Biological Forum – An International Journal **15(11): 01-05(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Evaluation of Conventional and Minimum Tillage System and Weed Management Practices on Weed Growth and Rice Productivity in a Rice based Cropping Sequence

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(Received: 15 August 2023; Revised: 15 September 2023; Accepted: 10 October 2023; Published: 15 November 2023)
(Published by Research Trend)

ABSTRACT: Two years of field investigation was laid to evaluate the effect of tillage and weed management practices on weed growth and productivity of *sali* rice in a *Sesbania aculeata* (S)-transplanted/direct seeded rice (TR/DSR)-Indian mustard (IM) cropping sequence during 2017-19 at the Instructional-cum-Research (ICR) farm, Assam Agricultural University (AAU), Jorhat. Treatment, minimum tillage/MT (S)-conventional tillage/CT (TR)-minimum tillage (IM) improved growth parameters, yield attributes as well as yield and recorded an increase in grain yield by 40.22 and 26.26% in 2017 and 2018, respectively with substantial reduction in weed density and weed dry matter over MT(S)-CT(DSR)-CT(IM) (T_3). Furthermore, among the weed management practices integrated weed management (IWM) and manual weeding (MW) recorded higher weed control efficiency and weed control index, and noted respective increase in grain yield of rice by 83.82 and 80.78% in 2017 and 93.29 and 98.83% in 2018 as compared to weedy check.

Keywords: Minimum tillage, Integrated weed management, Weed control efficiency and Weed control index.

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food grain of India cultivated in an area of about 43.90 million hectares with a production of 114.45 million tonnes. Out of the total area, *kharif* or winter or *sali* rice contributes to 90.07 % and 86.88 % of total rice area and production, respectively. In the country, Indian mustard is one of the important oilseed crops grown under diverse soil and climatic conditions due to greater adaptability and higher production potential. The medium duration variety of winter rice followed by medium duration variety of Indian mustard is widely adopted cropping sequence under medium land situation of Assam. The incorporation of an *in-situ* green manuring crop preceding to winter rice is practised in India from times immemorial. *Sesbania aculeata* as a leguminous crop avails nitrogen along with other nutrients to the succeeding non-leguminous crops in the sequence. However, land preparation decisions are very crucial for this sequence as transplanted winter rice (TR) needs puddled condition, but the succeeding *rabi* crop needs upland characteristics of soil for its establishment and subsequent growth. Conservation tillage practices such as minimum tillage in direct seeded rice (DSR) instead of conventional tillage in transplanted and DSR could solve the problem. When conservation tillage is being discussed, finding out an effective weed management strategy is inevitable. This paper describes the effect of conventional and minimum tillage systems and weed management practices on rice growth and productivity in a *Sesbania aculeata*-winter rice- Indian mustard cropping sequence.

MATERIALS AND METHODS

The experiment had been conducted during 2017-19 in AAU, Jorhat. It was consisted of with 5 tillage practices namely, T_1: CT (*Sesbania*)-CT (transplanted rice)-CT (Indian mustard), T_2: MT (*Sesbania*)-CT (transplanted rice)-MT (Indian mustard), T_3: MT (*Sesbania*)-CT (direct seeded rice)-CT (Indian mustard), T_4: MT (*Sesbania*)-MT (direct seeded rice)-MT+R/rice residue (Indian mustard), T_5: MT (*Sesbania*)-MT (direct seeded rice)-MT (Indian mustard) and 4 weed management practices namely, W_1: recommended herbicides (pretilachlor 0.75 kg/ha pre-emergence); W_2: IWM: integrated weed management (pretilachlor 0.75 kg/ha

pre-emergence + manual weeding 30 DAS/DAT), W_3: two manual weeding, W_4: weedy check (Kalita, 2020). The tillage practices and weed management practices were allocated in the main plots and the sub-plots, respectively in a split-plot design with 3 replications. The soil of the experimental field was sandy loam with acidic pH (5.59), medium organic carbon (0.62 %) and available N (290.60 kg/ha), low available P_2O_5 (21.70 kg/ha) and available K_2O (128.90 kg/ha). The field was ploughed thoroughly, first by tractor drawn disc plough followed by one ploughing with power tiller. Two harrowing operations were done to get a good tilth and the land was then puddled and levelled to prepare the main field for CT (transplanted winter rice/TR). For CT (direct seeded rice/DSR) treatment, all operations were carried out as in CT (transplanted winter rice/TR). In MT (DSR) treatments only one ploughing was done followed by one harrowing and levelling. During 2nd week of June, during both the years, the variety *Basundhara* was sown in the nursery bed under transplanting (45 kg/ha) and in the main field in case of direct seeded rice (75 kg/ha). For TR 30 days age seedlings were transplanted at 20 cm × 15 cm spacing in the main field. In DSR, sowing was done manually at depth of 4-5 cm depth with subsequent covering with soil at 20 cm row spacing and a thing operation was done at 15 days after sowing (DAS). As per treatment in recommended herbicide (RH), pre-emergence herbicide pretilachlor @ 0.75 kg/ha was applied 2 DAS/DAT of DSR/TR. As per treatment at 20 and 40 DAS/DAT of DSR/TR manual weeding (MW) was done. In integrated weed management (IWM), after application of pre-emergence herbicide pretilachlor @ 0.75 kg/ha, one manual weeding was done at 30 DAS/DAT of DSR/TR. The DSR was harvested on 3rd week of October and TR on 1st week of November. Observations on plant height, leaf area index (LAI), total tillers/m^2 and dry matter accumulation/m^2 at 60 and 90 DAS/DAT of DSR/TR were noted following standards procedures. Yield attributes like number of panicles/m^2, panicle length, number of filled grains/panicle and test weight as well as yields and harvest index (HI) were recorded using standards procedures.

The weed control efficiency (WCE) and weed control index (WCI) of the treatments were estimated by using the formula given below

$$\text{WCE (\%)} = \frac{\text{Weed density in weedy check} - \text{Weed density in treated plot}}{\text{Weed density in weedy check}} \times 100$$

$$\text{WCI (\%)} = \frac{\text{Weed dry matter in weedy check} - \text{Weed dry matter in treated plot}}{\text{Weed dry matter in weedy check}} \times 100$$

RESULTS AND DISCUSSION

Out of 16 species the most dominant weeds observed in transplanted rice (TR) and direct seeded rice (DSR) were *Echinochloa crusgalli* among the grasses, *Cyperus iria* among the sedges *and Ludwigia decurrens* among the broad-leaved weeds. Remarkable changes in different growth characteristics at different stages of rice had been observed during two years of experimentation. The higher number of tillers/m^2, LAI and dry matter accumulation (DMA) was calculated under MT(S)-CT(TR)-MT(IM) (T_2) at 60 and 90 DAT (Table 1). However, this treatment was statistically at par with respect to growth parameters of rice with all the treatment except MT(S)-CT(DSR)-CT(IM) (T_3). Significantly reduced LAI under T_3 might be attributed to spatial crop weed competition for leaf expansion and tillers/m^2. Moreover, increase in crop weed competition for other growth factors (Fig. 1) *viz*., light, space, water, nutrients etc. under T_3 resulted decrease in accumulation of phostosynthates in lesser leaf area resulting declined DMA of rice. The obtained outcomes are validated by similar findings of Mohammad *et al.* (2017); Ankit *et al*. (2022). However, tillage treatments didn't significantly influence plant height of rice at any growth stages of the crop. All the weed management treatments measured short stature of plant rice at 60 and 90 DAS/DAT of DSR and TR, respectively as compared to weedy check. The taller and thinner rice plants under weedy check could be ascribed to phototropism activity consequential of crop weed competition for light under almost weed cover condition in the same (Table 1). All the weed management treatments significantly increased LAI, tiller/m^2 and plant dry matter/m^2 at 60 and 90 DAS/DAT compared to weedy check. IWM and manual weeding were statistically superior in recording LAI at 60 and 90 DAS/DAT over RH and weedy check. The same treatments also recorded significantly higher number tillers/m^2 than RH and weedy check at 60 and 90 DAS/DAT. Again, IWM and manual weeding improved dry matter accumulation significantly during 60 and 90 DAS/DAT compared to RH and weedy check. The respective per cent enhancement in dry matter/m^2 due to IWM was 91.42 and 55.66 in 2017 and 91.25 and 39.66 in 2018 and manual weeding by 89.83 and 51.44 in 2017 and 91.31 and 38.43 in 2018 at 60 and 90 DAS/DAT over weedy check. The increase in growth attributes of rice might be due to improvement in light penetration throughout the rice canopy without hindrance of weeds canopy during the critical period of crop growth under IWM and manual weeding. This statement can be confirmed with higher WCE and WCI at 40, 60 and 90 DAS/DAT of rice under aforesaid treatments (Fig. 2 and 3). No or lesser crop weed competition created conducive conditions for tiller numbers enhancement and leaf expansion under these treatment augmented photosynthates accumulation and also improved nutrient uptake during the peak period of nutrient demand of the crop which ultimately increased dry matter accumulation/m^2. The LAI and dry matter accumulation strongly affirmed positive correlation with WCI (0.997 and 0.994, respectively). Equation 1 and 2 reflects that 1 %

increase in WCI at 60 DAS/DAT added 0.023 unit and 1.434g/m^2 LAI and dry matter of rice with an confirmation of 99.4 and 98.7 %, respectively (Table 4).

Among the yields attributes number of panicles/m^2 in rice plant was significantly influenced by different tillage practices. The highest count of the mentioned parameter was recorded under MT(S)-CT(TR)-MT(IM) (T_2) closely followed by with T_1, T_4 and T_5. (Table 2) which can be ascribed to favorable environment throughout the crop growth period resulting from reduced crop weed competition in all tillage practices other than MT(S)-CT(DSR)-CT(IM) (Fig. 1). Treatment MT(S)-CT(TR)-MT(IM) (T_2) recorded the highest grain and straw yields was at par with T_1, T_4 and T_5 during both the year of study. Treatment T_2 recorded an increase in grain yield by 40.22 and 26.26% in 2017 and 2018, respectively over MT(S)-CT(DSR)-CT(IM) (T_3) (Table 3). Treatment T_2 also attained higher harvest index of 41.24 and 41.29 %, respectively during both the years of study. Improved growth of crop attributed to improved yield attributes and yields (grain and straw) of rice due under these treatments as compared to T_3.

Statistically significant influence of weed management treatments on number of panicles/m^2, panicle length and filled grains/panicle of winter rice was recorded. Vital crop growth due to less crop weed competition contributed better synthesis and translocation of photosynthates from source to the sink (Kalita *et al.*, 2017) and thus boosted up yield attributes of rice such as number of panicles/m^2, panicle length and filled grains/panicle under IWM and manual weeding (Table 2) and both were statistically at par during each year of experimentation.

Table 1: Growth parameters of *sali* rice as affected by tillage system and weed management practices.

Treatment	Plant height (cm)				Dry matter accumulation (g/m^2)				LAI				Tiller/m^2			
	2017		2018		2017		2018		2017		2018		2017		2018	
	60 DAS/ DAT	90 DAS/ DAT	60 DAS/ DAT	90 DAS/ DAT	60 DAS/ DAT	90 DAS/ DAT	60 DAS/ DAT	90 DAS/ DAT	60 DAS/ DAT	90 DAS / DAT	60 DAS /DAT	90 DAS/ DAT	60 DAS/ DAT	90 DAS/ DAT	60 DAS/ DAT	90 DAS/DAT
TP																
T_1:	78.72	106.44	77.33	105.97	154.28	345.65	156.45	368.33	3.35	5.07	3.38	5.18	294.53	278.73	320.43	309.30
T_2:	79.06	106.34	77.13	105.89	163.63	380.95	165.58	380.03	3.50	5.29	3.51	5.31	301.72	283.69	334.10	320.56
T_3:	79.68	109.53	79.08	108.85	120.65	174.80	122.40	181.00	2.92	4.32	3.02	4.64	229.47	223.73	222.10	217.81
T_4:	79.40	107.04	77.05	107.47	157.60	356.38	159.43	370.15	3.42	5.20	3.49	5.29	286.48	275.38	329.33	318.63
T_5:	79.35	106.98	77.81	107.83	151.03	349.70	154.50	354.58	3.36	5.13	3.43	5.25	281.78	260.79	313.81	302.92
SEm±	2.24	3.73	2.41	2.96	5.70	15.50	6.70	16.50	0.10	0.12	0.10	0.14	10.56	7.12	12.52	10.13
CD (P=0.05)	NS	NS	NS	NS	18.60	50.56	21.85	53.80	0.33	0.39	0.33	0.45	34.45	23.23	40.82	33.03
WM																
W_1:	78.26	106.43	77.79	106.67	137.56	294.70	140.14	309.78	3.21	4.74	3.28	4.92	276.99	262.19	285.20	280.37
W_2:	75.81	105.18	76.11	105.63	183.04	379.02	184.90	378.06	3.77	5.71	3.79	5.91	300.91	287.01	360.72	343.10
W_3:	76.55	105.45	75.32	105.14	181.52	368.76	184.96	374.72	3.75	5.70	3.80	5.92	302.00	282.24	365.79	344.61
W_4:	86.34	112.01	81.49	111.37	95.62	243.50	96.68	270.70	2.51	3.87	2.59	3.78	235.28	226.41	204.10	207.28
SEm±	1.09	1.85	1.44	1.66	2.74	8.29	2.76	9.45	0.05	0.13	0.05	0.08	8.02	6.88	11.61	11.16
CD (P=0.05)	3.13	5.34	4.15	4.80	7.91	23.95	7.97	27.28	0.14	0.36	0.15	0.22	23.16	19.88	33.54	32.23

Note: Treatment details are explained in materials and methods; TP: Tillage practices; WM: Weed management, DAS: Days after sowing; DAT: Days after transplanting and NS: Non-significant

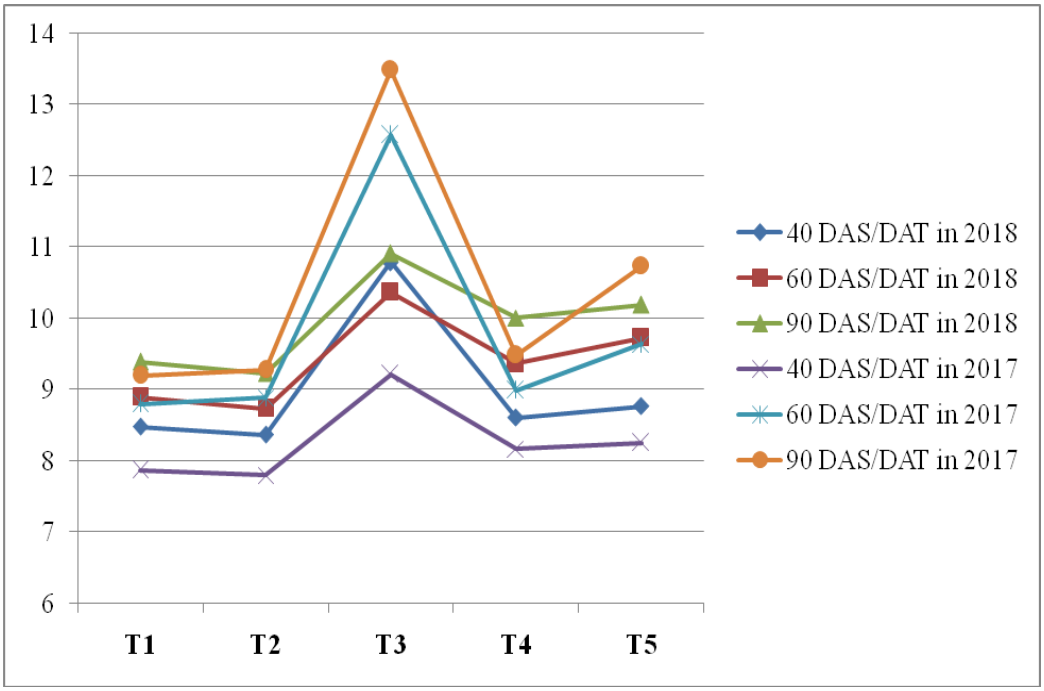

Fig. 1. Weed density (square root transformed value) under different tillage practices in rice.

These results are supported by the findings of Subramanian *et al.* (2006). The growth and yield attributes of rice were significantly improved which ultimately significantly enhanced grain and straw yields under manual weeding and IWM (Table 3). The yield was inversely linked to intensity of weed infestation (Sangramsingh and Dash 2021). The improvement in grain yield of rice due to IWM and manual weeding as compared to weedy check was 83.82 and 80.78 in 2017 and 93.29 and 98.83 in 2018, respectively. Panicle/m^2 was potively correlated (0.996) with dry matter accumulation at 60 DAS/DAT. Again, yield of the rice was strongly positively correlated (0.970) with panicle/m^2. Equation 3 and 4 explained that unit gain in dry matter (1 g/m^2) at 60 DAS/DAT of DSR/TR and panicle/m^2 of rice enhanced panicle/m^2 by 0.848 times and 0.170 q/ha of yield, respectively with an assurance of 99.1 and 94.1% (R^2). Higher harvest index of 41.39% in 2017 and 41.83% in 2018 was established by IWM (Table 4).

Table 2: Yield attributes of *sali* rice as affected by tillage system and weed management practices.

Treatment	Number of panicles/m^2		Panicle length (cm)		Number of filled grains/ panicle		1000-grain weight (g)	
	2017	2018	2017	2018	2017	2018	2017	2018
Tillage practices								
T_1: CT(S)-CT(TR)-CT(IM)	242.43	292.00	21.43	21.23	98.68	107.10	24.17	24.38
T_2: MT(S)-CT(TR)-MT(IM)	246.34	300.00	21.46	21.15	104.80	113.50	24.23	24.19
T_3: MT(S)-CT(DSR)-CT(IM)	176.08	207.00	21.16	21.49	97.31	101.74	24.14	24.09
T_4: MT(S)-MT(DSR)-MT+R(IM)	241.80	289.75	21.33	21.48	104.12	111.94	24.13	24.25
T_5: MT(S)-MT(DSR)-MT(IM)	229.43	288.58	21.24	21.53	101.58	111.26	24.21	24.17
SEm±	9.94	7.24	0.16	0.17	3.61	3.57	0.29	0.07
CD (P=0.05)	32.40	23.60	NS	NS	NS	NS	NS	NS
Weed management								
W_1: Pretilachlor 0.75 kg/ha pre-emergence (RH)	215.04	257.73	21.47	21.47	99.80	114.43	24.18	24.19
W_2: Pretilachlor 0.75 kg/ha pre-emergence + manual weeding 30 DAS/DAT (IWM)	260.97	323.53	21.58	21.57	106.67	123.93	24.19	24.27
W_3: Weeding 20 and 40 DAS/DAT (Manual)	247.27	330.80	21.37	21.43	107.91	122.27	24.14	24.23
W_4: Weedy check	185.60	189.80	20.87	21.03	90.80	75.81	24.19	24.17
SEm±	6.19	8.04	0.16	0.13	3.19	1.87	0.21	0.11
CD (P=0.05)	17.89	23.22	0.47	0.37	9.23	5.40	NS	NS

CT: Conventional tillage, MT: Minimum tillage, R: Residue, S: *Sesbania aculeata*, TR: Transplanted rice, DSR: Direct seeded rice, IM: Indian mustard, RH: Recommended herbicide, IWM: Integrated weed management, DAS: Days after sowing, DAT: Days after transplanting and NS: Non-significant

Table 3: Yields and harvest index of *sali* rice as affected by tillage system and weed management practices.

Treatment	Grain yield (q/ha)		Straw yield (q/ha)		Harvest Index (%)	
	2017	2018	2017	2018	2017	2018
Tillage practices						
T_1: CT(S)-CT(TR)-CT(IM)	32.44	33.55	46.65	48.22	41.02	41.03
T_2: MT(S)-CT(TR)-MT(IM)	36.22	36.25	51.61	51.54	41.24	41.29
T_3: MT(S)-CT(DSR)-CT(IM)	25.83	28.71	41.92	43.28	38.13	39.88
T_4: MT(S)-MT(DSR)-MT+R(IM)	34.44	35.06	50.13	51.50	40.73	40.93
T_5: MT(S)-MT(DSR)-MT(IM)	33.61	34.05	49.33	49.13	40.52	40.51
SEm±	1.30	1.26	1.75	1.67	-	-
CD (P=0.05)	4.22	4.10	5.70	5.44	-	-
Weed management						
W_1: Pretilachlor 0.75 kg/ha pre-emergence (RH)	33.59	33.50	48.40	47.91	40.96	41.15
W_2: Pretilachlor 0.75 kg/ha pre-emergence + manual weeding 30 DAS/DAT (IWM)	38.16	39.51	54.03	54.94	41.39	41.83
W_3: Weeding 20 and 40 DAS/DAT (Manual)	37.53	40.64	54.63	57.44	40.72	41.44
W_4: Weedy check	20.76	20.44	34.65	34.64	37.47	37.11
SEm±	1.06	0.86	1.41	1.25	-	-
CD (P=0.05)	3.05	2.48	4.07	3.62	-	-

CT: Conventional tillage, MT: Minimum tillage, R: Residue, S: *Sesbania aculeata*, TR: Transplanted rice, DSR: Direct seeded rice, IM: Indian mustard, RH: Recommended herbicide, IWM: Integrated weed management, DAS: Days after sowing, DAT: Days after transplanting and NS: Non-significant

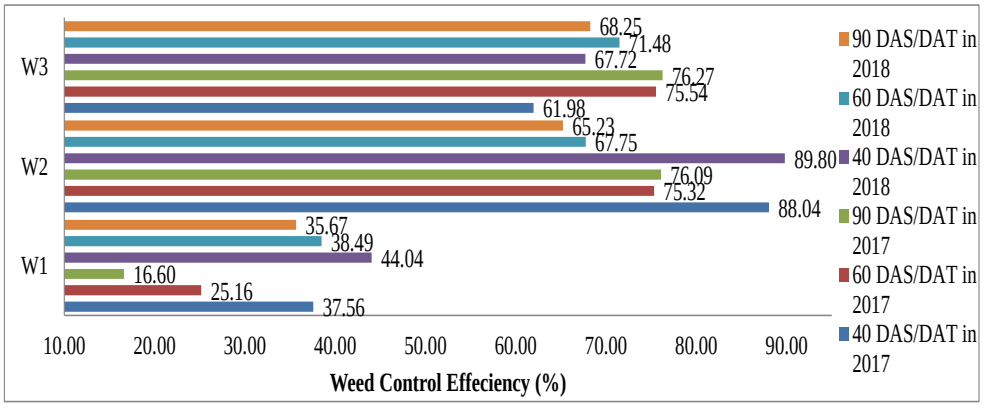

Fig. 2. WCE of weed management practices in rice.

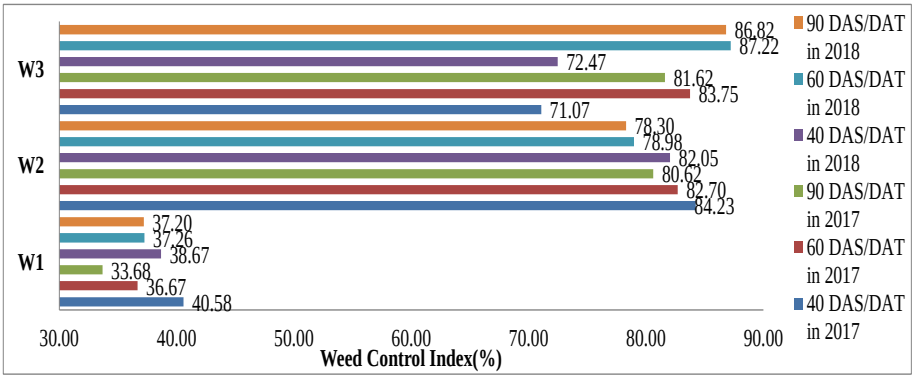

Fig. 3. WCI of weed management practices in rice.

Table 4: Association between the variables.

Equation no.	Regression equations (Y= a+ bX)	Correlation coeffecients	R^2
1	LAI = 3.880+0.023 WCI (%) 60 DAS/DAT	0.997**	0.994
2	Dry matter accumulation (g/m^2) =254.533+1.434 WCI (%) 60 DAS/DAT	0.994**	0.987
3	Panicle/m^2= (-) 26.331+0.848 Dry matter accumulation (g/m^2) 60 DAS/DAT	0.996**	0.991
4	Yield (q/ha) = (-) 9.599+0.170 Panicle/m^2	0.970*	0.941
Correlation is significant at the 0.01 level (2-tailed).** Correlation is significant at the 0.05 level (2-tailed).*			

CONCLUSION AND FUTURE SCOPE

It can be concluded from the present investigation that in terms of rice growth and productivity, tillage systems MT(S)-CT(TR)-MT(IM) and MT(S)-MT(DSR)-MT+R(IM) and among different weed management treatments two manual weeding and integrated weed management practices were the most effective. However, further investigation in different *sali* rice based cropping sequences of Assam must be done to assess the effect of tillage system and weed management practices.

Acknowledgments. The author acknowledges the AICRPWM, AAU, Jorhat and Jabalpur, India for providing professional guidance as well as material support.
Conflict of Interest. None.

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How to cite this article: Sontara Kalita, Jayanta Deka, Khagen Kurmi, Ramani Kanta Thakuria, Dhruba Jyoti Nath, Kaushik Das and Pompy Deka (2023). Evaluation of Conventional and Minimum Tillage System and Weed Management Practices on Weed Growth and Rice Productivity in a Rice based Cropping Sequence. *Biological Forum – An International Journal*, *15*(11): 01-05.