J. Soils and Crops 31 (2) 204-212, December 2021

ISSN 0971-2836 (Print)
ISSN 2582-2756 (Online)

INFLUENCE OF LAND CONFIGURATION AND RESIDUE MANAGEMENT IN *RABI* CROPS UNDER RAINFED ECOSYSTEM OF ASSAM

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ABSTRACT

Rainfed Agriculture had played a great role in the food security of India. A field experiment on sandy loam soil was conducted during *rabi* season of 2016-17 and 2017-18 at Biswanath College of Agriculture, Assam Agricultural University, Biswanath Charilai to study the effect of moisture conservation practices in terms of land configuration and residue management in *rabi* crops. The experiment was designed and analyzed in RBD with 4 replications. The treatments consisted of six (6) moisture conservation practices (Flatbed with residue incorporation, Flatbed without residue incorporation, Broad Bed Furrow (BBF) 60-30 cm bed with residue incorporation, BBF 60-30 cm bed without residue incorporation, BBF 120-30 cm bed with residue incorporation and BBF 120-30 cm bed without residue incorporation) .Results revealed that both the BBF of size 60-30 cm and BBF 120-30 cm with residue incorporation were superior over flatbed in respect of growth, yield attributes, seed and stover yield of the crops studied and among the beds, BBF 60-30 cm size with incorporation of residues resulted better performance over BBF 120-30cm bed and flatbed . Among the four *rabi* crops studied, toria performed comparatively better in terms of growth, yield attributes as well as yieldfollowed by linseed and niger.

(Key words : BBF, LAI, seed yield, stover yield, harvest Index)

INTRODUCTION

Broad Bed Furrow (BBF) method is an emerging practice of land configuration in *rainfed* farming system which acts as *in –situ* moisture conservation during rainless periods as well as draining of water in furrows during heavy rainfall. Proper use of excess rain water received during *kharif* season in Assam may provide better initial growth and higher yields from the *rabi* crops grown. In the *rabi* season toria, linseed, niger, buckwheat, potato, lentil, pea are some of the important crops which are grown mostly under *rainfed* situation of Assam and among them, linseed, niger, buck wheat are well suited in limited water supply. Therefore, considering the importance *in-situ* conservation of moisture in *kharif* season and residual effect of land configuration coupled with residue incorporation, a trial was conducted at BN College of Agriculture, Assam Agricultural University, Biswanath Chariali, Assam during *rabi* season of 2016-17 and 2017-18 consisting toria, linseed, niger and buckwheat in *rabi* season.

MATERIALS AND METHODES

The field experiments was conducted for two years (2016 -17 & 2017-18) involving four crops (toria, linseed, niger and buckwheat) in *rabi* season The experiment was conducted at BN College of Agriculture, Biswanath chariali of Assam Agricultural University, Assam. The weather condition at Biswanath charilai is hot and humid during summer and cold and moist during winter. During the crop growing period of *rabi* season in 2016-17 (45th SMW to 11th SMW) and 2017-18(45th SMW to 10th SMW) total rainfall received were 83.4 mm and 120.7 mm against the total evaporation of 264.0 mm and 261.7 mm, respectively. The mean maximum and minimum temperature ranged between 20.4^{0}C to 30.4 ^{0}C and 9.2 ^{0}C to 18.7^{0}C during 2016-17 and during 2017-18, it ranged between 24.2^{0}C to 28.8^{0}C and 8.67^{0}C to 18.9^{0}C. The number of rainy days was 9 in 2016-17and 10 days in 2017-18.

The soil of the experimental site was sandy loam in texture with an initial P^H of 5.2 and 5.4 in 2016 and 2017, respectively. The organic carbon content was 0.59% and the initial available soil nitrogen, phosphorus and potash were in the range of low (259.10 kg ha^{-1}), medium (25.65 kg ha^{-1}) and low (112.30 kg ha^{-1}). The treatments consisted of 6 moisture conservation practices consisting land configuration of Flat bed and Broad Bed Furrow (BBF) along with crop residue incorporation. Two different sizes of BBF were studied consisting 60 cm and 120 cm width

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with a gap of 30 cm furrow size in between beds. The treatments were Flat bed with crop residue incorporation (M_1), Flat bed with no residue incorporation (M_2), BBF 60-30 cm with residue incorporation (M_3), BBF 60-30 cm without residue incorporation (M_4), BBF 120-30 cm with crop residue incorporation (M_5) and BBF 60-30 cm without crop residue incorporation(M_6).

The experimental plot was ploughed by tractor drawn plough followed by one harrowing. Laddering was done properly to retain water uniformly in the field. The layout of the experiment consisting of the broad bed furrows at 60 cm and 120 cm apart, with 30 cm width furrow in between them were constructed manually along with the flatbeds. In *rabi* season, after harvest of *kharif* green gram grown in nearby farm area by up rooting the plant, the remaining pods that left after field pickings were separated, weighed and incorporated in the experimental plots @ 5 tonnes ha^{-1} on dry weight basis as treatments^{-1}. The remaining plots were kept as such without crop residues. The entire plots in each block were prepared manually, retained the broad bed furrows and four *rabi* crops *viz*.,toria, linseed, niger and buckwheat were allocated randomly. Due to dis-similarity in biometric observations on different *rabi* crop parameters, RBD was followed for analyses of variance. The *rabi* crops were sown in lines at the recommended spacing (30 cm) of the crops in first week of November of both the years and harvested in second week of February of next year except linseed which was harvested in March. The fertilizer application and all other cultural practices were also performed as per recommendations of the crop in Assam.

For all the crops, growth parameters like plant height (cm) at 30 days interval up to harvest, dry matter accumulation (gm^{-2}), Leaf Area Index (LAI), yield attributes and yield were recorded and analyzed statistically for interpretation. The plant height of the *rabi* crops were measured from the ground level to the stem apex of the plants at 30 days interval upto harvest of the crops. The number of branches plant^{-1} was recorded at maturity from the five randomly selected plants and the average value was calculated. The number of siliqua plant^{-1}and seeds siliqua^{-1} fortoria, capsule plant^{-1}and seeds capsule $^{-1}$for linseed, capitula plant^{-1} and seeds capitulum^{-1} for niger and cymes plant^{-1} and seeds cyme^{-1}for buckwheat were recorded at maturity from the five randomly selected plants and the average value was calculated. For taking 1000 seed weight of the *rabi* crops , three samples each containing 1000 number of filled seeds from each plot were taken and weight were recorded in grams and average value was calculated. Periodic dry matter accumulation plant^{-1} was recorded at 30 days interval from sowing to maturity of all the four *rabi* crops. Five representative plants from the border rows were collected, sun-dried and oven-dried later at 65 ^{0}C and weighed. For calculating seed yield of the crops the plants from the net plots were harvested, bundled and threshed separately and weight of the seeds was recorded after proper sun drying. After separating the seeds from the harvested plants, the weight of the stover from each plot was recorded separately after proper drying and expressed in q ha^{-1}. Harvest Index (HI) was calculated using the following formula:

$$\text{Harvest Index (\%)} = \frac{\text{Economic (seed) yield}}{\text{Biological yield}} \times 100$$

The leaf area plant^{-1} was measured with the help of a leaf area meter (Model C1-231). The area of the individual leaf was determined by taking the average of ten representative leaves covering very young and mature leaves from the same plant. The total leaf area of a plant was calculated out by multiplying the leaf area of the individual leaf with the number of functional leaf per plant^{-1}.

Leaf Area Index (LAI) = Leaf area plant^{-1}/ground area covered by the plant

RESULTS AND DISCUSSION

Rabi crops

Buckwheat

Growth parameters

In 2017-18, plant height from 60 DAS to harvest was more in BBF 60-30 cm and BBF 120-30cm than the flatbed without residue incorporation (Table 1). The plant height and dry matter accumulation was not influenced by any moisture conservation practices in 2016-17 but in 2017-18, dry matter accumulation was significantly more in BBF 60-30 cm and BBF 120-30 cm than flatbed without residue incorporation. Similarly in 2017-18, Leaf Area Index was significantly more in BBF than the flatbed at 30, 60 and 90 DAS (Table 2). The performance of plant growth was better under the broad beds having closure furrows i.e. BBF 60-30 cm as compared to BBF 120-30 cm. The higher crop growth under residue incorporated treatments might have associated with the effect of *kharif* green gram residue incorporation which also acted as mulch and helped in conserving soil moisture during lean periods. Better growth of maize crop in legume-cereal (chickpea-maize) system in crop residue incorporation plots over no residue was also reported by Arif *et al.* (2011).

Yield attributes and yields of buckwheat

The number of cymes plant^{-1}, and 1000-seed weight (Table 4) did not vary significantly due to different moisture conservation practices in both the years. But the number of seeds cyme^{-1} was significantly higher under the treatment BBF 60-30 cm with or without crop residue incorporation over the flat bed methods and the lowest seeds cyme^{-1} was recorded in flat bed without residue (Table 4). Gupta *et al.* (2018) also reported that furrow irrigated raised beds might have created better micro-climate that led to the prolonged duration of water supply during the period of moisture stress resulting in higher yield attributes including number of pods plant^{-1} in soybean as compared to the conventional flat bed.

In regards to seed and stover yields (Table 5) in both the year, BBF 60-30 cm with and without residue incorporation brought about significantly higher values over that of flat beds with and without residue incorporation. The highest seed (4.93q ha^{-1} and 5.35 q ha^{-1} in 2016-17 and 2017-18) and stover (14.19 q ha^{-1} and 15.43 q ha^{-1} in 2016-17 and 2017-18) yields were recorded under BBF 60-30 cm with residue incorporation in both the years. Pooled data of yield of buckwheat over the years also showed similar results in both the cases. Similar results of the increased seed yield of safflower due to different land configurations over the flat bed sowing was also reported by Khambalkar *et al*. (2014).

Linseed

Growth parameters

The height of linseed at harvest during both the years was significantly higher in BBF 60-30 cm over flatbeds and BBF 120-30 cm without residue incorporation (Table 6). At harvest, during both the years, the dry matter accumulation due to BBF 60-30 cm with residue were significantly higher over both the BBF 60-30 cm and BBF 120-30 cm without residue and flatbeds both with and without residue incorporation. In 2017-18, BBF 60-30 cm and BBF 120-30 cm both with and without residue produced significantly higher number of primary branches $plant^{-1}$ over the flatbeds. Prolonged rain water opportunity time in the *kharif* season due to the furrows of the BBF might have influenced positively in resulting better growth of the succeeding linseed crop. A better growth, higher crop growth rate and more photosynthetically active radiation interception of soybean under BBF as compared to flatbed method of sowing were also reported by Ram *et al.* (2011).

Yield attributes and yields of linseed

The treatment BBF 60-30 cm and BBF 120-30 cm both with residue incorporation produced significantly higher number of capsules $plant^{-1}$ over rest of the treatments (Table 9). In both the years, the seed yield (Table 10) of linseed due to BBF 60-30 cm both with (6.13 and 6.29 q ha^{-1} during 2016-17 and 2017-18) and without residue (5.50 and 5.72 q ha^{-1} during 2016-17 and 2017-18) and BBF 120-30 cm with residue incorporation (5.80 and 5.96 q ha^{-1} during 2016-17 and 2017-18) were at par and BBF 60-30 cm with residue produced significantly higher seed yield over rest of the treatments. Pooled data of seed yield of linseed over the years (Table 10) revealed that significantly the higher seed yield was recorded under the treatment BBF 60-30 cm with residue incorporation over rest of the treatments.

The highest stover yields (Table 10) were recorded under BBF 60-30 cm with residue incorporation (18.45 q ha^{-1} and 19.13 q ha^{-1} during 2016-17 and 2017-18). The provision of furrows in broad beds and residues incorporation might have led to increase in organic matter contents and more water intake capacity of the soil, which ultimately increased the residual soil moisture availability for the succeeding *rabi* crops like linseed. Kumar *et al*. (2016) also reported that the residual moisture availability in the BBF coupled with crop residue incorporation helped in both vegetative and reproductive growth of wheat, resulting in higher grain and straw yield in residue retained treatments of rice-wheat cropping sequence. The increased of 37.8% pod yield in groundnut crop under BBF system of sowing over traditional method was also reported by Ingole *et al*. (1998).

Niger

Growth parameters

The growth parameters of niger *viz;* plant height, dry matter accumulation and LAI at most of the growth stages and number of primary branches $plant^{-1}$, under the treatments BBF 60-30 cm with and without residue and BBF 120-30 cm with residue were at par and BBF 60-30 cm produced significantly higher values over the flatbeds during both the year (Table 11, Table12 and Table13). Mallareddy *et al.* (2015) underlined the beneficial effects of maize residue incorporation on improvement of physico-chemical properties of soil, besides supplying essential nutrients and ability to absorb more moisture from the soil by finger millet in finger millet + pigeon pea intercropping system resulting in better growth of the crop.

Yields attributes and yield of niger

In both the year, BBF 60-30 cm and BBF 120-30 cm with residue and without residue resulted in at par effect and recorded higher capitula $plant^{-1}$ over flatbed methods of sowing (Table 14). Similar trend of results was also observed in regards to number of seeds capitula $^{-1}$ during both the years. The seed and stover yield of niger showed higher in both BBF 60-30 cm and BBF 120-30 cm as compared to flatbed method of moisture conservation (Table 15). Increased yield attributes and yield of niger under BBF might be due to better moisture and nutrient availability to the crop which may be achieved through the provision of furrows that led to increased infiltration during the rainy periods in *kharif* for better utilization of residual moisture by the succeeding *rabi* crop. Increased in seed cotton yield, stalk yield and harvest index of cotton in raised bed sowing method due to better soil environment and more availability of soil moisture under the BBF in combination with crop residue incorporation over furrow and conventional sowing method was also reported by Meena *et al.* (2018).

Toria

Growth parameters

During both years, none of the soil moisture conservation practices had significant influenced on plant height of toria (Table16).However, the moisture conservation practices significantly influenced the dry matter accumulation of toria in all the growth stages during both the years, except at 30 DAS in 2016-17 (Table17). In 2017-18, BBF 60-30 cm with residue produced significantly higher values over other treatments. Increased dry matter accumulation of wheat grown after with different tillage system and rice residue incorporation (Singh *et al.,*2014) and increased leaf area as well as LAI of cotton with broad bed furrow coupled with the incorporation of crop residue by Kumar *et al.* (2017) were also reported.

Table 1. Effect of moisture conservation practices on plant height (cm) of buckwheat

Treatments	30DAS		60 DAS		90 DAS		At harvest	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Flat bed with residue	8.80	10.40	56.45	59.38	60.40	62.80	60.90	63.53
Flatbed without residue	8.62	9.18	55.63	56.88	59.25	58.55	59.63	59.45
BBF 60-30cm with residue	9.60	11.63	60.45	63.20	65.03	67.13	65.75	67.40
BBF 60-30cm without residue	9.40	9.80	61.25	62.13	64.00	63.31	64.43	63.75
BBF 120-30cm with residue	9.18	11.00	58.63	60.38	62.15	64.15	62.43	64.55
BBF 120-30cm without residue	9.13	9.93	57.98	58.63	61.75	62.38	62.43	62.93
SEm±	0.40	0.49	2.61	1.68	2.53	1.63	1.61	1.51
CD (P=0.05)	-	1.49	-	-	-	4.91	-	4.59

Table 2. Effect of moisture conservation practices on plant dry matter (g m^{-2}) of buckwheat

Treatments	30DAS		60 DAS		90 DAS		At harvest	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Flat bed with residue	20.18	21.75	92.94	103.75	147.30	153.52	171.38	187.56
Flat bed without residue	18.60	20.00	89.63	97.75	143.30	141.51	169.25	173.24
BBF 60-30cm with residue	23.05	26.53	114.60	125.25	167.10	197.54	209.38	233.51
BBF 60-30cm without residue	23.03	23.75	111.98	118.75	161.14	166.26	207.63	218.33
BBF 120-30cm with residue	22.15	24.50	111.78	109.25	154.98	156.50	192.13	207.38
BBF 120-30cm without residue	20.10	23.25	106.83	105.25	153.33	162.03	190.25	196.56
SEm±	1.42	1.21	4.66	4.79	5.11	6.87	7.85	8.04
CD (P=0.05)	-	3.65	14.04	14.41	15.41	20.72	23.66	24.20

Table 3. Effect of moisture conservation practices on leaf area index of buckwheat

Treatments	30DAS		60 DAS		90 DAS		At harvest	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Flat bed with residue	0.53	0.58	1.30	1.43	1.10	1.14	1.02	1.08
Flat bed without residue	0.50	0.52	1.26	1.29	1.00	1.05	1.00	1.00
BBF 60-30cm with residue	0.55	0.66	1.38	1.52	1.18	1.20	1.13	1.08
BBF 60-30cm without residue	0.49	0.58	1.35	1.44	1.08	1.10	1.10	1.06
BBF 120-30cm with residue	0.55	0.65	1.37	1.53	1.20	1.21	1.13	1.13
BBF 120-30cm without residue	0.51	0.61	1.35	1.37	1.05	1.13	1.09	1.00
SEm±	0.03	0.03	0.02	0.04	0.05	0.04	0.03	0.03
CD (P=0.05)	-	0.09	0.07	0.12	-	0.11	-	-

Table 4. Effect of moisture conservation practices on number of branches $plant^{-1}$ and yield attributes of buckwheat

Treatments	**Primary branches $plant^{-1}$**		**Cymes $plant^{-1}$**		**Seeds $cyme^{-1}$**		**1000-seed weight** (g)	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Flat bed with residue	5.23	5.53	17.45	17.88	4.20	4.50	18.69	18.60
Flat bed without residue	5.33	5.38	17.38	17.10	4.10	4.25	18.40	18.63
BBF 60-30cm with residue	6.10	6.40	18.13	18.38	5.18	5.60	18.88	18.75
BBF 60-30cm without residue	6.10	6.00	17.95	17.93	5.08	5.10	18.63	18.75
BBF 120-30cm with residue	5.93	6.20	17.50	17.63	4.88	5.10	18.70	18.63
BBF 120-30cm without residue	5.80	6.15	17.40	17.20	4.83	4.90	18.60	18.50
Sem ±	0.22	0.23	0.92	1.10	0.17	0.20	0.49	0.31
CD (P=0.05)	0.67	0.71	-	-	0.53	0.61	-	-

Table 5. Effect of moisture conservation practices on yield of buckwheat

Treatments	Seed yield (q ha^{-1})			Strover yield (q ha^{-1})			Harvest Index (%)	
	2016	**2017**	**Pooled**	**2016**	**2017**	**Pooled**	**2016**	**2017**
Flat bed with residue	3.87	4.21	4.04	11.93	12.69	12.31	24.49	24.91
Flat bed without residue	3.65	3.83	3.74	11.55	11.71	11.60	24.01	24.64
BBF 60-30cm with residue	4.93	5.35	5.14	14.19	15.43	14.81	25.78	25.80
BBF 60-30cm without residue	4.75	5.11	4.93	13.98	14.93	14.45	25.36	25.49
BBF 120-30cm with residue	4.43	4.73	4.58	13.41	13.55	13.48	24.83	25.87
BBF 120-30cm without residue	4.35	4.51	4.43	13.21	13.45	13.33	24.77	25.11
SEm±	0.14	0.20	0.29	0.58	0.59	0.52	0.45	0.36
CD (P=0.05)	0.42	0.60	0.87	1.75	1.78	1.56	1.36	1.10

Table 6. Effect of moisture conservation practices on plant height (cm) of linseed

Treatments	30DAS		60 DAS		90 DAS		At harvest	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Flat bed with residue	6.05	6.58	37.43	40.38	46.15	49.63	46.50	49.95
Flat bed without residue	5.93	6.15	36.33	38.13	46.00	49.13	46.42	49.50
BBF 60-30cm with residue	6.93	7.38	44.38	48.38	51.75	55.63	52.01	56.13
BBF 60-30cm without residue	6.70	6.83	44.00	45.63	50.43	52.38	50.88	52.88
BBF 120-30cm with residue	6.10	7.10	42.20	44.38	47.45	52.47	47.89	52.90
: BBF 120-30cm without residue	6.10	6.30	41.50	43.63	47.13	50.90	47.38	49.13
SEm±	0.30	0.40	1.29	1.70	1.31	1.37	1.41	1.52
CD (P=0.05)	NS	NS	3.85	5.13	4.00	4.13	4.24	4.57

Table 7. Effect of moisture conservation practices on plant dry matter (g m^{-2}) of linseed

Treatments	30DAS		60 DAS		90 DAS		At harvest	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Flat bed with residue	20.13	21.67	62.40	69.39	196.18	201.48	226.5	235.6
Flat bed without residue	18.40	19.13	56.30	64.13	181.48	190.48	210.3	216.3
BBF 60-30 cm with residue	23.20	24.20	67.80	74.18	201.21	228.55	273.6	285.3
BBF 60-30 cm without residue	21.40	22.08	64.40	72.98	194.40	212.90	244.9	251.3
BBF 120-30 cm with residue	22.20	22.48	67.75	69.61	199.80	197.88	265.3	271.3
BBF 120-30 cm without residue	20.80	20.87	62.43	67.19	191.90	196.50	238.2	238.6
SEm±	0.82	1.26	1.69	2.12	4.99	12.16	9.13	10.37
CD (P=0.05)	2.46	3.78	5.08	6.38	15.01	36.60	27.52	31.27

Table 8. Effect of moisture conservation practices on leaf area index of linseed

Treatments	30DAS		60 DAS		90 DAS		At harvest	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Flat bed with residue	0.35	0.41	1.34	1.44	1.25	1.33	0.95	0.99
Flat bed without residue	0.33	0.39	1.30	1.38	1.16	1.23	0.93	0.97
BBF 60-30cm with residue	0.37	0.43	1.40	1.48	1.33	1.41	1.03	1.04
BBF 60-30cm without residue	0.34	0.39	1.36	1.39	1.20	1.31	0.95	0.99
BBF 120-30cm with residue	0.36	0.42	1.41	1.46	1.27	1.39	0.96	1.06
BBF 120-30cm without residue	0.32	0.40	1.38	1.40	1.18	1.35	0.93	1.00
SEm±	0.01	0.01	0.05	0.03	0.04	0.05	0.03	0.02
CD (P=0.05)	-	-	-	-	-	-	-	-

Table 9. Effect of moisture conservation practices on numbers of branches plant^{-1} and yield attributes of linseed

Treatments	Primary branches plant^{-1}		Cymes plant^{-1}		Seeds cyme^{-1}		1000-seed weight (g)	
	2016	2017	2016	2017	2016	2017	2016	2017
Flat bed with residue	3.88	3.33	38.13	39.15	9.68	9.83	4.44	4.42
Flat bed without residue	3.70	3.15	33.35	33.90	9.70	9.70	4.43	4.41
BBF 60-30cm with residue	3.98	3.88	45.20	47.25	10.25	10.38	4.45	4.43
BBF 60-30cm without residue	3.75	3.80	39.60	40.13	10.10	10.10	4.44	4.42
BBF 120-30cm with residue	3.86	3.76	42.65	44.63	9.95	10.0	4.44	4.42
BBF 120-30cm without residue	3.64	3.52	38.98	39.60	9.95	9.95	4.43	4.40
SEm±	0.11	0.09	1.33	2.20	0.49	0.32	0.04	0.04
CD (P=0.05)	-	0.24	4.00	6.59	-	-	-	-

Table 10. Effect of moisture conservation practices on yield of linseed

Treatments	Seed yield (q ha^{-1})			Strover yield (q ha^{-1})			Harvest Index (%)	
	2016	2017	Pooled	2016	2017	Pooled	2016	2017
Flat bed with residue	4.89	4.94	4.91	15.78	16.10	15.94	23.65	23.47
Flat bed without residue	4.36	4.45	4.40	15.09	15.53	15.31	22.41	22.27
BBF 60-30cm with residue	6.13	6.29	6.21	18.45	19.13	18.79	24.93	24.74
BBF 60-30cm without residue	5.50	5.72	5.61	17.30	17.58	17.44	24.12	24.54
BBF 120-30cm with residue	5.80	5.96	5.88	17.96	17.83	17.89	24.41	25.05
BBF 120-30cm without residue	5.09	5.24	5.16	16.74	16.93	16.83	23.31	23.63
SEm±	0.22	0.20	0.11	0.42	0.35	0.35	0.79	0.70
CD (P=0.05)	0.66	0.60	0.28	1.26	1.06	0.90	2.37	2.10

Table 11. Effect of moisture conservation practices on plant height (cm) of niger

Treatments	30DAS		60 DAS		90 DAS		At harvest	
	2016	2017	2016	2017	2016	2017	2016	2017
Flat bed with residue	13.88	14.83	40.25	42.85	47.70	50.55	48.35	51.03
Flat bed without residue	12.50	14.48	39.40	41.35	46.85	49.90	47.50	50.20
BBF 60-30cm with residue	15.85	16.43	46.00	48.10	52.95	55.45	53.38	56.00
BBF 60-30cm without residue	15.60	16.00	45.70	46.00	52.10	52.85	52.50	53.25
BBF 120-30cm with residue	15.10	15.40	44.13	46.10	50.90	53.15	51.50	53.85
BBF 120-30cm without residue	14.95	14.85	43.38	44.20	50.35	50.70	50.55	51.30
SEm±	0.78	0.63	1.52	1.47	1.40	1.22	1.39	1.30
CD (P=0.05)	-	-	4.57	4.43	4.22	3.69	4.10	3.81

Table 12. Effect of moisture conservation practices on plant dry matter (g m^{-2}) of niger

Treatments	30DAS		60 DAS		90 DAS		At harvest	
	2016	2017	2016	2017	2016	2017	2016	2017
Flat bed with residue	21.17	22.48	60.21	62.73	131.75	146.81	176.38	198.38
Flat bed without residue	19.15	21.15	57.60	58.38	126.68	132.78	170.25	174.37
BBF 60-30cm with residue	23.12	26.40	71.40	74.80	149.91	162.15	198.25	211.35
BBF 60-30cm without residue	20.24	21.85	61.52	62.35	139.80	144.49	196.50	198.60
BBF 120-30cm with residue	21.43	24.10	67.55	64.65	142.36	154.26	190.50	195.63
BBF 120-30cm without residue	20.10	20.16	62.40	61.89	132.10	144.28	187.25	183.63
SEm±	1.42	0.95	2.96	3.00	4.75	5.25	4.77	7.45
CD (P=0.05)	-	2.86	8.92	9.04	14.31	15.83	14.38	22.47

Table 13. Effect of moisture conservation practices on leaf area index of niger

Treatments	30DAS		60 DAS		90 DAS		At harvest	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Flat bed with residue	0.49	0.57	2.08	2.21	1.13	1.30	1.10	1.18
Flat bed without residue	0.45	0.53	2.05	2.13	1.06	1.21	1.03	1.09
BBF 60-30cm with residue	0.52	0.60	2.35	2.45	1.34	1.48	1.18	1.22
BBF 60-30cm without residue	0.49	0.53	2.25	2.21	1.30	1.35	1.00	1.16
BBF 120-30cm with residue	0.50	0.61	2.29	2.39	1.24	1.40	1.13	1.18
BBF 120-30cm without residue	0.47	0.57	2.14	2.24	1.20	1.34	1.07	1.10
SE m±	0.01	0.03	0.07	0.07	0.05	0.05	0.07	0.05
CD (P=0.05)	-	-	0.22	0.22	0.17	0.15	-	-

Table 14. Effect of moisture conservation practices on number of branches plant^{-1} and yield attributes of niger

Treatments	**Branches plant^{-1}**		**Capitula plant^{-1}**		**Seeds capitula^{-1}**		**1000-seed weight (g)**	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Flat bed with residue	4.50	4.90	18.25	18.65	21.50	22.15	3.83	3.84
Flat bed without residue	4.43	4.47	17.90	18.35	21.10	21.35	3.80	3.83
BBF 60-30cm with residue	4.80	5.13	19.40	20.52	23.25	24.95	3.85	3.87
BBF 60-30cm without residue	4.85	4.90	19.00	19.20	23.00	23.20	3.84	3.84
BBF 120-30cm with residue	4.90	5.03	18.85	19.50	22.45	23.30	3.85	3.83
BBF 120-30cm without residue	4.80	4.83	18.75	18.98	22.25	22.70	3.85	3.82
SEm±	0.08	0.12	0.30	0.61	0.49	0.8	0.08	0.06
CD (P=0.05)	0.26	0.35	0.89	1.79	1.50	2.5	-	-

Table 15. Effect of moisture conservation practices on yield of niger

Treatments	Seed yield (q ha^{-1})			Strover yield (q ha^{-1})			Harvest Index (%)	
	2016	**2017**	**Pooled**	**2016**	**2017**	**Pooled**	**2016**	**2017**
Flat bed with residue	4.32	4.64	4.48	13.21	14.28	13.74	24.64	24.52
Flat bed without residue	4.21	4.45	4.33	12.93	13.41	13.17	24.56	24.91
BBF 60-30cm with residue	5.03	5.58	5.30	14.73	15.86	15.13	25.45	26.02
BBF 60-30cm without residue	4.94	5.05	4.99	14.52	14.03	14.12	25.38	26.46
BBF 120-30cm with residue	4.76	4.93	4.84	14.40	14.39	14.56	24.84	25.51
BBF 120-30cm without residue	4.65	4.76	4.70	14.21	14.13	14.32	24.65	25.19
SEm±	0.19	0.17	0.21	0.40	0.45	0.51	0.35	0.38
CD (P=0.05)	0.56	0.52	0.56	1.20	1.35	1.31	NS	1.14

Table 16. Effect of moisture conservation practices on plant height (cm) of toria

Treatments	30DAS		60 DAS		At harvest	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**
Flat bed with residue	23.15	23.28	73.63	80.75	79.50	82.50
Flat bed without residue	23.08	23.13	73.05	79.70	78.60	82.83
BBF 60-30cm with residue	24.50	25.48	76.85	82.40	83.61	87.25
BBF 60-30cm without residue	24.88	24.50	74.63	80.15	82.74	85.75
BBF 120-30cm with residue	24.13	25.33	76.38	82.38	82.31	85.63
BBF 120-30cm without residue	24.00	24.95	75.25	82.13	82.25	85.38
SEm±	0.45	0.69	1.34	1.61	1.69	1.97
CD (P=0.05)	-	-	-	-	-	-

Table 17. Effect of moisture conservation practices on plant dry matters (g m^{-2}) of toria

Treatments	30DAS		60 DAS		At harvest	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**
Flat bed with residue	22.95	31.85	94.63	127.35	161.11	197.30
Flat bed without residue	22.53	26.45	88.85	113.15	160.76	179.12
BBF 60-30cm with residue	25.73	37.10	122.40	142.30	200.12	240.27
BBF 60-30cm without residue	25.33	34.96	114.20	137.13	193.65	210.33
BBF 120-30cm with residue	24.40	32.28	119.45	133.60	195.14	203.12
BBF 120-30cm without residue	23.20	29.30	107.53	129.44	187.23	198.29
SEm±	0.96	2.17	5.80	4.87	7.12	8.11
CD (P=0.05)	-	6.53	17.48	14.68	21.47	24.43

Table 18.Effect of moisture conservation practices on leaf area index of toria

Treatments	30DAS		60 DAS		At harvest	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**
Flat bed with residue	0.73	0.85	1.83	1.90	1.22	1.30
Flat bed without residue	0.70	0.81	1.82	1.80	1.19	1.23
BBF 60-30cm with residue	0.79	0.96	1.90	1.96	1.29	1.35
BBF 60-30cm without residue	0.76	0.93	1.87	1.83	1.27	1.27
BBF 120-30cm with residue	0.78	0.90	1.86	1.93	1.30	1.32
BBF 120-30cm without residue	0.77	0.88	1.83	1.85	1.26	1.24
SEm±	0.03	0.04	0.04	0.05	0.03	0.03
CD (P=0.05)	-	-	-	-	-	-

Table 19.Effect of moisture conservation practices on number of branches $plant^{-1}$ and yield attributes of toria

Treatments	**Branches $plant^{-1}$**		**Siliqua $plant^{-1}$**		**Seeds $siliqua^{-1}$**		**1000-seed weight** (g)	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Flat bed with residue	3.33	3.41	42.50	48.11	10.38	10.43	3.29	3.31
Flat bed without residue	3.28	3.35	41.75	44.25	10.00	10.13	3.32	3.30
BBF 60-30cm with residue	3.90	4.02	48.00	51.60	11.95	12.13	3.33	3.35
BBF 60-30cm without residue	3.86	3.70	46.75	47.13	11.15	11.88	3.33	3.33
BBF 120-30cm with residue	3.70	3.90	47.50	50.13	11.85	11.50	3.31	3.31
BBF 120-30cm without residue	3.67	3.59	46.25	48.50	11.00	10.75	3.30	3.30
SEm±	0.12	0.09	1.85	2.06	0.58	0.66	0.02	0.03
CD (P=0.05)	0.37	0.28	5.55	6.18	-	-	-	-

Table 20. Effect of moisture conservation practices on yield of toria

Treatments	Seed yield (q ha^{-1})			Strover yield (q ha^{-1})			Harvest Index (%)	
	2016	**2017**	**Pooled**	**2016**	**2017**	**Pooled**	**2016**	**2017**
Flat bed with residue	4.96	5.21	5.08	11.83	14.31	13.07	29.54	26.69
Flat bed without residue	4.73	4.81	4.77	11.13	13.28	12.20	29.82	26.58
BBF 60-30cm with residue	6.10	6.34	6.22	13.75	16.18	14.96	30.73	28.15
BBF 60-30cm without residue	5.71	5.80	5.75	13.50	15.43	14.71	28.76	27.31
BBF 120-30cm with residue	5.65	5.73	5.69	13.63	15.03	14.46	29.30	27.60
BBF 120-30cm without residue	5.40	5.48	5.44	13.43	14.88	14.15	28.67	26.91
SEm±	0.23	0.20	0.32	0.45	0.33	0.74	0.42	0.49
CD (P=0.05)	0.70	0.61	0.82	1.35	1.01	1.90	1.26	1.47

Yield attributes and yields of Toria

During both the years, different moisture conservation practices brought about significant impact on number of siliquae plant^{-1} of toria (Table19). But it failed to show any significant variation on number of seeds siliqua^{-1} and 1000-seed weight of toria. In 2016-17, the seed yield due to BBF 60-30 cm and BBF 120-30 cm and in 2017-18, BBF 60-30 cm both with and without and BBF 120-30 cm with residue incorporation were at par and significantly higher values of seed yield were recorded under BBF 60-30 cm with residue (6.10 q ha^{-1}and 6.34 q ha^{-1} during 2016-17 and 2017-18, respectively) over other treatments (Table 20).The BBF 60-30 cm with residue recorded 30.40 % increase in seed yield of toria over the flatbed without residue incorporation. Due to better tillering and crop growth, 12% higher wheat grain yield with ridge furrow planting in comparison to farmer's practice of flat planting was reported by Hussain *et al*. (2018).In respect of stover yield of the crop pooled data showed that BBF 60-30 cm with residue (14.96 q ha^{-1}) recorded significantly better over flatbed without residue incorporation (12.20q ha^{-1}).The increased of seed yield by 38.21% and stover yield by 25.91% of soybean crop under moisture conservation practices of opening of furrows over normal sowing grown at IFSR field of Dr.PDKV, Akola was also reported by Kadu *et al*. (2018).

The moisture conservation practices in terms of land configuration of Broad Bed Furrow system along with residue incorporation was beneficial in regards to growth, yield attributes and yield of different *rabi* crops *viz.,* toria, linseed, niger and buckwheat.Among the BBF, the bed size of 60-30 cm was better as compared to the 120-30 cm size bed in relation to the performance of the crops studied. The residue incorporation treatments were superior over no residue incorporation along with BBF system in all the four crops studied. Among the four *rabi* crops, linseed and niger also showed almost equal performance with toria in BBF method of land configuration in rainfed eco system of Assam.

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Rec. on 29.04.2021 & Acc. on 10.05.2021