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Effect of Conservation Tillage and Residue Mulch on Weed Dynamics and Productivity of Wheat Crop

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ABSTRACT

Background: Conservation tillage and residue mulch plays an important role in controlling weed and enhancing wheat yield. These practices reduce soil disturbance and suppress weeds, improving soil health and moisture retention. This leads to better crop growth and higher wheat productivity.

Methods: A experiment was conducted during *rabi* 2020-21 and 2021-22 at MARS, University of Agricultural Sciences, Dharwad to assess the effect of conservation tillage and residue mulch on weeds in wheat. The experiment was laid out in split plot design with 10 treatment combinations, including a randomized complete block design to compare outside control with treatment combinations.

Result: Experimental results revealed that conventional tillage significantly reduced density of weeds. Conventional tillage decreased the total number of weeds and dry weight of weeds and higher weed control efficiency at 20, 40, 60 DAS and harvest stage, respectively. Conventional tillage significantly higher grain yield resulted lower weed index over minimum tillage. The high infestation of weeds under minimum tillage resulted in the lowest weed control efficiency among the tillage practices. Residue mulch application of glyricidia recorded lower number of weeds and dry weight of weeds. An increase in grain yield was registered with residue mulch application of glyricidia, maize, soybean and groundnut as compared to no residue. Glyricidia residue mulch recorded higher values of weed control efficiency and lower weed index. Based on the findings, it was concluded that conventional tillage with glyricidia residue mulch reduced population of mixed weed flora diversity and resulted in higher grain yield of wheat.

Key words: Conventional tillage, Crop residue, Glyricidia, Minimum tillage, Weeds.

INTRODUCTION

Wheat is major cereal crop, accounts for 26 per cent of world cereal production and plays an important role in nutritional and food security. It is extensively grown, cereal in the world. The primary causes of decreasing wheat productivity include late sowing inadequate nutrient levels and weed infestations. Wheat fields heavily infested with both narrow and broad-leaved weeds, resulted in reduction in grain yield. Rao (2018) found that weeds in India cause a 20-40 yield loss in wheat. Weeds growing along with crops consume significant portion of nutrients and soil moisture, consequently led to poor crop growth (Sneha and Sheeja, 2022). Weeds pose significant challenges in conservation agriculture-based systems. Decrease in tillage affects weed infestation. The diversity of weed species and their respective timing of emergence vary between conservation tillage and conventional tillage systems. Perennial weeds like *Cynodon dactylon, Cyperus rotundus* and *Sorghum halepense* generally reproduce from underground structures and are predominant in conservation agriculture systems (Sharma and Singh, 2016). Conservation tillage encourages stolons and tubers of these perennial weeds by not burying them to depths that are unfavourable for emergence. The tillage systems affect the vertical dispersion of weed seeds within soil layers and diversity of weed species (Selvakumar and Ariraman, 2023). In a no-till cropping system, the majority of weed seeds remain concentrated within the upper 1.0 cm of the soil profile. However, in deep tillage decrease in weed population occurs due to the soil inversion caused by mouldboard ploughing, resulting in most weed seeds being buried deeper in the soil and unable to emerge.

Crop residues comprise organic materials like green mulch and crop or plant residue used in different cropping systems. Crop residues, its quantity and allelopathic property effect the weed seed germination and emergence. Crop residue mulch on the soil surface suppresses weed seed germination by reducing the light transmission and their allelopathic effect. Delayed weed emergence provides crop to take competitive advantage over weeds which have

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less effect on crop yield loss. Ranaivoson *et al.* (2017) reported that incorporation of crop residue of 1 t/ha or more helps in reduction of weed emergence and its biomass by 50% as compared to conventional practices. However, maximum suppression was observed with 4 t/ha or above. Types of crop residue and time of cover also influence the weed dynamics. The emergence of weed is reduced by increasing the crop residue and its uniform spread over the soil surface. Mulches are cost-effective and readily accessible, making them suitable for weed control in wheat cultivation. Moreover, it offers advantages such as soil conservation, temperature regulation and salinity reduction. Keeping this in view, the present investigation was carried out to evaluate effect of conservation tillage and residue mulch on the dynamics of weeds in wheat crop.

MATERIALS AND METHODS

A field experiment was conducted during the winter season of 2020-21 and 2021-22 at AICRP on wheat improvement, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (15. 49598° North latitude, 74. 98143° East longitude and at 678 m MSL), Karnataka. Experimental field soil was loam in texture with pH of 7.4. Experimental soil was low in organic carbon (0.47%), available nitrogen (158.41 kg/ha), high in available phosphorus (32.15 kg/ha) and medium in available potassium (291.52 kg/ha). The experiment was conducted in split plot design and replicated thrice, including a randomized complete block design to compare outside control with interactions. The experiment comprised of two tillage practices *viz*. conventional tillage, minimum tillage as main plot treatments and five residue mulch *viz*. no residue, soybean residue, maize residue, groundnut residue and glyricidia mulch 3 t/ha as sub plot and outside control (weed free). Wheat cultivar 'UAS334' was sown at row to row spacing of 20 cm. Wheat crop fertilized with 120:60:40 kg N, P_2O_5, K_2O/ha. Entire doses of phosphorus and potassium, along with half of the nitrogen dose, was applied as basal dose at the time of sowing. The remaining half of the nitrogen was applied 30 days after sowing. The weed count and weed dry matter accumulation were recorded using quadrate of 1 m^2 size. The weeds were dried in an oven till constant weight and converted into g/m^2.

Weed count and weed dry weight data were analysed to square root transformation ($\sqrt{X+1}$) to normalize their distribution (Gomez and Gomez, 2010).

Weed control efficiency (WCE):

$$WCE\ (\%) = \frac{\text{Dry matter of weeds in weedy check plot (g)} - \text{Dry matter of weeds in treated plot (g)}}{\text{Dry matter of weeds in weedy check plot (g)}} \times 100$$

Weed index (WI):

$$WI\ (\%) = \frac{X - Y}{X} \times 100$$

Where,
X = Wheat yield from weed free plot.
Y = Wheat yield of the treated plot.

RESULTS AND DISCUSSION

Weed flora

The experimental crop was heavily infested with grass weeds, sedges and broad-leaved weeds. Among the grass weeds *Dinebra retroflexa, Echinochloa colona, Digitaria sanguinalis, Brachiaria eruciformis* and *Cynodon dactylon.* Among broad-leaved weeds, *Lagascea mollis, Euphorbia geniculate, Ageratum houstonianum, Convolvulus arvensis*, *Alternanthera sessilis, Parthenium hysterophorus, Amaranthus viridis, Physalis minima, Phyllanthus niruri, Commelina diffusa, Portulaca oleracea.* Among sedges, *Cyperus rotundus* was noticed. The weed population were increased from 60 DAS to harvest stage of wheat crop due to degradation of residue mulch over time. The data clearly indicated that tillage and the crop residue mulch had considerable effect on weed density.

Grasses

Tillage along with residue mulch affected number of grass weeds significantly at all the stages of wheat (Fig 1). Among tillage, significantly lowest number of grass weeds (3.6, 5.0, 12.6 and 21.8/m^2) were observed with conventional tillage over minimum tillage at different growth stages of crop. However, among the residue mulch, significantly lowest number of grasses recorded with glyricidia residue mulch compared to other treatments of residue mulch (Fig 2). Interaction effect between tillage and crop residue application was significant. Significantly lowest number of grass weeds was observed in conventional tillage with glyricidia residue as compared to other treatments. Significantly highest grass weeds were recorded in minimum tillage-with no residue. Compared to treatment combinations of tillage and crop residue, control treatment recorded significantly lowest number of grass weeds.

Sedges

At different growth stages of wheat (Fig 1), conventional tillage recorded lower number of sedges compared to minimum tillage. Among residue mulch, glyricidia residue registered significantly lower number of sedges compared to no residue, groundnut, soybean and maize residue (Fig 2). No residue recorded higher sedges compared to all other residue mulch application. Among interactions, lower sedge number was recorded in conventional tillage with glyricidia residue treatment. Number of sedges was higher in minimum tillage with no residue treatment. Control treatment recorded lower sedge number compared to all other interactions.

Broad-leaved weeds

Number of broad-leaved weeds was substantially lower at 20, 40, 60 DAS and harvest stages of wheat (Fig 1) in conventional tillage compared to minimum tillage. Among residue mulch application, glyricidia residue observed a notable reduction in broad leaved weed count compared to maize residue, soybean and groundnut residue treatments (Fig 2). Significantly higher broad leaved weed number was in no residue treatment. Conventional tillage with glyricidia residue recorded significantly lower broad-leaved weeds. Significantly higher broad-leaved weeds were recorded in minimum tillage with no residue treatment. In the control (weed free), there were significantly fewer broad-leaved weeds compared to all other treatments.

Total dry weight of weeds

Dry weight of weeds increased as the crop growth stages advanced from emergence to harvest (Table 1). At all crop growth stages, significantly lowest total dry weight of weeds recorded in conventional tillage in comparison with minimum tillage. Wozniak and Soroka (2017) revealed that minimum tillage increased weed infestation of crops and indicate higher biomass of weeds in the minimum tillage than in the conventional tillage. Significantly total weed dry weight was lower with glyricidia residue compared to other treatments of residue mulch. This might have happened due to lower population of broad-leaved weeds, grasses and sedges. No residue recorded higher total weed dry weight among other residue mulch treatments.

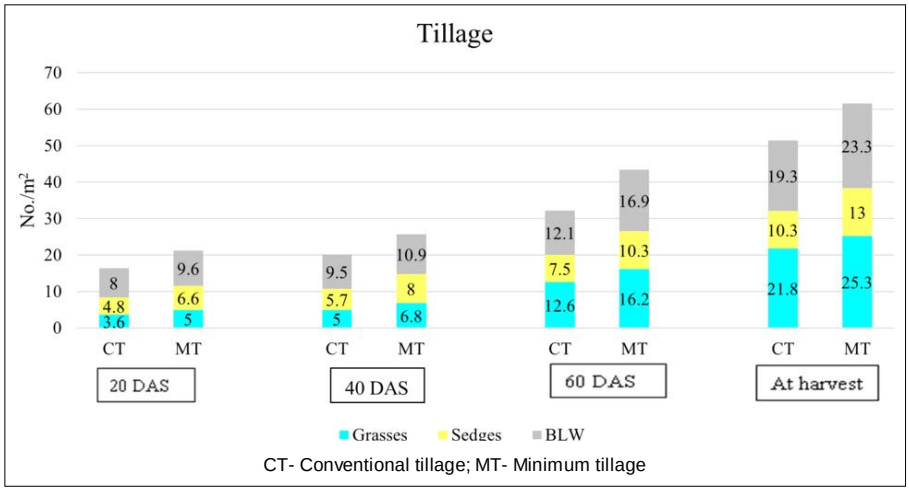


Fig 1: Number of grasses, sedges and broad-leaved weeds (BLW) at different stages as influenced by tillage practices.

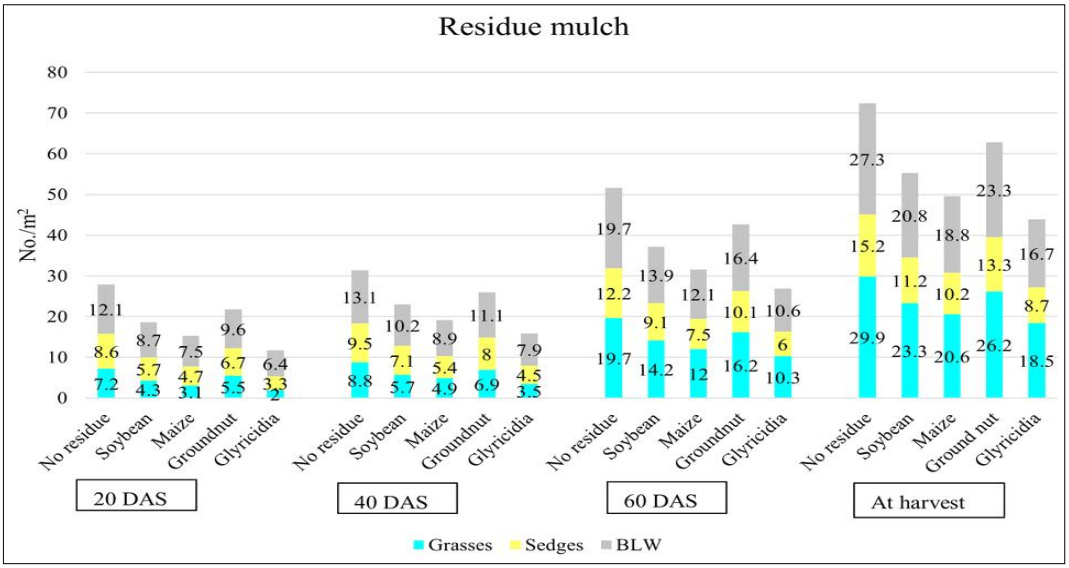


Fig 2: Number of grasses, sedges and broad-leaved weeds (BLW) at different stages as influenced by residue mulch.

Similar findings were reported by Zhang and Lan-Fang (2021) in wheat-maize cropping system under semi-arid climatic condition of Calcaric Fluvisol and Ganapathi *et al.* (2024) in maize-greengram cropping system in conservation agriculture.

Conventional tillage with glyricidia residue significantly decreased the weed dry weight as compared to other treatments. Minimum and conventional tillage without residue was not efficient in reducing weed dry weight because soil without residue favours weed emergence, rapid growth and higher weeds dry weight. On the other hand, lowest total dry weight of weeds was recorded in control. This could be attributed to control of weeds at regular intervals, which resulted in reduced dry matter production by weeds.

Weed control efficiency

It is an important parameter to decide effectiveness of different tillage practices in managing weeds. Higher weed control efficiency recorded with conventional tillage over minimum tillage at different stages (Table 2) of wheat. These results align with the findings of Wasnik *et al.* (2022) that improved weed management with conventional tillage in maize crop. The application of residue mulch resulted in a significant reduction of the dry weight of weeds, indicating higher weed control efficiency as compared to no residue. Highest weed control efficiency recorded glyricidia residue. This could be because of effective management of weeds. The remaining crop residue of maize, soybean and groundnut residue recorded higher weed control efficiency as compared to no residue treatment. The combined effect of tillage with residue mulch application registered higher weed control efficiency as compared to tillage without residue. Conventional tillage with glyricidia residue recorded higher weed control efficiency due to lower weed density and weed dry weight.

Weed index

It is an index of yield loss. The reduced weed index indicates enhanced effectiveness of weed control treatments. Weed index differed significantly with tillage and residue mulch application (Table 2). Lowest weed index recorded with conventional tillage and higher with minimum tillage (29.8%). Among residue mulch application, no residue treatment recorded highest weed index (38.3%) and glyricidia residue mulch resulted in lowest weed index

Table 1: Effect of tillage and residue mulch on total dry weight of weeds at growth stages of wheat (pooled data of 2 years).

Treatment	Dry weight of weeds (g/m^2)			
	20 DAS	40 DAS	60 DAS	At harvest
Tillage				
T_1: Conventional tillage	2.0 (3.2)	2.6 (5.7)	3.3(10.1)	4.1(15.9)
T_2: Minimum tillage	2.3 (4.5)	2.8 (7.1)	3.6 (12.4)	4.6 (20.1)
SEm (±)	0.03	0.03	0.02	0.05
CD (5%)	0.17	0.18	0.16	0.28
Residue mulch				
M_1: No residue	2.7 (6.2)	3.2 (9.1)	3.9 (14.3)	5.0 (24.1)
M_2: Soybean	2.1 (3.7)	2.7 (6.4)	3.5 (11.0)	4.3 (17.5)
M_3: Maize	1.9 (2.9)	2.5 (5.3)	3.3 (9.7)	4.0 (15.4)
M_4: Groundnut	2.4 (4.7)	2.9 (7.5)	3.7(12.9)	4.6 (20.2)
M_5: Glyricidia	1.7 (2.1)	2.2 (4.0)	3.1 (8.6)	3.8 (13.6)
SEm (±)	0.04	0.03	0.05	0.03
CD (5%)	0.13	0.08	0.14	0.10
Interaction				
T_1M_1	2.5 (5.5)	3.1 (8.8)	3.7 (13.2)	4.7 (21.5)
T_1M_2	2.0 (3.1)	2.5 (5.6)	3.3 (9.9)	4.0 (15.6)
T_1M_3	1.9 (2.5)	2.3 (4.5)	3.0 (8.5)	3.8 (13.8)
T_1M_4	2.2 (3.8)	2.8 (7.0)	3.6 (11.9)	4.3 (18.0)
T_1M_5	1.6 (1.6)	2.1 (3.6)	2.9 (7.7)	3.5 (11.8)
T_2M_1	2.8 (7.1)	3.2 (9.6)	4.0 (15.5)	5.2 (26.7)
T_2M_2	2.3 (4.5)	2.9 (7.5)	3.6 (12.2)	4.5 (19.4)
T_2M_3	2.0 (3.5)	2.7 (6.3)	3.4 (10.9)	4.3 (17.3)
T_2M_4	2.6 (5.8)	3.0 (8.1)	3.8 (13.9)	4.8 (22.5)
T_2M_5	1.9 (2.6)	2.3 (4.6)	3.3 (9.7)	4.0 (15.4)
Control (WFC)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)
SEm (±)	0.09	0.08	0.08	0.15
CD (5%)	0.25	0.22	0.23	0.46

Data in parenthesis are original values and subjected to $\sqrt{X+1}$.

Table 2: Effect of tillage and residue mulch on weed control efficiency, weed index and grain yield of wheat (pooled data of 2 years).

Treatment	Weed control efficiency (%)				Weed index	Grain
	20 DAS	40 DAS	60 DAS	At harvest	(%)	yield (t/ha)
Tillage						
T_1: Conventional tillage	54.8	39.5	34.1	40.1	21.9	3.30
T_2: Minimum tillage	35.7	25.3	19.9	24.3	29.8	2.97
SEm (±)	-	-	-	-	-	0.03
CD (5%)	-	-	-	-	-	0.22
Residue mulch						
M_1: No residue	12.5	4.6	7.6	9.9	38.3	2.61
M_2: Soybean	48.8	32.4	28.9	35.0	23.3	3.24
M_3: Maize	59.7	44.8	37.5	42.3	20.1	3.38
M_4: Groundnut	34.3	21.6	16.8	24.5	30.4	2.94
M_5: Glyricidia	71.0	58.6	44.1	49.4	17.1	3.50
SEm (±)	-	-	-	-	-	0.03
CD (5%)	-	-	-	-	-	0.08
Interaction						
T_1M_1	25.1	9.2	15.1	19.7	35.9	2.71
T_1M_2	58.0	42.0	36.2	42.3	18.1	3.46
T_1M_3	65.3	54.4	44.9	48.9	16.2	3.55
T_1M_4	47.9	28.4	23.3	33.0	26.8	3.09
T_1M_5	77.8	63.6	50.8	56.5	12.2	3.70
T_2M_1	-	-	-	-	40.7	2.51
T_2M_2	39.6	22.8	21.6	27.8	28.5	3.02
T_2M_3	54.1	35.1	30.0	35.6	24.1	3.21
T_2M_4	20.6	14.8	10.3	15.9	33.9	2.79
T_2M_5	64.3	53.6	37.5	42.4	21.9	3.30
Control (WFC)	100.0	100.0	100.0	100.0	-	4.22
SEm (±)	-	-	-	-	-	0.04
CD (5%)	-	-	-	-	-	0.14

(17.1%). Lowest weed index recorded in conventional tillage with glyricidia residue (12.2%). This happened mainly because all types of weeds were effectively controlled during the critical weed competition stage of wheat crop. Higher weed index (40.7%) was obtained in minimum tillage with no residue was primarily because of lower wheat grain yield due to competition offered by weed for nutrients, moisture, space and light.

Yield

The conventional tillage produces higher wheat grain yield (3.30 t/ha) compared to minimum tillage (2.97 t/ha). Birla *et al.* (2023) revealed that conventional tillage lowers the crop-weed competition and improves crop availability by providing an adequate and balanced proportion of plant nutrients, moisture, space and sunshine during the growth and reproductive stages, which ultimately contributes to yield. Residue mulch application statistically significant effect on grain yield (Table 2). Significantly higher wheat grain yield (3.50 t/ha) recorded with glyricidia mulch compared to maize (3.38 t/ha), soybean (3.24 t/ha), groundnut (2.94 t/ha) and no residue (2.61 t/ha) treatments. Significantly lowest wheat grain yield was observed with no residue treatment. Ngullie *et al.* (2022) reported that incorporation of mulching materials might have increased the soil moisture, temperature, soil organic matter and microbial activity which in turn increased the crop yield. However, wheat grain yield (3.70 t/ha) in conventional tillage with glyricidia was higher than rest of the treatments. Lowest wheat grain yield (2.51 t/ha) under minimum tillage with no residue. Control (weed free) considerably increased grain yield (4.22 t/ha) compared to other interactions with minimum tillage and mulch. Significantly highest yield in control was obtained because it provided a weed-free environment for the crop throughout the crop's growth period and the crop didn't compete for nutrients and water, which improved growth as well as yield (Rathod *et al.*, 2021).

CONCLUSION

The study clearly indicates that tillage type and residue mulch significantly influence weed density, dry weight and control efficiency in wheat crop. Conventional tillage with glyricidia residue proved to be the most effective, reducing grasses, sedges, broad leaved weeds, weed dry weight

and weed control efficiency, ultimately leading to higher wheat grain yield. In contrast, minimum tillage with no residue resulted in increased weed growth, competition and a reduced yield. These findings highlight the importance of integrated tillage and residue management in optimizing weed control and enhancing crop productivity in wheat cultivation.

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Conflict of interest

All authors declare that they have no conflict of interest.

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