significant. Besides, the average values of main plot, sub plot and interactions were individually analysed with Duncan Multiple Range Test (DMRT), applying the relevant error mean sum of squares and degrees of freedom.

Results and Discussion

Plant height

According to the pooled analysis indicated that conventional tillage exhibited statistically increased plant height (31.0, 70.5, and 83.6 cm) than minimum tillage (30.0, 68.3, and 81.2 cm) at 30, 60 DAS and at harvest (Table 1). The greater plant height observed with conventional tillage in comparison to minimum tillage could be the result of the decreased soil bulk density and increased soil proliferation of roots for uptake of water and nutrients. Loosening the soils through improved tillage and creates an ideal seedbed condition which influences the growth of crops leading to taller plants. Consistent results of substantially higher plant heights in tilled treatment than those under no-till was stated by Diaz-zorita (2000).

Residue mulch application had no influence on plant height at every growth stage (at 30, 60 DAS and at harvest) of wheat. It was observed that glyricidia residue (31.9, 71.4 and 84.8 cm) statistically higher plant height over no residue (28.5, 67.2 and 79.8 cm) being on par with maize (31.2, 70.4 and 83.3 cm) soybean (30.9, 69.3 and 82.4 cm) and groundnut (30.1, 68.7 and 81.7 cm) residue. Pervaiz *et al.* (2009) also noted that maize showed increased height with higher mulch levels, as there was more soil moisture available to support plant growth. The mulch condition affected the plant height. The rise in plant height could be linked to improved absorption and conservation of more moisture by crop residue application which reflected in more plant height.

Interactions among the tillage, residue mulch indicated that conventional tillage with glyricidia residue (32.5, 72.4 and 85.7 cm at 30, 60 DAS and at harvest, respectively) recorded considerably taller plant height compared to other treatment combinations excluding conventional tillage with maize residue (31.6, 71.5 and 84.6 cm at 30, 60 DAS and at harvest, respectively) with which it was on par. Significantly reduced plant height was noted in minimum tillage with no residue (27.7, 66.3 and 78.7 cm at 30, 60 DAS and at harvest, respectively) compared to rest of treatments. Weed free check (32.9, 74.9 and 87.4 cm at 30, 60 DAS and at harvest, respectively) recorded taller plant height compared to other interaction combination.

Table 1: Impact of tillage and residue mulching on plant height and number of tillers at various growth stages of wheat

Treatment	Plant height (cm)			Number of tillers/m^2		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
Tillage						
T_1: Conventional tillage	31.0^a	70.5^a	83.6^a	220.9^a	372.4^a	427.4^a
T_2: Minimum tillage	30.0^b	68.3^b	81.2^b	202.1^b	338.1^b	406.2^b
SEm ±	0.09	0.09	0.19	1.04	4.27	1.01
Residue mulch						
M_1: No residue	28.5^c	67.2^c	79.8^b	194.0^e	336.7^d	399.7^e
M_2: Soybean	30.9^{ab}	69.3^b	82.4^{ab}	209.6^c	354.6^c	415.3^c
M_3: Maize	31.2^a	70.4^{ab}	83.3^{ab}	220.5^b	363.7^b	425.7^b
M_4: Groundnut	30.1^b	68.7^{bc}	81.7^{ab}	201.6^d	346.2^{cd}	406.8^d
M_5: Glyricidia	31.9^a	71.4^a	84.8^a	231.9^a	375.1^a	436.5^a
SEm ±	0.23	0.38	1.00	0.87	2.05	1.07
Interaction						
T_1M_1	29.3^c	68.1^{de}	80.9^{bc}	203.1^e	351.7^{de}	413.3^d
T_1M_2	31.2^b	70.6^{bc}	83.6^{ab}	218.8^c	374.0^b	425.5^c
T_1M_3	31.6^{ab}	71.5^{ab}	84.6^{ab}	230.8^b	381.1^b	434.6^b
T_1M_4	30.6^b	69.9^{bc}	83.0^{a-c}	210.2^d	362.3^c	416.8^d

T_1M_5	32.5^{a}	72.4^{a}	85.7^{a}	241.9^{a}	393.2^{a}	447.0^{a}
T_2M_1	27.7^{d}	66.3^{e}	78.7^{c}	184.9^{g}	321.8^{g}	386.0^{g}
T_2M_2	30.8^{b}	68.0^{de}	81.1^{abc}	200.3^{e}	335.1^{f}	405.1^{e}
T_2M_3	30.8^{b}	69.2^{cd}	82.1^{abc}	210.2^{d}	346.3^{e}	416.8^{d}
T_2M_4	29.6^{c}	67.6^{de}	80.3^{bc}	193.1^{f}	330.1^{fg}	396.8^{f}
T_2M_5	31.3^{b}	70.4^{bc}	83.8^{ab}	221.9^{c}	357^{cd}	426.2^{c}
SEm±	0.30	0.49	1.28	1.51	4.99	1.69
Control (WFC)	32.9	74.9	87.4	247.3	399.1	455.0
SEm ±	0.57	0.62	1.44	1.62	5.42	2.98
$LSD_{0.05}$	1.71	1.83	4.28	4.82	16.12	8.84

The values presented in the table represent the average of three replicates; means with different letters in the same column are significantly different at P<0.05.

Number of tillers/m^2

Markedly increased number of tillers/m^2 was obtained in conventional tillage (220.9, 372.4 and 427.4 /m^2) compared to minimum tillage (202.1, 338.1 and 406.2/m^2) at 30, 60 DAS and at harvest (Table 1) in the pooled data analysis. Minimum tillage recorded higher weed infestation, which resulted in weed-crop struggle for sunlight, space, water and nutrient leading to poor crop performance. Conventional tillage had lesser weed infestation and weed-crop competition, which ultimately leading to better crop growth (Minhas *et al*., 2023). Glyricidia mulch (231.9, 375.1 and 436.5/m^2 at 30, 60 DAS and at harvest, respectively) recorded highest number of tillers/m^2 compared to all other crop residue applications. The remaining treatments varied from one another i.e., maize (220.5, 363.7 and 425.7/m^2), soybean (209.6, 354.6 and 415.3/m^2) and groundnut residue (201.6, 346.2 and 406.8/m^2). No residue (194.0, 336.7 and 399.7/m^2) treatment recorded markedly fewer number of tillers/m^2 over rest of the crop residue application treatments. Significantly higher number of tillers/m^2 was noted in conventional tillage with glyricidia (241.9, 393.2 and 447.0/m^2 at 30, 60 DAS and at harvest, respectively) over all other treatments. Significantly lower number of tillers/m^2 was observed in minimum tillage with no residue (184.9, 321.8 and 386.0/m^2 at 30, 60 DAS and at harvest, respectively) compared to other treatments. Weed free check (247.3, 399.1 and 455.0/m^2 at 30, 60 DAS and at harvest, respectively) observed a markedly higher number of tillers/m^2 compared to tillage with residue mulch combinations.

Table 2: Effect of tillage and residue mulch on plant dry weight (g/0.5 m row length) and chlorophyll content (SPAD value) at various crop growth stages of wheat

Treatment	Plant dry weight g/0.5 m row length			SPAD value		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
Tillage						
T_1: Conventional tillage	9.9^{a}	25.1^{a}	104.5^{a}	45.5^{a}	47.3^{a}	38.6^{a}
T_2: Minimum tillage	8.2^{b}	21.1^{b}	100.3^{b}	43.2^{b}	45.0^{b}	35.9^{b}
SEm ±	0.19	0.39	0.55	0.31	0.21	0.15
Residue mulch						
M_1: No residue	7.0^{e}	20.6^{e}	99.5^{e}	42.4^{e}	44.2^{e}	32.7^{e}
M_2: Soybean	9.0^{c}	22.8^{c}	102.1^{c}	45.2^{b}	47.1^{b}	39.3^{b}
M_3: Maize	10.1^{b}	24.4^{b}	103.7^{b}	43.5^{d}	45.3^{d}	36.5^{d}
M_4: Groundnut	8.1^{d}	21.9^{d}	100.9^{d}	44.7^{c}	46.5^{c}	37.8^{c}
M_5: Glyricidia	11.3^{a}	25.8^{a}	105.9^{a}	46.1^{a}	47.8^{a}	39.8^{a}
SEm ±	0.21	0.19	0.1	0.09	0.08	0.13
Interaction						
T_1M_1	8.1^{e}	22.5^{e}	101.5^{f}	43.7^{f}	45.6^{f}	33.9^{g}
T_1M_2	9.8^{cd}	24.9^{c}	104.3^{c}	46.3^{b}	48.0^{b}	40.5^{a}
T_1M_3	10.8^{b}	26.6^{b}	105.6^{b}	44.9^{d}	46.8^{d}	38.1^{cd}
T_1M_4	9.0^{d}	23.9^{d}	103.0^{e}	45.7^{c}	47.3^{c}	39.3^{b}
T_1M_5	12.1^{a}	27.7^{a}	108.1^{a}	47.1^{a}	48.8^{a}	41.0^{a}
T_2M_1	6.0^{g}	18.7^{h}	97.5^{i}	41.1^{h}	42.8^{h}	31.5^{h}

T_2M_2	8.1^{e}	20.7^{f}	100.0^{g}	44.2^{e}	46.2^{e}	38.0^{d}
T_2M_3	9.3^{d}	22.1^{e}	101.8^{f}	42.1^{g}	43.7^{g}	34.8^{f}
T_2M_4	7.1^{f}	19.9^{g}	98.7^{h}	43.5^{f}	45.6^{f}	36.4^{e}
T_2M_5	10.4^{bc}	23.8^{d}	103.7^{d}	45.1^{d}	46.8^{d}	38.6^{c}
SEm±	0.32	0.46	0.56	0.33	0.23	0.23
Control (WFC)	13.6	29.3	110.5	47.7	49.6	41.6
SEm ±	0.34	0.41	0.49	0.25	0.19	0.20
$LSD_{0.05}$	0.99	1.22	1.46	0.75	0.57	0.60

The values presented in the table represent the average of three replicates; means with different letters in the same column are significantly different at P<0.05

Plant dry weight

Based on a study of pooled data, conventional tillage led to a statistically higher plant dry weight (9.9, 25.1 and 104.5 g) at every growth stage when contrasted with minimum tillage (8.2, 21.1 and 100.3 g) at 30, 60 DAS and at harvest, respectively. This was primarily due to better harvesting of solar radiation and higher chlorophyll content which helped the plant to accumulate more photosynthates in leaves, stem and reproductive parts (Ali *et al.*, 2013).

Application of residue mulch increased the plant dry weight at various growth stages of the crop (Table 2). Production of dry matter and its accumulation in various parts of plant achieved was only with the development of vegetative growth *viz*., plant height, number of tillers/m^2. These growth parameters resulted at every stage of crop growth, there were statistically greater results were observed with the application of crop residue as mulch over no mulch practice. Among the various treatment combinations, conventional tillage combined with glyricidia residue (11.3, 25.8 and 105.9 g at 30, 60 DAS and at harvest, respectively) led to greater dry weight of plant when in relation to the other treatment combinations. Conversely, minimum tillage without residue exhibited a lower plant dry weight, indicating reduced growth in this parameter. Notably, the weed-free check treatment registered the greater dry matter (13.6, 29.3 and 110.5 g at 30, 60 DAS and at harvest, respectively) relative to all the other treatment combinations. Dry matter accumulations were notably reduced in minimum tillage, potentially due to soil compaction at plough layer depth during the initial years of minimum tillage, which could adversely affect root and plant growth.

SPAD Value

In the pooled data analysis, SPAD values are indirect indicator of relative content of chlorophyll and leaf nitrogen. The maximum value was observed at 60 DAS of wheat (Table 2). Kulig *et al.* (2010) observed that conventional soil tillage increased SPAD in spring wheat compared with the simplified tillage. Crop residue application impact on SPAD values was significant. Glyricidia recorded higher SPAD value (46.1, 47.8 and 39.8 at 30, 60 and 90 DAS, respectively) in contrast to crop residue application and no residue treatment. This may be due to the dark leaf colour, higher chlorophyll content in leaf and leaf nitrogen concentration which resulted in higher SPAD value. Kulig *et al.* (2010) suggested that under residue return, SPAD was found higher than under residue removal. Conventional tillage with glyricidia residue (47.1, 48.8 and 41.0 at 30, 60 and 90 DAS, respectively) recorded higher SPAD value and on the contrary minimum tillage with no residue (41.1, 42.8 and 31.5 at 30, 60 and 90 DAS, respectively) recorded lower SPAD value. Weed free check led to greater SPAD value (47.7, 49.6 and 41.6 at 30, 60 and 90 DAS, respectively) probably due to lack of competition from weeds for nutrients.

Grain yield

Grain yield varied considerably depending on the tillage methods and crop residue application, their interactions and control treatment (Fig.1a). Conventional tillage produced a notably higher grain yield (33.01 q/ha) than minimum tillage (29.66 q/ha). Tillage influences weeds by uprooting, dismembering, and burying them deep enough to prevent their emergence, altering the soil environment to inhibit weed germination and establishment. This fosters an optimal soil environment for plant growth, leading to improved yields (Jadhav 2014).

Grain yield showed a marked increase with glyricidia residue (35.02 q/ha). The next higher yield was in maize (33.77 q/ha), soybean (32.41 q/ha) and groundnut residue (29.38 q/ha) and they differed significantly (Fig. 1b). Reduced yield was noted with no residue application (26.11 q/ha). Mulched plots showed an increased grain yield due to conserved soil moisture and increased infiltration provided by the mulch. Zhang and Lan-Fang (2021) reported that retention of crop residue treatments produced greater wheat yields compared to residue removal, indicating that field mulching with crop residue enhances yield.

Among the interactions, conventional tillage combined with glyricidia residue (37.04 q/ha) resulted in notably greater grain yield in contrast to the other treatment combinations (Fig.1c). Grain yield obtained in T_1M_3 and T_1M_2 were on par. Conventional tillage with groundnut residue and T_2M_2 produced on par grain yields. Minimum tillage with no residue (25.09 q/ha) produced significantly inferior grain yield. Markedly higher grain yield was achieved with the weed free check (42.17 q/ha) compared to all other interactions.

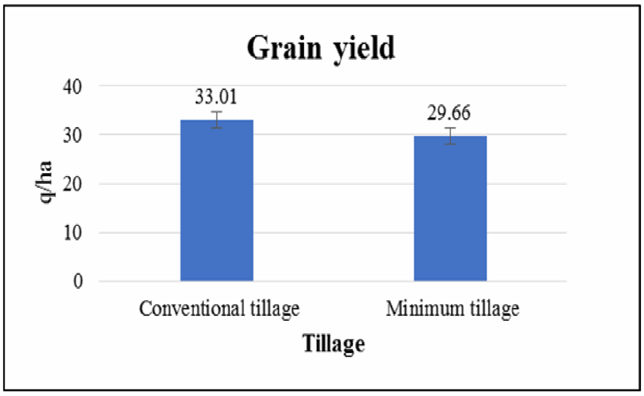

Fig. 1a: Grain yield as influenced by tillage system

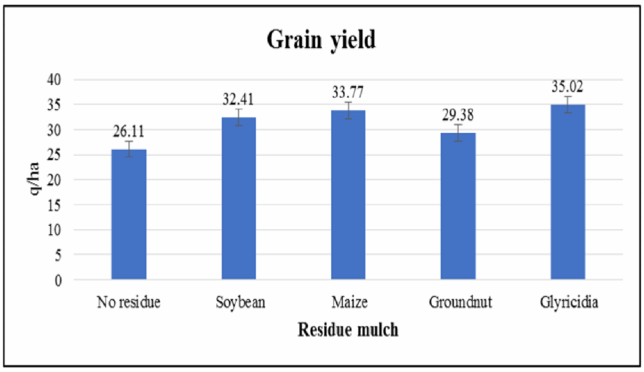

Fig. 1b: Grain yield as influenced by residue mulch application

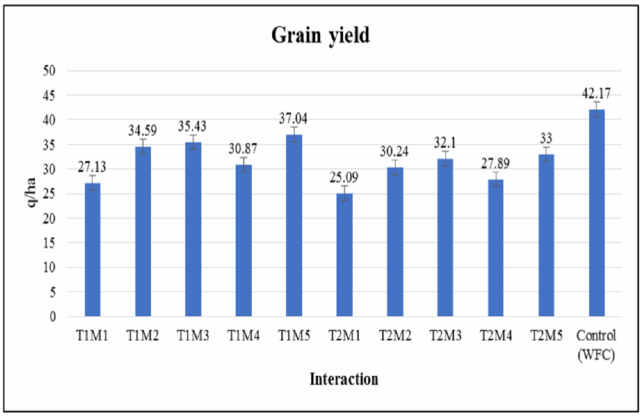

Fig. 1c: Grain yield as influenced by interaction of tillage with residue mulch application

Conclusion

From the results, conventional tillage of one ploughing and two harrowing performed better growth parameters and yield of wheat over minimum tillage. Plant height, number of tillers/m^2, plant dry weight, SPAD value and grain yield notable increases in glyricidia mulch and was followed by maize, soybean, groundnut and no residue. Conventional tillage with residue mulch recorded higher growth parameter and yield than conventional tillage with no residue and minimum tillage with no residue.

Conflict of interest

The authors declare that they have no conflicts of interest.

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