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Weed management and rapeseed mustard productivity in conservation agriculture based rice - yellow mustard - greengram cropping system in lateritic belt of West Bengal

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ABSTRACT

A field experiment was conducted during 2015-16 and 2016-17 at Agriculture Farm, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal to study the effect of tillage and weed management practices on weed growth and productivity of yellow mustard in direct-seeded rice - yellow mustard - greengram cropping system. The experiment was laid out in a strip plot design with four horizontal tillage strips and three vertical weed management strips replicated thrice. Results revealed that conservational tillage (zero tillage + residue) along with recommended herbicide (RH) (pendimethalin at 0.75 kg/ha) + one hand weeding (HW) recorded the lower values of total weed density (6.20 and 6.43 no/m^2) and dry weight (1.22 and 1.42 g/m^2) and higher values of seed yield (1.20 and 1.46 t/ha) in first and second year, respectively. In second year, conservational tillage even with RH alone registered at par values of total weed density and dry weight with conventional tillage + RH + 1 HW and it also recorded 10.2% higher seed yield than conventional tillage + RH + 1 HW. Thus, conservation tillage along with recommended herbicide alone in yellow mustard appeared to be a promising technique with respect to weed suppression and productivity of yellow mustard in conservation agriculture based rice-mustard sarson-greengram cropping system.

INTRODUCTION

Rice - yellow mustard (yellow sarson) - greengram is one of the predominant cropping systems in eastern India providing food, vegetable oil and protein. The productivity of yellow mustard in rice-yellow mustard system is far below than its potential yield due to many constraints. The major contributory causes are delayed sowing due to late harvesting of preceding long duration rice varieties and soil wetness and moisture stress at critical stage of the crop growth resulting in reduced yield (Duary *et al.* 2016a). *Rabi* season in eastern India is characterized with short and mild winter. Proper utilization of short and mild winter is one of the major challenges for the cultivation of *Rabi* crops. Time of sowing is an important non monetary input for obtaining higher yield in rapeseed-mustard. In the lateritic belt of West Bengal, the optimum time of sowing of the crop is last week of October to the second fortnight of November (Duary *et al.* 2016b). Late transplanting and delayed harvesting of rice usually result in late sowing of succeeding rapeseed-mustard when raised under conventional method of sowing which in turn reduces the yield significantly. However, this yield reduction can be minimized through manipulation of tillage operations enabling early sowing of rapeseed-mustard by adopting reduced tillage systems. Zero tillage (ZT) can advance the sowing time through a single tractor operation using a specially designed seed-cum-fertilizer drill. However, ZT practices are more advantageous when crop residues are retained on the soil surface, which serves as physical barrier towards emergence of weeds, moderate soil temperature, conserve soil moisture add organic matter and solve the problem of air pollution arising due to large-scale burning of straw residues (Sharma *et al.* 2012). Thus conservation agriculture (CA) is a viable alternative which is suitable for today's limited natural resources and changing climate (Nichols *et al.* 2015).

Conservation agriculture systems, comprising no or minimum mechanical soil disturbance, organic mulch soil cover and crop diversification, in conjunction with other good practices of crop and production management are now practiced globally on about 157 Mha (Kassam *et al.* 2015). In India,

over the past few years, the adoption of ZT and CA has expanded to cover about 1.5 million hectares (Jat *et al.* 2014). Heavy weed infestation in initial years is the major hindrance in wide-scale adoption of conservation agriculture technologies. However, it has been experienced that weed problems gradually decrease after a few years of true conservation agriculture (Sharma and Singh 2014). Weed management has been recognized as an essential component of CA and, thus, requires special attention. In CA, weed can be controlled manually or by using herbicides. However, labour is becoming expensive and is rarely available at the critical time of weeding. Herbicides are being extensively used in CA, but there is no single herbicide which can be applied for a wide spectrum of weeds. Hence, integrated weed management is highly desirable to enhance the sustainability of CA. Keeping this in view, a field experiment was carried out to study the effect of tillage and weed management practices on weed growth and productivity of yellow mustard in a conservation agriculture based rice-yellow mustard – greengram cropping system.

MATERIALS AND METHODS

A field experiment was conducted during 2015-16 and 2016-17 at Agriculture Farm, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal. The soil of the experimental field was sandy loam in texture with acidic reaction (5.72) and low in available nitrogen (158.3 kg/ha), P_2O_5 (38.75 kg/ha), K_2O (102.5 kg/ha) and organic carbon (0.39%).

The experiment was laid out in a strip plot design with three replications. Four tillage practices comprising of conventional tillage (CT) (direct-seeded rice) — CT (yellow mustard) — CT (greengram), CT (direct-seeded rice) — zero tillage (ZT) (yellow mustard) — ZT (greengram), ZT (direct-seeded rice) — ZT (yellow mustard) — ZT (greengram), ZT + residue (R) (direct-seeded rice) — ZT + R (yellow mustard) — ZT + R (greengram) were allocated to the horizontal strip and three weed management practices, *viz.* recommended herbicides (RH) (pendimethalin at 1.0 kg/ha followed by bispyribac-sodium at 25 g/ha in direct-seeded rice, pendimethalin at 0.75 kg/ha each in yellow mustard and greengram), Recommended herbicides + hand weeding (HW) at 35 days after sowing (DAS), Unweeded control were assigned to the vertical strip. Pre-sowing (12 days before sowing) application of glyphosate was done at 1.0 kg/ha on the established weeds in zero and conservation tillage plots. Full amount of crop residue (100%) of direct seeded rice, yellow mustard and greengram from respective treatments of conservation tillage were retained in the plot itself. Crop varieties '*MTU-1010*', '*B-9*' and '*Samrat*' were used for rice, yellow sarson, and greengram, respectively. Direct-seeded rice, yellow mustard and greengram were mechanically sown with zero till ferti-seed drill machine (National Zero Till Ferti-Seed drill, Ludhiana). The line to line spacing of zero-till drill was adjusted at 20 cm for direct-seeded rice and 30 cm each for yellow mustard and greengram. Seed rate was fixed by adjusting the lever at 60 kg/ha for direct seeded rice, 5 kg/ha for yellow mustard and 25 kg/ha for greengram. Recommended N, P_2O_5 and K_2O at 80:40:40 kg/ha in rice, 80:40:40 kg/ha in yellow mustard and 20:40:40 kg/ha in greengram were applied as per recommended practice. In yellow mustard full amount of phosphorus and potash and half of the nitrogen was applied as basal at the time of sowing. The remaining dose of nitrogen was top dressed at the pre-flowering stage (at first irrigation). A basal dose of nutrients were drilled through 10-26-26 and urea. Hand operated knapsack sprayer fitted with a flat fan type nozzle was used for spraying the herbicides with a spray volume of 500 litres/ha. All other recommended agronomic practices were followed and plant protection measures were adopted as per need. The density of monocot and dicot weeds was recorded at 45 DAS by placing a quadrat of 50 × 50 cm from the marked sampling area of 1.0 m^2 in each plot. For recording their biomass, weed samples were sun-dried and later oven dried at 70° C until constant weight was attained. The data were subjected to a square root transformation to normalize their distribution. Yield attributes and seed yield of yellow mustard was recorded at harvest and statistically analyzed at a 5% level of significance.

RESULTS AND DISCUSSION

The total number of weed species was 16 out of which *Echinochloa colona, Digitaria sanguinalis, Cynodon dactylon* and *Cyanotis axillaris* among monocots and *Ageratum conyzoides, Spilanthes paniculata, Polygonum plebeium, Gnapahalium purpureum, Chenopodium album, Physalis minima, Eclipta alba, Oldenlandia corymbosa, Cleome viscosa, Ludwigia parviflora, Solanum nigrum* and *Indigofera hirsuta* among dicots made the composition of weed flora in yellow mustard field. Duary *et al.* (2015) also reported similar weed flora in yellow mustard.

Tillage and weed management practices exerted significant influence on density and dry weight of monocot, dicot and total weeds at 45 DAS in both the years. Among different tillage practices conventional

tillage (CT-CT-CT) recorded significantly the lowest density of monocot weeds at 45 DAS in the first year but in the second year it was the lowest under conventional *fb* zero tillage (CT-ZT-ZT) having no significant difference with conservation tillage (ZT+R- ZT+R- ZT+R) (**Table 1**). All tillage practices except zero tillage (ZT-ZT-ZT) recorded at par values of dry weight of monocot weeds in the first year while in the second year it was significantly the lowest under conservation tillage (ZT+R- ZT+R- ZT+R). Conservation tillage (ZT+R- ZT+R- ZT+R) recorded the lowest density and dry weight of dicot weeds at 45 DAS and was statistically at par with zero tillage (ZT-ZT-ZT) during both years of study. Although conservation tillage (ZT+R- ZT+R- ZT+R) registered at par values of total weed density with conventional tillage (CT-CT-CT) in the first year but in the second year the lowest density of total weeds was noticed under conservation tillage (ZT+R- ZT+R- ZT+R). Conservation tillage (ZT+R- ZT+R- ZT+R) maintained significant superiority over other tillage practices in registering the lowest total weed dry weight at 45 DAS in both the years accounting 8.3 and 67.5% lower than conventional tillage (CT-CT-CT) in the first and second year, respectively (**Table 1**).

Under conservation tillage (ZT+R- ZT+R- ZT+R) the minimum disturbance of soil might have contributed to the unfavourable conditions for germination at the surface which prevented the emergence of weeds (Sharma and Singh 2014). The retention of previous crops residues under conservation tillage might have suppressed the weed growth by influencing light transmittance, soil temperature, soil moisture and enhancing weed seed predation (Nichols *et al*. 2015). Among weed management practices pre-emergence application of pendimethalin at 0.75 kg/ha + one HW at 35 DAS recorded significantly the lowest density and dry weight of monocot, dicot and total weeds at 45 DAS in both the years (**Table 1**). Mitra (2011) and Patel *et al*. (2013) also reported similar efficacy of pendimethalin followed by one HW in reducing the density and dry weight of total weeds. Interaction effect on density and dry weight of monocot, dicot and total weeds at 45 DAS in both the years (**Figure 1-4**) expressed that conventional tillage (CT-CT-CT) along with RH + 1 HW registered the lowest density of monocot and total weeds at 45 DAS in both the years and remained at par with CT-ZT-ZT + RH+1 HW in the first year and all other tillage practices + RH + 1 HW in the second year. Similarly, the dry weight of monocot and total weeds was the lowest under CT-CT-CT + RH + 1 HW in the first year but under conservation tillage + RH+1 HW in the second year. Even conservation tillage in unweeded plots also registered at par values of dry weight of monocot and total weeds with conventional tillage + RH in the second year. All tillage practices with RH + 1 HW registered zero density and dry weight of dicot weeds at 45 DAS in both the years excepting conventional tillage + RH + 1 HW in the second year (**Figure 2 and 4**).

Effect on crop

The highest number of siliquae/plant, seeds/ siliqua and test weight was registered under conservation tillage (ZT+R- ZT+R- ZT+R) in both the years and was statistically at par with CT-CT-CT in the first year and with ZT-ZT-ZT in the second year. Although conservation tillage (ZT+R- ZT+R- ZT+R) registered at par values of seed yield with conventional tillage (CT-CT-CT) in the first year but in the second year it registered 35.4, 24.5 and 19.3% higher seed yield than CT-CT-CT, CT-ZT-ZT, and

Table 1. Density and dry weight of weeds in yellow mustard under different tillage and weed management practices at 45 DAS

Treatment	Weed density (no./m^2)						Weed dry weight (g/m^2)					
	Monocot		Dicot		Total		Monocot		Dicot		Total	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Tillage practice												
T_1- CT(DSR) – CT(YS) – CT(G)	11.7	23.6	2.97(8.3)	3.72(13.4)	23.27	39.82	2.56(6.04)	21.05	2.07(3.8)	2.39(5.2)	3.17(9.5)	27.52
T_2- CT(DSR) – ZT(YS) – ZT(G)	15.3	16.7	3.40(11.0)	2.19(4.3)	30.78	22.45	2.46(5.54)	9.21	2.65(6.5)	1.80(2.7)	3.50(11.8)	13.13
T_3- ZT(DSR) – ZT(YS) – ZT(YS)	22.6	21.9	3.03(8.7)	1.78(2.7)	34.83	25.43	2.72(6.89)	9.93	2.46(5.5)	1.48(1.7)	3.59(12.4)	12.25
T_4- ZT(DSR)+R – ZT(YS) + R – ZT(G)+R	20.1	18.8	2.17(4.2)	1.70(2.4)	25.94	21.85	2.57(6.11)	7.03	1.80(2.7)	1.44(1.6)	3.04(8.7)	8.94
LSD (p=0.05)	0.92	2.3	0.17	0.12	2.02	2.13	0.12	2.03	0.13	0.14	0.09	1.80
Weed management practice												
W_1- Recommended herbicide(RH)	14.4	14.6	2.94(8.1)	2.48(5.7)	22.94	21.35	2.38(5.15)	6.36	2.19(4.3)	1.68(2.3)	3.16(9.5)	9.01
W_2- RH + one hand weeding	3.9	6.2	0.71(0)	0.89(0.3)	3.90	6.56	1.11(0.74)	2.22	0.71(0)	0.76(0.1)	1.11(0.7)	2.30
W_3- Unweeded control	33.9	40.1	5.03(24.8)	3.67(13.0)	59.27	54.26	4.24(17.5)	26.84	3.8(14.2)	2.90(7.9)	5.70(31.9)	35.07
LSD (p=0.05)	1.50	0.98	0.26	0.19	3.44	1.63	0.17	1.51	0.24	0.14	0.19	1.43

Figures in parentheses are the original values. The data was transformed to SQRT ($\sqrt{x+0.5}$) before analysis
CT-Conventional tillage, ZT-Zero tillage, R-Residue, DSR-Direct seeded rice, YS-Yellow mustard

Table 2. Yield attributes and seed yield of yellow mustard as influenced by tillage and weed management practices

Treatment	No. of siliquae/ plant		Seeds/ siliqua		1000 seed Weight (g)		Seed yield (t/ha)	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015 -16	2016-17
Tillage practice								
CT (DSR) – CT (YS) – CT (G)	86	73	19	19	2.50	2.43	1.11	0.87
CT (DSR) – ZT (YS) – ZT (G)	82	80	20	20	2.37	2.51	0.99	0.95
ZT (DSR) – ZT (YS) – ZT (G)	75	83	20	21	2.31	2.58	0.95	0.99
ZT (DSR) + R – ZT (YS) + R – ZT (G)+R	87	90	20	21	2.56	2.77	1.07	1.18
LSD (p=0.05)	7.16	7.22	1.44	0.86	0.14	0.14	0.09	0.07
Weed management practice								
Recommended herbicide	85	84	21	21	2.55	2.66	1.07	1.01
Recommended herbicide+ one hand weeding	97	97	21	22	2.61	2.85	1.21	1.24
Unweeded control	65	64	18	18	2.15	2.21	0.80	0.76
LSD (p=0.05)	5.66	6.69	1.83	0.77	0.13	0.15	0.09	0.07

CT-Conventional tillage, ZT-Zero tillage, R-Residue; DSR-Direct-seeded rice, YS-Yellow mustard, G-Greengram

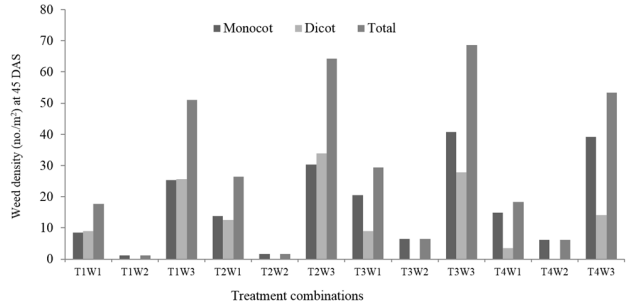

Figure 1. Interaction effect of tillage and weed management practices on density of monocot, dicot and total weeds in yellow mustard at 45 DAS during 2015-16

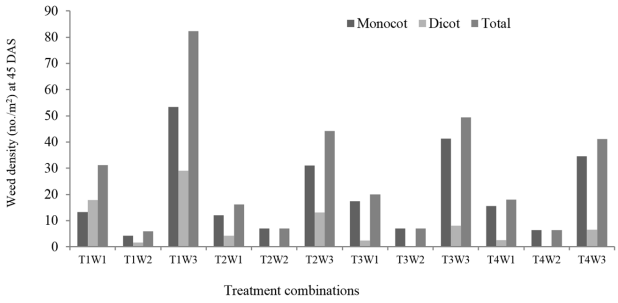

Figure 2. Interaction effect of tillage and weed management practices on density of monocot, dicot and total weeds in yellow mustard at 45 DAS during 2016-17

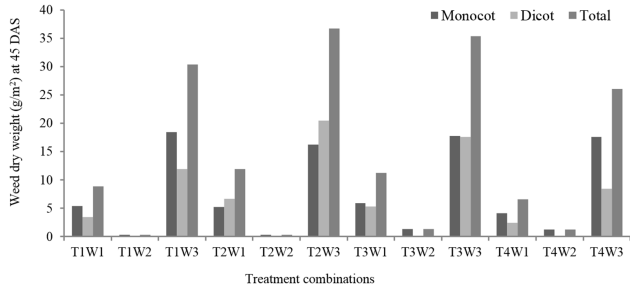

Figure 3. Interaction effect of tillage and weed management practices on dry weight of monocot, dicot and total weeds in yellow mustard at 45 DAS during 2015-16

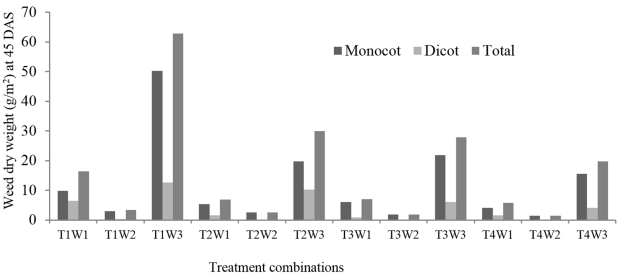

Figure 4. Interaction effect of tillage and weed management practices on dry weight of monocot, dicot and total weeds in yellow mustard at 45 DAS during 2016-17

ZT-ZT-ZT, respectively (**Table 2**). The higher values of yield attributes and seed yield of yellow mustard with conservation tillage was due to favorable influence of zero tillage and cumulative effect of residue retention which helped in greater availability of nutrients that led to increasing in growth and yield attributes and finally the seed yield. Higher yield with residue retention under conservation agriculture was also reported by Das *et al*. (2015) and Nath *et al*. (2015). Significantly the highest values of yield attributes and seed yield were recorded with RH + 1 HW at 35 DAS in both the years (**Table 2**). Significant effect of interaction was observed on number of siliquae/plant, test weight and seed yield of yellow mustard in both the years. Conservation tillage (ZT+R- ZT+R- ZT+R) with RH + 1 HW recorded at par values of siliquae/plant, test weight and seed yield with conventional tillage + RH + 1 HW in first year (**Figure 5**). But in second year, conservation tillage (ZT+R- ZT+R- ZT+R) even with recommended

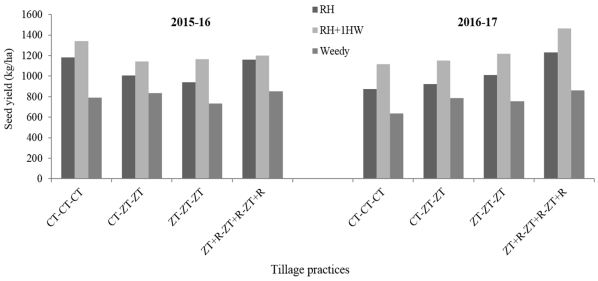

Figure 5. Interaction effect of tillage and weed management practices on seed yield of yellow mustard

herbicide only recorded at par values of siliquae /plant and test weight with conventional tillage + RH + 1 HW. Conservation tillage (ZT+R- ZT+R- ZT+R) with recommended herbicide alone recorded 10.2% higher seed yield than conventional tillage + RH + 1 HW in second year (**Figure 5**).

The results revealed the superiority of conservation tillage (ZT+R-ZT+R-ZT+R) than other tillage practices irrespective of with or without weed management. Residue retention and zero tillage are fundamental principles of conservation tillage, which themselves are the methods of weed control providing weed free environment during critical period of growth stages. The competition between crops and weeds was less from the very early stage of the crop till maturity facilitating higher nutrient and water uptake, accelerated photosynthetic activity, availability of optimum space for better crop growth resulting into higher dry matter accumulation and higher values of growth attributes and partitioning of dry matter towards seed formation (Das *et al*. 2015 and Nath *et al*. 2015).

Thus, after two cycles of CA based rice-yellow mustard-greengram cropping system, conservation tillage with recommended herbicides and one hand weeding in all the crops resulted in effective weed management and higher seed yield of yellow mustard. However, conservation tillage along with recommended herbicide alone in yellow mustard appeared to be a promising technique as it was as good as conventional tillage with integrated use of recommended herbicide and hand weeding with respect to weed suppression and productivity of yellow mustard in conservation agriculture based rice - yellow mustard - greengram cropping system.

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