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Planting method, row arrangement and crop residue mulch influence on weed dynamics and productivity of toria mustard

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ABSTRACT

A field study was conducted at ICAR-Research Complex for NEH Region, Basar during 2012-13 to study the effect of planting methods, row arrangement and mulching on toria (*Brassica campestris* L.) and associated weeds. Results revealed that at 30 and 60 days after sowing (DAS), the weed density and weed dry biomass were lesser in ridge and furrow; among row arrangement lower weeds at 6 rows followed by 3 rows over normal row planting. However, between the mulch, at 30 DAS the lower density and dry biomass were recorded with groundnut haulm mulching at 4 t/ha over no mulch, whereas at 60 DAS, dramatically no mulch plots had lesser weeds as compared to mulched plots. The number of branches/plant, siliqua/plant, seeds/siliqua, seed and stover yields were higher in ridge and furrow at 6 rows arrangement with groundnut haulm mulch at 4 t/ha.

Oilseeds are the second largest agricultural commodities in India next to cereals. The oilseed requirement in India has been significantly increased and among oilseed crops rapeseed and mustard is major contributor. During 2015-16, the rapeseeds and mustard has been grown in an area of 5.76 million ha with production of 6.82 million tonne and the productivity was 1184 kg/ha (Anonymous 2017). Toria (*Brassica campestris* L.) belongs to the group of rapeseed and mustard, perform best in the winter season and are a potentially valuable crop in rainfed condition. However, weeds are major biological constraints in toria production; the losses due to weeds vary from 20-30% (Singh *et al.* 2010). Weeds compete with crop for available resources, *viz*. space, light, nutrients, water *etc*. and the competition is more serious during early stages due to slow growth during the first 4-6 weeks after sowing. It has also been reported that if weeds are abandoned, are capable of reducing yield even more than 80% (Singh *et al.* 2012) and up to 76.3% (Kumar *et al.* 2012) in Indian mustard.

In humid climate, weeds are major production constraints. Yield losses due to weeds can be minimized using locally available crop residue as mulch material (Choudhary *et al.* 2013 and 2016). Mulch with crop residues has a significant effect on weed suppression, nutrient uptake, thermal regulation, water retention and higher microbial activities (Choudhary and Kumar 2018). Use of legume mulch has a faster rate of decomposition, thus may not provide long duration weed-free condition as cereals but can provide a considerable effect on growth and productivity. Similarly, alteration in land configuration influence the weed composition, growth and productivity, which has been documented in maize-frenchbean-toria cropping system (Choudhary 2016). Change in row arrangement of a crop may provide weed suppression due to closure planting and have better growth of either side of the row plants. However, there is limited information available on the effect of groundnut mulch, planting methods and row arrangement on weed suppression and productivity on toria mustard. Therefore, an attempt was made to study the effect of planting methods, row arrangement and mulch on toria in the fragile North Eastern Himalayan agro-ecosystem.

A field study was conducted during 2012-13 at ICAR, Research Complex for NEH Region, Basar, Arunachal Pradesh (27° 95′ N latitude and 94° 76′ E longitude, 664 m above mean sea level). The soil characteristics of the site were acidic in nature (pH 5.7) with high in organic carbon (0.87%), low in available nitrogen (210.5 kg/ha) and phosphorus (7.8 kg/ha) and high in available potash (310.5 kg/ha). The experiment was laid out in factorial randomized block design (FRBD) and replicated thrice. The gross plot size of the smallest unit was 3 × 3 m. There were three factors *i.e.* planting method (flat bed and ridge and furrow), row arrangement [normal (30 × 10 cm), 3 rows (20 × 20 × 50 cm) and 6 rows (20 × 20 × 20 × 20 × 20 × 80 cm)] and mulching (no mulch and mulching with groundnut haulm at 4 t/ha). Toria seeds (5 kg/ha) of variety '*TS-38*' were sown on 28 October 2012 with recommended package of practices except the treatment variability. Crop was applied with recommended dose of fertilizer *i.e.* 60:30:30 kg N, P_2O_5 and K_2O/ha. The crop was harvested on 15 February 2013.

Data on various yield attributes were recorded by randomly taking five tagged plants from each plot. The seed yield of toria was recorded at maturity and seed moisture content was adjusted to 9% while calculating final yield. To record the weed density, weeds were pulled out from the 0.5 × 0.5 m quadrate at 30 and 60 days after sowing (DAS) and grouped into broad-leaved, grassy weeds and sedges. Further, weed roots and soil particle adhere were separated from the plant and kept in an oven at 70±1°C for 72 hours till constant weight was observed and this was considered weed dry biomass. The weed data (weed density and dry biomass) were subjected to square root transformation ($\sqrt{x+0.5}$). The weed suppression efficiency (WSE) was recorded as per the standard formula suggested by Choudhary *et al.* (2018).

$$WSE\ (\%) = [(WDB_{control} - WDB_{treatment})/WDB_{control}] \times 100$$

where, $WDB_{control}$, weed dry biomass in normal sowing in flatbed with no mulch plot; $WDB_{treatment}$, weed dry biomass in treatment imposed plots

The data were subjected to statistical analysis using SAS 9.2 (SAS Institute, Cary, NC). The significance of the treatment was determined by the F-test and the difference between means was compared using the critical difference (CD) at 5% probability level. The interactions between factors were non-significant.

Effect on weed density and dry biomass

The study area comprised with broadleaved weeds *i.e. Ageratum conyzoides, Galinsoga parviflora, Commelina benghalensis, Chromolaena odorata* and *Borreria hispida* and grasses *i.e. Digitaria sanguinalis, Eleusine indica, Dactyloctenium aegyptium, Echinochloa colona* and *Cynodon dactylon* etc. whereas; *Cyperus rotundus* was only sedge present. At 30 DAS, between planting method, flat bed recorded the highest broad-leaved weeds, grasses and sedge by 21.3, 33.6 and 28.4%, respectively over ridge and furrows. Among row arrangement, the lowest weeds were recorded in 6 row arrangements by 25.2, 15.6 and 13.4% followed by 3 rows by 18.1, 11.4 and 12.4%, respectively over normal row planting. Between mulching, placement of mulch recorded 49.1, 20.5 and 27.3% lower weed density over no mulch. Reduction in group-wise weed density resulted in the lowering of total weed density by 22.6% in ridge and furrow, 60.7 and 22.0% in 6 and 3 rows arrangement and 40.2% in mulched plots over others (**Table 1**).

Weed dry biomass followed the trend of weed density and recorded lower weed dry biomass of broad-leaved, grasses and sedge in ridge and furrow by 30, 30.4 and 35.8%, respectively over flat bed. In 6 row arrangements, these were reduced by 30.7, 16.6 and 13.8%, respectively over normal planting, and 3 row arrangement lowered by 22, 10.9 and

Table 1. Effect of planting methods, row arrangement and mulching on weed density, weed dry biomass and weed suppression efficiency at 30 DAS in toria

Treatment	Weed density (no./m²)				Weed dry biomass (g/m²)				WSE
	BLW	Grasses	Sedge	Total	BLW	Grasses	Sedge	Total	(%)
Planting method									
Flat bed	6.0(37.1)*	3.8(14.3)	3.0(8.6)	7.7(60.0)	3.3(11.3)	3.0(8.7)	2.3(4.7)	5.0(24.7)	29.5
Raised bed	5.4(29.2)	3.4(11.1)	2.6(6.2)	6.8(46.4)	2.8(7.9)	2.5(6.0)	1.9(3.0)	4.1(17.0)	51.6
LSD(p=0.05)	0.28	0.09	0.09	0.23	0.15	0.07	0.06	0.11	
Row arrangement									
Normal	6.2(38.8)	3.8(13.9)	2.9(8.1)	7.8(60.8)	3.4(11.6)	2.9(8.1)	2.2(4.2)	4.9(23.9)	31.6
3 rows	5.6(31.8)	3.6(12.3)	2.7(7.1)	7.1(51.2)	3.0(9.1)	2.8(7.2)	2.0(3.7)	4.5(20.0)	42.8
6 rows	5.3(29.0)	3.5(11.8)	2.7(7.0)	6.9(47.8)	2.8(8.1)	2.7(6.8)	2.0(3.6)	4.3(18.5)	47.2
LSD (p=0.05)	0.35	0.11	0.11	0.28	0.18	0.09	0.08	0.13	
Mulching									
No mulch	6.6(43.9)	3.8(14.1)	3.0(8.6)	8.2(66.6)	3.7(13.2)	2.9(8.3)	2.2(4.5)	5.1(26.0)	25.7
Mulch at 4 t/ha	4.7(22.4)	3.4(11.2)	2.6(6.2)	6.3(39.8)	2.5(5.9)	2.6(6.4)	1.9(3.2)	4.0(15.6)	55.4
LSD (p=0.05)	0.28	0.09	0.09	0.23	0.15	0.07	0.06	0.11	-

BLW= Broad-leaf weeds; WSE= Weed smothering efficiency; *Figures in parentheses are original means and data are subjected to square root transformation

11.4%, respectively. The total weed dry biomass was 31.2% lower in ridge and furrow (17.0 g/m^2) than flat beds. Among row arrangements, 6 rows have total weed dry biomass lesser by 22.9% (18.5 g/m^2) followed by 3 rows by 16.4% (20 g/m^2) over normal row planting. Between mulching, placement of mulch reduced the weed dry biomass by 40.0% (15.6 g/m^2) over no mulch. Lower weed density and dry biomass helped in achieving higher weed suppression efficiency (WSE) in ridges and furrow by 22.1% over flat bed, whereas, 6 rows arrangement had 15.6% and 3 rows had 11.2% lower WSE than the normal planting. Between mulches, placement of mulch recorded 297% lower weed suppression over no mulch.

At 60 DAS, a weed density and dry biomass followed the similar trend of 30 DAS. However, between planting methods, ridge and furrow recorded considerably lesser broad-leaf weeds by 34.6 and 43.3%, grasses by 44.2 and 51.9% and sedge by 29.2 and 39.0%, respectively which was considerably more than of 30 DAS. Among row arrangement, with progress in crop duration there was an increase in weed density of broad-leaf, grasses and sedge, however, at 6 rows it was lower by 20.5 and 28.6%, 27.4 and 34.1%, 16.4 and 24.7%, respectively and in 3 rows it was 15.6 and 16.2%, 14.7 and 17.1%, 6.0 and 24.7%, respectively over normal row planting. Between mulch, the weed density of broad-leaved and sedge was dramatically increased in a mulched plot by 32.7 and 23.4%, 21.7 and 10.0%, respectively whereas, grasses were lower by 32.9 and 41.3%, respectively. This resulted in an overall reduction of weed density by 23.8% and 8.4%, respectively in no mulch (**Table 2**). The more density and dry biomass were mainly due to the progress in crop duration, the placed mulch started decomposing and the land area gets exposed resulted in more and more emergence and establishment of weeds. Similarly, the release of plant nutrients from groundnut haulm further intensified the growth and development of weeds (Choudhary 2016). Hence, poor weed suppression obtained in groundnut haulm mulched plots at later sampling time. Under such condition, the use of herbicides is not advised due to soil health hazards and environmental pollution in such a fragile ecosystem. In ridge and furrow, better WSE of 36.0% obtained as compared to the flat bed. Similarly, 6 row arrangements had 21.5% and 3 rows had 11.2% better weed suppression than normal planting. In contrarily, placement of groundnut haulm mulch had 5.1% lesser weed suppression than no mulch plots.

Yield attributes and yield

Planting method, row arrangement and mulching influenced the yield attributes and yield of toria mustard (**Table 3**). Between the planting methods, ridges and furrow had 5% more branches/plant, 11% higher siliqua/plants and 8% more seeds/plant, these help in harvesting higher seed yield of toria mustard by 11% (1218.3 kg/ha) over flat bed planting (1.097.8 kg/ha). A similar finding was also corroborated by Choudhary *et al.* (2013) in maize. Among row arrangements, at 3 and 6 row arrangements each has 8% more branches/plant, whereas, 6 rows have 6% higher siliqua and 4% more seeds/plants, while 3 rows have obtained 4% higher siliqua over normal row planting (30 × 10 cm). Better yield attributes in 6 row arrangements resulting in

Table 2. Effect of planting methods, row arrangement and mulching on weed density, weed dry biomass and weed suppression efficiency at 60 DAS in toria mustard

Treatment	Weed density (no./m^2)				Weed dry biomass (g/m^2)				WSE (%)
	BLW	Grasses	Sedge	Total	BLW	Grasses	Sedge	Total	
Planting method									
Flat bed	13.0(170.1)	5.7(32.6)	3.7(13.3)	14.6(216.0)	6.5(42.9)	3.7(13.5)	2.7(7.0)	8.0(63.4)	19.3
Raised bed	10.5(111.2)	4.3(18.2)	3.1(9.4)	11.7(138.8)	5.0(24.3)	2.6(6.5)	2.2(4.3)	5.9(35.1)	55.3
LSD (p=0.05)	0.51	0.18	0.32	0.48	0.25	0.12	0.22	0.24	
Row arrangement									
Normal	12.4(158.0)	5.4(29.5)	3.5(12.2)	14.0(199.7)	6.2(39.5)	3.5(12.1)	2.6(6.3)	7.5(57.9)	26.4
3 rows	11.6(138.2)	5.0(25.2)	3.5(11.8)	13.1(175.2)	5.7(33.1)	3.2(10.0)	2.5(5.9)	7.0(49.0)	37.6
6 rows	11.1(125.7)	4.6(21.4)	3.2(10.2)	12.5(157.3)	5.3(28.2)	2.8(7.9)	2.3(4.8)	6.4(40.9)	47.8
LSD(p=0.05)	0.62	0.22	NS	0.58	0.31	0.14	NS	0.29	
Mulching									
No mulch	10.6(113.1)	5.5(30.4)	3.2(10.0)	12.3(153.5)	5.4(29.1)	3.5(12.6)	2.4(5.4)	6.8(47.1)	39.8
Mulch at 4 t/ha	12.9(168.2)	4.5(20.4)	3.6(12.8)	14.1(201.3)	6.1(38.0)	2.8(7.4)	2.5(6.0)	7.1(51.4)	34.7
LSD (p=0.05)	0.51	0.18	0.32	0.48	0.25	0.12	NS	0.24	

BLW= Broad-leaf weeds; WSE= Weed smothering efficiency; *Figures in parentheses are original means and data are subjected to square root transformation

Table 3. Effect of planting methods, row arrangement and mulching on yield attributes and yield of toria

Treatment	Branches /plant	Siliqua /plant	Seeds /siliqua	Seed yield (kg/ha)	Stover yield (t/ha)
Planting method					
Flat bed	4.0	140	8.1	1.10	2.27
Raised bed	4.2	155	8.7	1.22	2.52
LSD (p=0.05)	NS	2.8	0.3	0.02	0.04
Row arrangement					
Normal	3.9	143	8.3	1.11	2.28
3 rows	4.2	148	8.3	1.16	2.41
6 rows	4.2	151	8.6	1.20	2.50
LSD (p=0.05)	NS	3.5	NS	0.03	0.06
Mulching					
No mulch	3.8	138	8.1	1.08	2.23
Mulch at 4 t/ha	4.4	157	8.7	1.23	2.56
LSD (p=0.05)	0.23	2.8	0.3	0.02	0.05

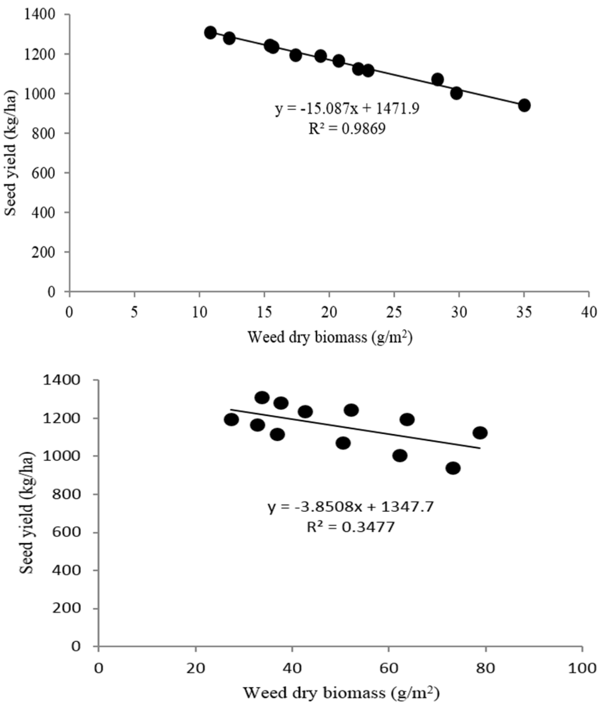

Figure 1. Relationship between seed yield and a) weed dry biomass at 30 DAS, and b) weed dry biomass at 60 DAS in toria

higher seed yield of 9% (1205.4 kg/ha) and stover yield by 10% (2999.1 kg/ha) and in 3 rows it was 5 and 6% (1162.8 and 2407.8 kg/ha, respectively) over normal row planting. Between mulch, placement of groundnut haulm mulch at 4 t/ha recorded better yield attributes *i.e.* 15% more branches/plant, 14% higher siliqua/plant and 8% more seeds/siliqua over no mulch resulted in harvesting higher seed and stover yield by 14 and 15% (1232.8 and 2562.4 kg/ha, respectively) over no mulch. The findings are conformity with the earlier findings of Choudhary (2016) in maize-frenchbean-toria cropping system. The seed yield of toria and weed dry biomass at 30 DAS has found strong negative linear relationship with coefficient of determination of 0.98 (**Figure 1a**). Whereas, with progress of crop duration at 60 DAS, there was negative correlation but the effect was non-significant (**Figure 1b**).

It can be concluded that in the fragile ecosystem of North-Eastern Himalayan Region, sowing of toria mustard in ridges and furrow with 6 or 3 row arrangements and mulching with groundnut haulm would be sustainable options for effective weed suppression and higher productivity.

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