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Studies on the Effects of Different Tillage and Weed Management Approaches on Weed and Growth Parameters in Maize Crops and Its Influence on Yield

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Abstract

A field experiment was conducted at AICRP on Weed Management, MRS, Hebbal, Bengaluru during *kharif* 2019 and 2020 to study the effect of different conservation tillage and weed management approaches on weed density, weed dry weight, and days to 50 per cent tasseling, silking, leaf area index and also kernel yield of maize and B:C ratio. The experiment was laid out in a split-plot design with five main plots of different tillage treatments and three sub-plots of different weed management practices replicated thrice. The main plot tillage treatments consisted of conventional tillage, zero tillage, minimum tillage, minimum tillage + zero tillage (combination) and permanent bed. Among tillage practices, permanent bed recorded the least total weed density (65.3 No.m^{-2}) and weed dry weight (7.6 g m^{-2}) at 60 DAS compared to other tillage practices and also high leaf area index, kernel yield, and B: C ratio (2.5, 3.36 t ha^{-1} and 1.44, respectively) due to less weed infestation, good root growth, adequate aeration and nutrient availability compared to other tillage practices. The subplot weed management practices consisted of W_1-Recommended herbicides (Pendimethalin-750 g ha^{-1} (PE) + *fb* tembotrione 120 g ha^{-1} + atrazine 500 g ha^{-1}), W_2-Integrated weed management (Pendimethalin-750 g ha^{-1} (PE) + Hand weeding at 30 DAS) and W_3- Unweeded. Among weed management practices, *i.e.*, Integrated weed management (Pendimethalin-750 g ha^{-1} (PE) +Hand weeding at 30 DAS) recorded the least total weed density at 60 DAS, weed dry weight (60.9, 7.2, respectively) compared to unweeded treatment (82.6, 8.8, respectively) and early, 50 per cent tasseling and silking, (51.2 and 57.2, respectively) compared to unweeded (53.9 and 61.8) and also high leaf area index, kernel yield, and B: C ratio (2.8, 3.43 t ha^{-1} and 1.45, respectively) due to less weed infestation, compared to unweeded treatment (1.7, 2.47 t ha^{-1} and 1.28, respectively).

Keywords: Zero tillage, Minimum tillage, Weed management, Maize

Maize (*Zea mays* L.), popularly known as the queen of cereals, is considered as the third most important cereal crop after wheat and rice in the world. India ranks fourth in terms of the maize growing country in the world with 9.72 m ha area, 28.64 m tonnes of production and average productivity of 2945 kg ha^{-1} (Anonymous, 2020). In Karnataka, it occupies 1.40 m ha area, with 3.96 m tonnes of production and average productivity of 2839 kg ha^{-1}. It contributes to more than half of the coarse cereal production of the country and is widely used as a dual-purpose crop for animal feed as well as industrial raw material in the developed countries, whereas, in the developing countries it is used as a general feed for a human being. In concern to the Indian agricultural scenario, the growth in maize area and production was steady since 1950 but the growth rate in both area and production of maize increased unprecedented in the country during the last ten years due to the adoption of improved production technologies, varieties / hybrids as well as expansion in non-traditional areas / states like Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu etc. In order to meet the growing requirements of the human and livestock population in the years to come, there will be greater pressure on the lands of rainfed regions of India to produce more which may aggravate degradation if remedial measures are not adopted. Improving SOC stock is, therefore, crucial to sustaining soil quality and enhancing agricultural productivity particularly from the rainfed regions (Srinivasa *et al*., 2011).

Reducing the tillage intensity and maximizing the surface cover through the retention of crop residues are the essential components of conservation agriculture (FAO, 2013). Conservation agriculture (CA), considered as an alternative strategy world over to sustain and possibly improve agricultural production, is widely reported to reduce soil erosion, enhance infiltration, improve soil organic stocks and enhance soil quality in varied crops and environments, while reducing risks of soil degradation under rainfed conditions (Vlek and Tamene, 2010). Minimizing the intensity of tillage is one of the major conservation agricultural practices which needs to be evaluated under various crops and cropping systems for Indian conditions (Veeresh *et al.,* 2016). The fundamental principle for all agro-technologies is to maximize the yield by utilizing the soil and other natural resources without making a negative impact on the environment. Dhanapal *et al.* (2019) studied crop rotation involving alternating different crops in a systematic sequence on the same land. It is an important strategy for developing a sound long-term weed control program. Weeds tend to compete with crops for similar growth requirements as their own and cultural practices designed to contribute to the crop may also benefit the growth and development of weeds.

Material and Methods

The field experiment was conducted during *kharif,* 2019 and 2020 to study the effect of different tillage and weed management practices on weed occurrence and growth parameters and yield of maize. The field study was conducted at AICRP on weed management, Main Research Station, Hebbal, Bengaluru. The soil of the experimental site was sandy loam with a pH of 6.34 and with low organic carbon content (0.34 %). The field experiment was conducted using split-plot design with five main plots on different tillage treatments and three sub-plots of different weed management practices replicated thrice. The main plot of tillage treatments consisted of conventional tillage, zero tillage, minimum tillage, minimum tillage + zero tillage (combination) and permanent raised bed. The sub-plot weed management practices consisted of W_1- Recommended herbicides (Pendimethalin-750 g ha^{-1} (PE) + *fb* tembotrione 120 g ha^{-1} + atrazine 500 g ha^{-1}), W_2-Integrated weed management (Pendimethalin-750 g ha^{-1} (PE) + Hand weeding at 30 DAS) and W_3-Unweeded(control). The experiment consists of five main tillage treatments and three sub weed management treatments which were replicated thrice in split-plot design.

The maize (MAH 14-5) was sown at a spacing of 60 cm x 30 cm between row and plants. Fertilizer level of 150 kg N, 75 kg P_2O_5 and 40 kg K_2O ha^{-1} was applied as per the recommendation, all the fertilizers were given as basal dose only. The pre-emergence and post-emergence herbicides were applied using a spray volume of 750 litres ha^{-1} and 500 liters ha^{-1} with a knapsack sprayer having WFN nozzle. The data on species wise weed count in a quadrant of 50 cm x 50 cm were collected at 60 DAS (days after sowing). Data averaged over three replications. From density of major weed species per m^2 and density of weeds category-sedges, grass and broad leaf weeds on 60 DAS were worked out (Table 1). In addition, total dry weight was also recorded at 60 DAS. The data on weeds density and dry weight were subjected to the transformation of square root (x+0.5) depending on the variability and weed index calculated by using the formula suggested by Gill and Vijaykumar (1969). Leaf area index was calculated at 60 DAS by using the below formula given by Watson (1947).

$$LAI = \frac{\text{Leaf area of plant}}{\text{Ground area covered by plant}}$$

The data collected on different traits were statistically analyzed using the standard procedure and the results were tested at a five per cent level of significance as given by Gomez and Gomez (1984). The least significant differences were used to compare treatment means.

Results and Discussion

Effect of Conservation Tillage and weed management practices on Weeds

The tillage practices did not significantly influence the weed density and weed dry weight at 60 DAS. The

TABLE 1

Weed density (No. m^{-2}) at 60 DAS in *kharif* maize (2019 and 2020) as influenced by tillage and weed management practices

Treatments	Sedge			Grasses			Broad leaf weeds			Total		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Tillage practices (T)												
M_1= Conventional tillage (CT)	4.3 (19.2)	5.17 (26.3)	4.9 (24.2)	6.0 (37.8)	3.74 (14.1)	5.1 (25.9)	4.3 (18.0)	4.94 (24.4)	4.4 (19.3)	8.6 (75.0)	8.06 (64.8)	8.3 (69.4)
M_2= Zero Tillage (ZT)	4.3 (18.8)	5.19 (26.9)	4.9 (24.3)	5.7 (34.4)	3.79 (14.8)	4.9 (24.6)	3.8 (14.1)	5.25 (27.3)	4.8 (22.3)	8.1 (67.3)	8.31 (69.0)	8.4 (71.2)
M_3= Minimum Tillage (MT)	4.5 (20.3)	5.57 (30.7)	5.1 (25.7)	5.5 (32.1)	3.55 (13.1)	4.6 (22.2)	4.5 (20.0)	5.30 (28.0)	5.0 (25.2)	8.4 (72.4)	8.48 (71.8)	8.5 (73.2)
M_4= Zero Tillage (ZT)	4.0 (15.3)	5.92 (34.7)	5.4 (29.5)	5.8 (34.6)	3.68 (13.7)	4.9 (23.8)	4.4 (19.4)	4.81 (22.9)	4.6 (20.7)	8.2 (69.3)	8.45 (71.3)	8.6 (74)
M_5= Permanent raised bed	3.6 (12.8)	4.87 (23.3)	4.7 (22)	5.6 (32.6)	3.40 (11.2)	4.8 (23.3)	3.2 (10.2)	4.47 (20.9)	4.5 (19.9)	7.4 (55.6)	7.43 (55.4)	8.1 (65.3)
S.Em±	0.17	0.136	0.08	0.31	0.200	0.13	0.16	0.213	0.15	0.30	0.19	0.10
LSD (P=0.05)	0.56	0.44	0.27	NS	NS	NS	0.53	NS	NS	NS	0.63	0.31
Weed management (W)												
W_1=Recommended herbicide Pendimethalin-750 g ha^{-1} (PE) +*fb* tembotrione 120 g ha^{-1} + atrazine 500 g ha^{-1}	4.3 (18.5)	5.31 (27.9)	4.6 (21.2)	6.1 (38.2)	3.78 (14.1)	5.2 (26.7)	4.0 (15.6)	4.71 (22.0)	4.5 (20.4)	8.5 (72.3)	8.01 (64.0)	8.3 (68.3)
W_2=IWM - Pendimethalin 750 g ha^{-1} PE +Hand weeding at 30 DAS	3.7 (13.5)	5.41 (29.1)	5.1 (26.2)	4.4 (19.9)	2.89 (8.07)	3.9 (15.4)	3.6 (12.7)	4.46 (20.1)	4.4 (19.2)	6.8 (46.2)	7.57 (57.3)	7.8 (60.9)
W_3= Unweeded control	4.4 (19.9)	5.31 (28.2)	5.3 (28)	6.6 (44.7)	4.22 (17.9)	5.5 (29.8)	4.5 (20.7)	5.69 (32.0)	5.0 (24.8)	9.2 (85.3)	8.85 (78.1)	9.1 (82.6)
S.Em±	0.23	0.155	0.20	0.38	0.206	0.28	0.17	0.168	0.14	0.34	0.12	0.28
LSD (P=0.05)	0.62	NS	0.52	1.01	0.544	0.74	0.44	0.444	0.36	0.89	0.33	0.74
Interaction (TxW)												
S.Em±	0.33	0.310	0.31	0.76	0.413	0.54	0.34	0.337	0.33	0.68	0.25	0.46
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

interaction effect between tillage and weed management practices was also not significant.

Weed management practices significantly influenced the weed density and weed dry weight at 60 DAS (Table 1). At 60 DAS, integrated weed management practices of pre-emergence application of pendimethalin 750 g ha^{-1} followed by hand weeding at 30 DAS recorded significantly lower total weed density (60.9 No. m^{-2}) of sedges, grasses and broadleaf weeds compared to unweeded control (82.6 No. m^{-2}). Similar results were obtained by Singh *et al.* (2017) reported that the application of pendimethalin @ 1 kg ha^{-1} + two hoeings at 25 DAS and 45 DAS recorded lower weed density and weed dry weight at 60 DAS.

Integrated weed management practices of pre emergence application of pendimethalin 750 g ha^{-1}

TABLE 2

Weed dry weight (g m^2) and leaf area index at 60 DAS in *kharif* maize (2019 and 2020) as influenced by tillage and weed management practices

Treatments	Total Weed dry weight (g m^2) at 60 DAS			Leaf area index at 60 DAS		
	2019	2020	Pooled	2019	2020	Pooled
Tillage practices (T)						
M_1= Conventional tillage (CT)	2.9 (7.9)	2.78 (7.4)	2.84 (7.5)	2.38	2.46	2.42
M_2= Zero Tillage (ZT)	2.9 (8.2)	2.88 (8.0)	2.97 (8.4)	2.28	2.41	2.34
M_3= Minimum Tillage (MT)	3.0 (8.8)	2.75 (7.2)	2.84 (7.6)	2.27	2.37	2.32
M_4= Zero Tillage (ZT)	2.9 (8.2)	2.84 (7.7)	2.89 (7.9)	2.18	2.35	2.26
M_5= Permanent raised bed	2.8 (7.6)	2.58 (6.3)	2.82 (7.5)	2.44	2.54	2.49
S.Em±	0.04	0.03	0.03	0.06	0.04	0.04
LSD (P=0.05)	0.12	0.09	0.07	0.17	0.12	0.10
Weed management(W)						
W_1= Recommended herbicide-Pendimethalin-750 g ha^{-1} (PE) + *fb* tembotrione 120 g ha^{-1} + atrazine 500 g ha^{-1}	2.9 (8.0)	2.69 (6.9)	2.82 (7.5)	2.63	2.77	2.70
W_2= IWM – Pendimethalin 750 g ha^{-1} PE +Hand weeding at 30 DAS	2.8 (7.2)	2.50 (5.8)	2.77 (7.2)	2.66	2.80	2.73
W_3= Unweeded control	3.1 (9.2)	3.11 (9.2)	3.04 (8.8)	1.63	1.71	1.67
S.Em±	2.9	0.127	0.033	0.06	0.05	0.04
LSD (P=0.05)	0.10	0.33	0.17	0.19	0.14	0.12
Interaction (TxW)						
SEm±	0.08	0.25	0.16	0.061	0.063	0.08
LSD (P=0.05)	NS	NS	NS	NS	NS	NS

TABLE 3

Days to 50 per cent tasseling and silking in maize as influenced by different tillage and weed management practices

Treatments	Days to 50 per cent Tasseling			Days to 50 per cent Silking		
	2019	2020	Pooled	2019	2020	Pooled
Tillage practices (T)						
M_1= Conventional tillage (CT)	51.9	52.3	52.1	58.9	59.3	59.1
M_2= Zero Tillage (ZT)	52.2	52.7	52.4	59.2	59.7	59.4
M_3= Minimum Tillage (MT)	52.6	52.8	52.7	59.6	59.8	59.7
M_4= Zero Tillage (ZT)	52.7	52.8	52.7	59.7	59.8	59.7
M5= Permanent raised bed	51.6	51.9	51.7	58.6	58.9	58.7
S.Em±	0.3	0.2	0.2	0.3	0.2	0.2
LSD (P=0.05)	NS	NS	NS	NS	NS	NS
Weed management(W)						
W_1= Recommended herbicide-Pendimethalin-750 g ha^{-1} (PE) + fb tembotrione 120 g ha^{-1} + atrazine 500 g ha^{-1}	51.9	51.9	51.9	58.9	59.0	59.0
W_2= IWM - Pendimethalin 750 g ha-1 PE +Hand weeding at 30 DAS	51.3	51.1	51.2	57.3	57.1	5.7.2
W^3= Unweeded control	53.3	54.4	53.9	61.3	62.3	61.8
S.Em±	0.15	0.18	0.11	0.15	0.20	0.12
LSD (P=0.05)	0.43	0.52	0.33	0.43	0.59	0.35
Interaction (TxW)						
S.Em±	0.56	0.37	0.42	0.56	0.37	0.44
LSD (P=0.05)	NS	NS	NS	NS	NS	NS

followed by hand weeding at 30 DAS recorded significantly lower total weed dry weight (7.2 g. m^{-2}) of sedges, grasses, and broadleaf weeds compared to unweeded control (8.8 g. m^{-2}). Similarly Rajeshkumar *et al*. (2018) reported that the application of pendimethalin at 0.75 kg ha^{-1} followed by one rotary hoeing on 35 DAS recorded the highest weed control efficiency (85.9) and reduced weed populations and weed dry matter (9.52 g m^{-2}) production at 60 DAS. A similar trend was observed at 90 DAS and at harvest. In unweeded control at 60 DAS, the density of broadleaf weeds (*Ageratum conyzoides, Commelina benghalensis*, *Alternanthera sessilis* and *Borreria hispida* was highest followed by sedges and grasses. Sanodiya *et al*. (2013) reported that weed control efficiency (WCE) was maximum with pendimethalin 1.0 kg ha^{-1} + hand weeding at 30 DAS, but the lowest WCE was found with the pre-emergence application of atrazine 1.0 kg ha^{-1} alone in fodder maize.

Effect of Conservation Tillage and Weed Management Practices on Growth Parameters and Quantitative Parameters of mMaize

The plots imposed with Permanent bed and conventional tillage numerically recorded the highest leaf area index (2.5), whereas other tillage practices almost recorded leaf area index (Table 2). Among the

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weed management practices, the plots treated with pendimethalin 750 g ha^{-1} followed by hand weeding at 30 DAS recorded the highest leaf area index (2.8) compared to unweeded control (1.7). Unweeded control recorded the lowest leaf area index (1.7) due to less effective control of weeds throughout the crop growth period, unweeded control lowered the leaf area as a result of the severe competition of weeds particularly broadleaf weeds and sedges.

Similar results were found by Singh *et al.* (2017). Similar results obtained by long term application of conservation tillage practices resulted in higher values of plant height, dry matter accumulation, LAI, crop growth rate (CGR) and relative growth rate (RGR) under the permanent bed with legume residue than no-residue, and this might be due to better soil health and micro-environment created by the continuous adoption of these resources conserving practice (Memon *et al.,* 2014).

Among weed treatments, significantly higher number of days were taken for 50 per cent tasseling and silking in unweeded control (53.9 and 61.8, respectively) when compared to two other treatments (Table 3). Similar results were found by Kommireddy,(2018) reported that among different treatments, the significantly higher number of days taken for 50 per cent tasseling and silking in unweeded control when compared to all other treatments.

TABLE 4

Kernel yield and B: C ratio in maize as influenced by tillage and weed management practices

Treatments	Kernal yield (t ha^{-1})			B : C ratio		
	2019	2020	Pooled	2019	2020	Pooled
Tillage practices (T)						
M_1= Conventional tillage (CT)	3.11	2.92	3.02	1.47	1.18	1.33
M_2= Zero Tillage (ZT)	2.9	2.93	2.91	1.47	1.26	1.37
M_3= Minimum Tillage (MT)	2.87	2.94	2.91	1.46	1.25	1.36
M_4= Zero Tillage (ZT)	2.87	2.9	2.89	1.43	1.25	1.34
M_5= Permanent bed	3.19	3.52	3.36	1.49	1.38	1.44
S.Em±	0.03	0.05	0.03	NA	NA	NA
LSD (P=0.05)	0.10	0.16	0.10			
Weed management(W)						
W_1= Recommended herbicide -Pendimethalin-750 g ha^{-1} (PE) + fb tembotrione 120 g ha^{-1} + atrazine 500 g ha^{-1}	3.12	3.18	3.15	1.46	1.26	1.36
W_2= IWM - Pendimethalin 750 g ha-1 PE +Hand weeding at 30 DAS	3.34	3.51	3.43	1.53	1.37	1.45
W_3= Unweeded control	2.5	2.44	2.47	1.40	1.17	1.28
S.Em±	0.05	0.05	0.03	NA	NA	NA
LSD (P=0.05)	0.12	0.14	0.09			
Interaction (TxW)						
S.Em±	0.09	0.11	0.08	NA	NA	NA
LSD (P=0.05)	NS	NS	NS			

Crop Yield

The plots imposed with Permanent raised bed significantly recorded the highest seed yield (3.36 t ha^{-1}), compared to other tillage practices (Table 4). Similar results were found by Jat *et al.* (2011) reported that permanent bed planting gave maximum system productivity during both years as compared to conventional tillage in maize-wheat-mungbean cropping systems. Among the weed management practices, the plots treated with pendimethalin 750 g ha^{-1} followed by hand weeding at 30 DAS recorded the highest seed yield (3.43 t ha^{-1}) compared to the use of only recommended herbicide (3.15 t ha^{-1}). Unweeded control recorded the lowest seed yield (2.47 t ha^{-1}) due to less effective control of weeds throughout the crop growth period. Unweeded control lowered the yield as a result of the severe competition of weeds particularly broadleaf weeds and sedges. Similar results were found by Rajeshkumar *et al.* (2018) when pendimethalin at 0.75 kg ha^{-1} was applied followed by one rotary hoeing on 35 DAS resulted. Similarly, a field experiment conducted at Ludhiana (India), found about 25 per cent higher grain yield with a permanent bed planting of maize than flat sowing (Kaur and Mahey, 2012) The highest yield in bed planting with the bed was due to increased number of cobs per plant and more grains per cob than flat sowing.

Economics

The higher B: C ratio (1.44) was noticed in Permanent raised bed and integrated weed management (1.45) (pendimethalin 750 g h^{-1} a followed by Hand weeding at 30 DAS). The least was recorded in unweeded control (1.28) treatment (Table 4).

Results of the experiment indicated that *kharif*- maize performed better under permanent bed due to better establishment, high seedling vigor and superior growth as a consequence of better land preparations and preparation of permanent beds compared to other tillage practices. Among weed management practices, integrated approach of pre-emergence herbicide followed by one hand weeding at 30 DAS effectively controlled the weeds up to the critical period of weed competition in maize, thereby resulted in significantly superior growth and growth attributes over-application of pre-emergence herbicide alone and unweeded control in a maize.

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