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WEED CONTROL AND PRODUCTIVITY STUDIES IN DIRECT SEEDED *ORYZA SATIVA* L. THROUGH *SESBANIA* BROWN

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Abstract

The weed density under direct seeded rice (DSR) with *Sesbania* brown manuring (SBM) was found to be significantly less as compared to without SBM at 30 DAS and onwards. However, the production efficiency was significantly higher under DSR with SBM (28.99 kg/ha/day) as compared to DSR without SBM (23.99 kg/ha/day). Consequently, SBM gave higher net returns (20.75%) and B: C ratio (9.2%) as compared to without SBM treatment. Among weed management practices, bispyribac sodium @ 25 g/ha + (Chlorimuron + metsulfuron) @ 4 g/ha followed by one hand weeding at 45 DAS recorded higher grain yield (4.677 t/ha), production efficiency and net returns. It also reduced the weed density and weed biomass of grasses, broad leaf weeds, sedges and other weeds at 30 - 90 DAS.

Introduction

Rice (*Oryza sativa* L.) is one of the integral staple foods for more than 50% of the world's population. Asia produces and consumes 90% of world's rice (FAO 2014). Among the rice growing countries, India ranks first in area followed by China and Bangladesh. Rice a major cereal crop of India occupies an area of 42.1 million hectare and produces 90.6 million tonnes with average productivity of 2180 kg/ha. In Uttar Pradesh, rice is cultivated in an area of 5.93 million hectares with an annual production of 11.9 million tonnes with average productivity of 2129 kg/ha (Anon. 2015). In India, especially in Indo Gangetic plains, rice is predominantly grown under puddled system by transplanting seedlings. Under this system, soil kept for flooded conditions (Anaerobic) for most part of the growing season. The puddled soil ensures good crop establishment, weed control with standing water, and reduces deep-percolation losses (Sharma *et al*. 2003). However, the conventional method of rice crop establishment requires a large amount of water, labour, and energy, which are gradually becoming scarce and more expensive. Because of high rate of withdrawal of ground water in conventional tillage based puddled transplanted rice (PTR), water tables in some areas of North-West Indo-Gangetic Plains (IGP) has been declining by 0.1-1.0 m per year, resulting in increased cost of water pumping (Humphreys *et al*. 2010).

In DSR systems, dry rice seeds/sprouted seeds are sown with or without tillage and watered periodically to maintain soil at field capacity. DSR has water saving of 11-18% in irrigations (Tabbal *et al*. 2002) and reduces total labour requirement (11 - 66%) compared to PTR, depending on season, location and type of DSR (Kumar *et al*. 2009). Other benefits of DSR include faster and easier planting, improved soil health, higher tolerance to water deficit, less methane emission and often higher profit in areas with an assured water supply (Pathak *et al*. 2009). Brown manuring with *Sesbania* is another technique to reduce weed problems in rice. It aims to suppressing the weeds without affecting the soil physico-chemical properties and its associated microbes. It can be achieved through raising green manure crops as inter crop and control the same by application of post-emergent herbicides.

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However, weed management is the major challenge in DSR (Rao *et al*. 2007, Singh *et al*. 2007). DSR systems are subject to much higher weed pressure than PTR system (Rao *et al*. 2007), in which weeds are suppressed by standing water and transplanted rice seedlings that provide ‘head start’ over germinating weed seedlings (Moody 1982). In DSR, weeds emerge simultaneously with crop seedlings and grow more quickly in moist soil than in PTR (Khaliq *et al.* 2011), resulting in severe competition for resources to the crop. Therefore, weed represents the main biological constraint to the success of DSR and failure to control weeds result in yield losses ranging from 50 to 90% (Chauhan and Johnson 2011). Farmers generally apply herbicides by mixing them in sand for easy operation and prefer to use either single application of pre- or post herbicides which fail to control diverse weed flora observed in DSR (Chauhan and Johnson 2011). However, it is important to use an integrated weed management programme including pre- and post emergent herbicides for season-long effective weed control and to avoid shifts toward problematic weed species (Chauhan and Johnson 2011) or evolution of herbicide-resistant weed biotypes. Crop safety to new herbicides is another concern. Therefore, studies were conducted to evaluate the efficacy of brown manuring and weed control measures in suppression of weeds and potentiality of production efficiency.

Materials and Methods

A field experiment was conducted during Kharif 2013 and 2014 at the student’s instructional farm at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh. This location has a typical sub-tropical climate characterized by hot and dry summers and cool winters. The mean annual rainfall of Kanpur was 893 mm. The rainfall received during the crop growing period from June to December was 1104.4 mm in 2013 and 505.7 mm in 2014. Maximum temperature during Kharif 2013 and 2014 was 24.5 to 38.6°C and 21.7 to 45.0°C, respectively. The minimum temperature during Kharif 2013 and 2014 varied from 7.1 to 25.8°C and 9.7 to 26.8^{0}C. The soil was sandy loam in texture with pH 8.1, organic C 0.61%, available N 217.5 kg/ha, available P_2O_5 21.0 kg/ha and available K_2O 201.5 kg/ha.

The experiment was laid out in split plot design with two establishment techniques *viz*., Direct Seeded Rice (E1), Direct Seeded Rice + *Sesbania* brown manuring (E2) in main plots. Weed control practices weedy check (W0), bispyribac sodium @ 25 g/ha + (Chlorimuron + metsulfuron) @ 4 g/ha, (W1), bispyribac sodium @25 g/ha + (Chlorimuron + metsulfuron) @ 4 g/ha followed by one hand weeding at 45 DAS (W2), Two hand weeding at 20 DAS and 45 DAS (W3) are in sub-plots and replicated thrice. Crops were grown as per recommended package of practices. In DSR, seeds were first kept immersing in water for 24 hrs and then in moist gunny bags for 36 hrs until radical and plumule protrude. A seed rate of 80 kg/ha was used for sowing direct seeding at 20 cm apart. *Sesbania rostrata* L. with the seed rate of 30 kg/ha was grown for brown manuring between the rice rows. *S. rostrata* was then knocked down by the application of 2, 4-D @ 0.5 kg/ha at 25 DAS followed by its mulching with the help of rotary paddy weeder. Pant 12 cultivar was used for experimental purpose. Sowing of the crop was done on first week of June and harvesting in October during both the experimental year. The weed control efficiency (WCE) calculated by using following formulae:

$$WCE = (WPC – WPT/WPC) \times 100$$

where, WPC, weed dry weight in control plot; WPT, weed dry weight in treated plot.

Results and Discussion

The predominant weeds observed in the experimental plot grasses were *Echinochloa crusgalli* L. and *Echinochloa colonum* L., Fam: Poaceae; *Leptochloa chinensis* L. Nees, Fam: Poaceae;

Comonelina benghalensis L., Fam: Commelinaceae; *Eclipta alba* L. Hassk, Fam: Asteraceae among broad leaves; *Cyperus* species (*C. iria* L. and *C. difformis* L.) Fam: Cyperaceae among sedges and other weeds in both the years of experimentation. The significant differences were found among the rice establishment techniques for the grasses, broad leaved weeds, sedges and other weeds density at 30, 60 and 90 DAS (Tables 1-3). Our results showed that the density of *Echinochloa* spp., *L. chinensis*, *C. benghalensis*, *Eclipta alba*, *Cyprus* spp. and other weeds under DSR + SBM were significantly less (25.1, 15.5, 20.9, 27.4, 64.2 and 11.8 plants/m^2, respectively) as compared to without SBM (38.2, 21.6, 32.3, 39.4, 91.6 and 17.9 plants/m^2) at 30 DAS. Similarly, dry weed biomass was 31.1, 18.5, 31.0, 29.5, 29.7 and 24.0 per cent higher under without SBM as compared to with SBM (Table 1) at 30 DAS, respectively. The weed density and weed dry biomass were also increased at 30 days onwards in without SBM (Tables 2-3). However, there was decline trend in the weed population and weed biomass at maturity as compared to the observation recorded at 60 and 90 in both the years of experimentation. Under *Sesbania* green manuring, there is an advantage of weed suppression between the rows. These *Sesbania* plants are more competitive against the emerging weed seedlings.

DSR has been shown to encounter a more diverse weed flora than PTR (Tomita *et al*. 2003). In the present study, W3 treatment followed by W2 was prevented the germination and establishment of the first cohort of typical rice and aerobic grass weeds and small-seeded broad leaf weeds. Therefore, weed control treatment plots were largely free from these weeds at critical stage up to 60 DAS. W3 treatment reduced the weed density of grasses, broad leave weeds, sedges and other weeds ranged from 90 to 99% followed by W2 ranged from 69.0 to 97% as compared to control at 30, 60 and 90 DAS (Tables 1 - 3). Similarly, weed biomass was reduced under W3 90 to 99% followed by W2 treatment from 72 to 94% as compared to control at 30, 60 and 90 DAS (Tables 1 - 3). However, in a previous study, herbicide combinations or herbicide plus hand weeding provided excellent control of weeds than the single application of herbicides (Sangeetha *et al*. 2011). Mahajan and Chauhan (2015) reported improved control of aerobic grass weeds with the tank-mix of fenoxaprop and bispyribac.

Population and dry weight was significantly reduced due to herbicidal treatment at all stages of observation. This may be attributed to the inhibition of germination of weeds owing to paralysis of vital metabolic process *viz.* Cell division, protein synthesis etc. and subsequently drying of susceptible weed species (Kumar and Ladha 2011).

Number of panicle/m^2, length per panicle (cm) and number of grains per panicle were significantly influenced due to *Sesbania* brown manuring. *Sesbania* brown manuring on an average increased 8.13, 7.28 and 1.78% number of panicle, length of panicle and number of grains per panicle, respectively. Higher growth and yield attributes under *Sesbania* brown manuring led to the 17.25% higher grain yield as compared to without *Sesbania* brown manuring (Table 4). Consequently, the production efficiency was significantly higher under DSR with SBM (28.99 kg/ha/day) as compared to DSR without BM (23.99 kg/ha/day) (Table 4). Similarly, *Sesbania* brown manuring fetched the 20.75% higher net returns and 9.2% higher B : C ratio as compared to without SBM treatment (Table 4). The present result is in agreement with the results of Mishra and Singh (2012), who stated that yield attributes and yield were observed higher due to brown manuring. DSR with brown manuring provide congenial environment for growth and development due to less weeded plot during the critical period, which increase rice grain yield significantly (Kumar *et al*. 2014, Pramanick *et al*. 2014). Yield attributes like number per panicle/m^2, length of panicle (cm) and number of grains per panicle of rice was significantly varied due to weed control approaches. On an average, number of panicle/m^2, length per panicle (cm) and number of grains/panicle increased in the tune of 15.1, 15.1 and 4.9% under W3 treatment followed by W2 (10.9, 12.2 and 4.1%), respectively than the control. The maximum grain yield (4.67 t/h) was

Table 1. Efficacy of *Sesbania* brown manuring and weeds control on weed dynamics (No./m^2) and weed biomass (g/m^2) at 30 DAS (mean of two years).

Treatments	*Echinochloa* spp.		*L. chinensis*		*C. benghalensis*		*Eclipta alba*		*Cyperus* spp.		Other weeds	
	WD	WB	WD	WB	WD	WB	WD	WB	WD	WB	WD	WB
Sowing methods												
E1	6.22	3.29	4.70	2.43	5.73	2.51	6.31	2.88	9.60	3.79	4.29	1.73
	(38.2)	(10.3)	(21.6)	(5.4)	(32.3)	(5.8)	(39.4)	(7.8)	(91.6)	(13.8)	(17.9)	(2.5)
E2	5.06	2.76	4.00	2.20	4.63	2.13	5.28	2.46	8.04	3.19	3.50	1.54
	(25.1)	(7.1)	(15.5)	(4.4)	(20.90	(4.0)	(27.4)	(5.5)	(64.2)	(9.7)	(11.8)	(1.9)
LSD (p = 0.05)	0.80	0.39	0.33	0.12	0.66	2.51	0.34	0.11	0.77	0.29	0.49	0.12
Weed control												
W0	11.32	5.97	9.98	4.91	10.23	4.44	10.82	4.93	15.44	6.10	6.03	2.41
	(127.6)	(35.1)	(99.2)	(23.6)	(104.2)	(19.2)	(116.5)	(23.8)	(238.0)	(36.7)	(35.8)	(5.3)
W1	6.74	3.56	4.82	2.38	6.15	2.67	5.65	2.57	10.50	4.14	4.22	1.69
	(45.0)	(12.2)	(22.7)	(5.2)	(37.3)	(6.6)	(31.4)	(6.1)	(109.7)	(16.7)	(17.3)	(2.3)
W2	3.11	1.64	1.70	1.09	2.67	1.22	4.15	1.89	6.40	2.52	3.40	1.43
	(9.2)	(2.2)	(2.4)	(0.7)	(6.6)	(1.0)	(16.7)	(3.1)	(40.4)	(5.9)	(11.1)	(1.5)
W3	1.39	0.93	0.91	0.90	1.66	0.96	2.58	1.28	2.95	1.19	1.94	1.02
	(1.43)	(0.36)	(0.33)	(0.31)	(2.26)	(0.42)	(6.16)	(1.14)	(8.20)	(0.92)	(3.26)	(0.54)
LSD (p = 0.05)	1.44	0.36	0.32	0.31	2.25	0.41	6.13	1.13	8.18	0.92	3.27	0.53

Data were subjected to $\sqrt{x} + 0.5$ transformations before statistical analysis. Figures in parentheses are the original values. WD and WB represent weed density and weed dry biomass, respectively.

Table 2. Efficacy of *Sesbania* brown manuring and weeds control on weed dynamics (No. /m^2) and weed biomass (g/m^2) at 60 DAS (mean of two years).

Treatments	*Echinochloa* spp.		*L. chinensis*		*C. benghalensis*		*Eclipta alba*		*Cyperus* spp.		Other weeds	
	WD	WB	WD	WB	WD	WB	WD	WB	WD	WB	WD	WB
Sowing method												
E1	8.01	3.93	5.91	3.14	7.01	3.22	7.69	4.81	12.85	4.90	5.79	2.48
	(63.7)	(15.0)	(34.5)	(9.4)	(48.7)	(9.9)	(58.6)	(22.6)	(164.7)	(23.5)	(33.0)	(5.6)
E2	6.50	3.21	5.08	2.83	5.64	2.62	6.45	4.08	10.83	4.11	4.80	2.11
	(41.7)	(9.8)	(25.3)	(7.5)	(31.4)	(6.4)	(41.1)	(16.2)	(116.9)	(16.4)	(22.6)	(3.9)
LSD (p = 0.05)	0.29	0.02	0.30	0.13	0.75	0.34	0.40	0.26	0.44	0.39	0.30	0.20
Weed control												
W0	14.54	7.07	12.58	6.47	12.38	5.65	12.88	7.70	20.51	7.88	8.19	3.48
	(211.0)	(49.5)	(157.7)	(41.4)	(152.8)	(31.5)	(165.4)	(58.7)	(420.2)	(61.6)	(66.6)	(11.6)
W1	8.69	4.21	6.18	3.21	7.54	3.44	7.17	5.19	14.31	5.36	5.72	2.44
	(75.0)	(17.2)	(37.7)	(9.8)	(56.4)	(11.4)	(50.9)	(26.5)	(204.3)	(28.2)	(32.2)	(5.4)
W2	4.04	1.98	2.17	1.25	3.29	1.48	4.97	3.27	8.63	3.26	4.62	1.98
	(15.8)	(3.4)	(4.2)	(1.1)	(10.3)	(1.7)	(24.2)	(10.2)	(73.9)	(10.1)	(20.9)	(3.4)
W3	1.75	1.01	1.07	1.00	2.10	1.10	3.26	1.63	3.93	1.50	2.65	1.27
	(2.56)	(0.52)	(0.64)	(0.50)	(3.90)	(0.71)	(10.15)	(2.14)	(14.91)	(1.76)	(6.51)	(1.12)
LSD (p = 0.05)	0.59	0.25	0.43	0.19	0.39	0.14	0.48	0.22	0.69	0.41	0.70	0.28

Table 3. Efficacy of *Sesbania* brown manuring and weeds control on weed dynamics (No./m^2) and weed biomass (g/m^2) at 90 DAS (mean of two years).

Treatments	*Echinochloa* spp.		*L. chinensis*		*C. benghalensis*		*Eclipta alba*		*Cyperus* spp.		Other weeds	
	WD	WB	WD	WB	WD	WB	WD	WB	WD	WB	WD	WB
Sowing method												
E1	10.06	4.79	7.46	3.67	8.37	3.86	9.69	4.67	17.29	7.88	7.79	4.11
	(100.6)	(22.5)	(55.1)	(13.0)	(69.6)	(14.4)	(93.5)	(21.3)	(298.4)	(61.5)	(60.1)	(16.4)
E2	8.67	4.15	6.31	3.20	6.80	3.15	7.89	3.80	14.57	6.64	6.46	3.41
	(74.7)	(16.7)	(39.4)	(9.8)	(45.8)	(9.4)	(61.7)	(13.9)	(211.8)	(43.5)	(41.2)	(11.1)
LSD (p = 0.05)	0.26	0.12	0.15	0.12	0.85	0.35	0.98	0.48	0.59	0.27	0.40	0.20
Weed control												
W0	18.16	8.67	15.39	7.47	14.87	6.84	16.20	7.81	27.57	12.55	11.03	5.82
	(329.3)	(74.6)	(236.3)	(55.3)	(220.7)	(46.2)	(262.0)	(60.5)	(759.3)	(157.1)	(121.1)	(33.4)
W1	11.62	5.53	8.06	3.93	9.15	4.21	8.80	4.24	19.28	8.79	7.69	4.06
	(134.5)	(30.1)	(64.5)	(14.9)	(83.3)	(17.2)	(76.9)	(17.5)	(371.3)	(76.8)	(58.7)	(16.0)
W2	5.37	2.55	2.81	1.37	3.81	1.73	6.16	2.96	11.61	5.29	6.20	3.27
	(28.4)	(6.0)	(7.4)	(1.4)	(14.0)	(2.5)	(37.4)	(8.3)	(134.2)	(27.5)	(37.9)	(10.2)
W3	2.30	1.14	1.28	0.98	2.51	1.25	4.00	1.93	5.27	2.40	3.58	1.90
	(4.8)	(0.8)	(1.1)	(0.5)	(5.8)	(1.1)	(15.5)	(3.2)	(27.2)	(5.2)	(12.3)	(3.1)
LSD (p = 0.05)	0.74	0.37	0.60	0.29	0.60	0.23	0.69	0.32	0.89	0.40	0.92	0.48

obtained with W3 treatment followed by W2 (4.237 t/ha) and the lowest was observed in control treatment (3.107 t/ha)**.** Similarly, W3 (31.20 kg/ha/day) followed by W2 (28.25 kg/ha/day) enhanced the production efficiency as compared to control treatment (20.68 kg/ha/day) (Table 4). Consequently, W3 treatment fetched the highest net returns (Rs 50.63 × 10^3/ha) as compared to control (Rs 30.41 × 10^3/ha). The B: C ratio was also highest in same treatment (3.57) than control (2.88) (Table 4). The better performance of these treatments in term of grain yield could be attributed to better expression of their yield attributes due to reduction in crop weed competition as evidenced by higher weed control efficiency and lower weed index. This could be attributed to their selectivity to crop and significant reduction in the weed growth.

Table 4. Effect of *Sesbania* brown manuring and weed control on yield attributes, production efficiency and net returns.

Treatments	Number of panicles/ m^2	Length panicle (cm)	Number of grains/ panicle	Grain yield (t/ha)	Production efficiency (kg/ha/day)	Net returns (Rs 10^3/ha)	B : C ratio
Sowing methods							
E1	284.26	20.38	88.54	3.598	23.99	36.96	3.16
E2	309.42	21.98	90.14	4.348	28.99	46.64	3.48
LSD (p = 0.05)	12.67	0.81	0.40	0.184	1.17	2.31	0.12
Weed control							
W0	270.93	19.10	86.62	3.107	20.68	30.41	2.88
W1	293.15	21.37	89.33	3.872	25.83	41.31	3.43
W2	304.23	21.75	90.37	4.237	28.25	44.86	3.40
W3	319.03	22.50	91.05	4.677	31.20	50.63	3.57
LSD (p = 0.05)	6.03	1.95	1.66	0.222	1.50	3.34	0.19

The highest weed control efficiency was found in the DSR with SBM treatment than without SBM treatment. The weed control efficiency of DSR + SBM was 52.3, 53.5, 46.7, 46.3, 41.5 and 34.9 for the controlling of *Echinochloa* spp., *L. chinensis*, *C. benghalensis*, *Eclipta alba*, *Cyprus* spp. and other weeds as compared to 45.3, 51.8, 46.8, 45.2, 41.4 and 28.3% under without SBM at 30 DAS (Fig. 1). Similarly, the weed control efficiency was higher under DSR + SBM than without SBM at 60 and 90 DAS (Fig. 1).

Amongst weed control treatments the highest weed control efficiency was achieved at 30, 60, 90 DAS and at maturity stage under W3 treatment followed by W2. Under W3, the WCE were 83.9, 81.4, 78.2, 74.4, 80.6 and 57.0 % as compared to W2 treatment (72.2, 77.9, 72.5, 61.5, 58.7 and 39.9%) and W1 treatment (39.1, 51.4, 40.0, 47.1, 32.1 and 29.6%) for the control of *Echinochloa* spp., *L. chinensis*, *C. benghalensis*, *Eclipta alba*, *Cyprus* spp. and other weeds, respectively at 30 DAS. However, the WCE was higher for the controlling of grasses, broad leave weeds, sedge and other weeds were under the same treatment at 60 and 90 DAS. Similar results were reported in a previous study for effective weed control in rice (Khare *et al*. 2014).

DSR rice with *Sesbania* brown manuring significantly reduces the weed dynamics (density), weed biomass and found highest weed control efficiency as well as enhanced the production efficiency as compared to without SBM. Among weed management practices, two hand weeding

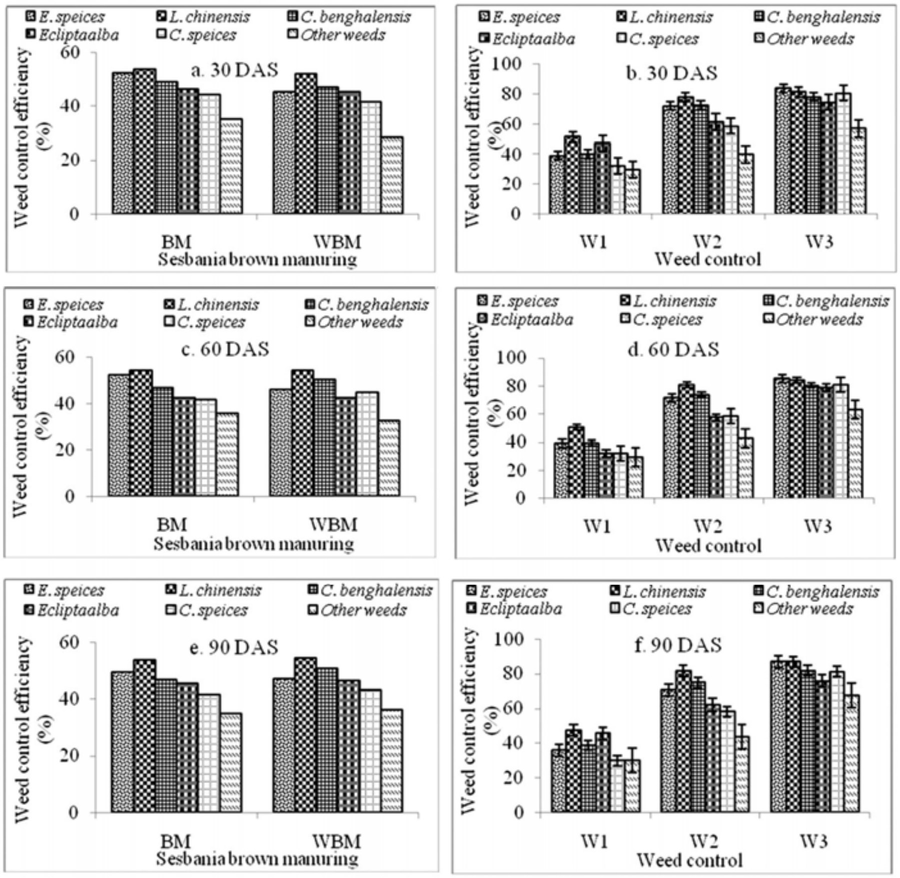

Fig. 1. Effect of *Sesbania* brown manuring and weed control on weed control efficiency.

at 20 and 45 DAS significantly reduced the weed dynamics (density), weed dry biomass with highest weed control efficiency as compared to control treatment. Consequently, the same treatment enhanced the production efficiency, net returns and B : C ratio.

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