ISSN (Online): 2091-2609
DOI Prefix: 10.3126/ijasbt
International Journal of Applied Sciences and Biotechnology
(IJASBT)

Research Article

Impact of Different Seed Rates and Knocking Down Days of *Sesbania* on Weed Density and Yield of Dry Direct Seeded Rice

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Abstract

The weed is a major constraint of dry-direct seeded rice (DDSR) due to change in establishment methods and shifting weed flora towards competitive grasses and sedges. To minimize the weed density, its species and dry weight with brown manuring and for optimizing the yield of DDSR, the experiment was conducted during monsoon season of 2014 at Chitwan, Nepal. The experiment was done using a strip plot design to find the optimum seed rate and killing date of *Sesbania* under rice-*Sesbania* co-culture. Among different seed rates (60, 80, 100 kg ha^{-1}) and knocking down days (21, 28, 35 & 42 DAS) of *Sesbania*, the optimum seed rate of *Sesbania* was 102 kg ha^{-1} and killing date was 32 days. The individual plot size was 5 x 4 m^{2}. The growing of *Sesbania* with 100 kg seeds ha^{-1} along with its knocked down at 28 DAS was seen best to minimize the weeds having better performance of rice. The experiment clearly demonstrated the importance of brown manuring on effective control of weeds and on grain yield of rice under dry direct seeded rice.

Keywords: Brown manuring, dry direct seeded rice, grain yield, *Sesbania*, Weed density

Introduction

Rice (Oryza sativa L.) is the principle source of the food for more than half of the world's population who depends for their daily sustenance (Chauhan and Johnson, 2011). In spite of the first position of rice in terms of importance, area and production in Nepalese context, the present productivity remains low (3.17 t ha^{-1}), which is far below than that of other rice growing countries (FAOSTAT, 2012 & 2005). Rice is mainly cultivated by transplanting in puddle field, which results in the formation of hard pan and damages soil structure, though it helps in retention of more water and effective in weed control, but this needs more time, labour and energy. With the advent of resource conserving technologies, direct seeding is being emerged as a viable alternative to transplanted rice (Tripathi *et al.*2004). Farmers are keen to adopt direct seeded rice instead of transplanted rice as there is acute shortage of labour and sky rocketing wages of labourers at the time of transplanting. It is suggested that alternate method of planting i.e. Dry-DSR is gaining popularity regarding its high water use, labor use and energy use efficiencies (Kumar and Ladha, 2011). Thus being cost effective the dry direct seeding method also

Cite this article as:

S.K. Chaudhary et al. (2018) Int. J. Appl. Sci. Biotechnol. Vol 6(4): 359-365. DOI: 10.3126/ijasbt.v6i4.22114

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allows early sowing of wheat. The effective weed management is a major challenge for farmers when adopting dry DSR because of weed flora shifts toward more difficult-to-control and competitive grasses and sedges. Higher weed infestation is a major problem in dry-DSR causing major loss to rice production worldwide. It is important to manage the weeds to sustain the yield when transplanting is being replaced widely by dry-DSR. Weeds compete with rice plant for all critical growth factors such as space, light, temperature, water and nutrients and reduced the yield by 30-90% (Singh, Bharadwaj, Thakur, Pachauri, Singhand, & Mishra 2009).

Sesbania co-culture is different from other types of weed management practices. It overcomes the cost associated with manual and herbicidal weeding along with removal of negative impact of chemical herbicide to the soil condition and plant or human life. *Sesbania* followed by 2,4-D was more effective in suppressing broad leaves and sedges and less effective on grasses (Kumar and Ladha, 2011). *Sesbania rostrata* is a small semi-aquatic leguminous tree which forms a symbiotic relationship with Gram-negative rhizobia and leads to the formation of nitrogen fixing nodules on both stem and roots. This technology can reduce the weed population by nearly half without any adverse effect on rice yield (Kamboj *et al*., 2012). Growing of *Sesbania* as an intercrop with direct seeded rice up to 30 DAS reduced the weed infestation by 30% (Singh, Johnson, Mortimer, & Orrr, 2003). The atmospheric nitrogen fixation and facilitation of crop emergence in areas of soil crust formation are other benefits of this technique in addition to weed suppression (Gopal *et al*., 2010; Singh *et al*., 2009). It helps in adding about 15 kg N ha^{-1} along with smothering of weeds and conserving moisture (Gaire *et al*., 2013). Thus, the major part is to evaluate its effect on weeds and on the performance of dry direct seeded rice through this experiment.

Materials and Methods

The experiment was carried out at Agronomy Farm of Agriculture and Forestry University (AFU), Rampur, Chitwan. The site is located 9.8 km South-West from Bharatpur, headquarter of Chitwan district. This location is situated at 27^0 37' N latitude and 84^0 25' E longitudes with the elevation of 256 m above mean sea level (Thapa and Dangol, 1988). Rice variety "US-312" via line sowing and seed of *Sesbania* rostrata via broadcasting were sown together manually on 7th of June, 2014. The soil of experimental plot was sandy loam which had medium type of total N (0.2%), available P (46.62 kg ha^{-1}) and organic carbon (1.9%) but low in available K (82.8 kg ha^{-1}). Twelve treatment combinations were tested in Strip Plot Design and replicated three times. Each 20 m^2 plot had 20 rows of 5m length, with an inter-row spacing of 0.2 m. The fertilizer was applied in the form of urea, di-ammonium phosphate (DAP), and murate of potash (MOP) whereas the recommended dose of NPK in each experimental plot was 150:80:80 kg ha^{-1}. One third of nitrogen, full dose of phosphorus and potash were applied as basal dose at final land preparation. Remaining two third dose of Nitrogen was applied at tillering stage and panicle initiation stage in equal split. Zinc sulphate @ 25 kg ha^{-1} was also applied at final land preparation for correction of zinc deficiency in soil.

Results and Discussion

Weeds species

The major weed species found during experiment of this brown manuring research have been listed in Table 1. These have been categorized along with three dates of appearance and the weeds were *Cynodon dactylon, Echinochloa colana, Setaria glauca, Paspalum scrobiculatum, Para grass, Melochia corchorifolia, Cyperus iria, Fimbristylis miliaceae,* etc.

Effect on Weed Density

The seed rates of *Sesbania* had significant effect on total weed density and non-significant to the individual weed categories at 30 DAS (Table 2). Increasing seed rate of *Sesbania* caused to decrease total weed density and weed density of individual weed categories. Significantly the lowest total weed density was recorded with the seed rate of 100 kg ha^{-1} (92.92 weeds m^{-2}) followed by lower seed rate of *Sesbania*. The total weed density with 100 kg ha^{-1} was 83.31% lower than weedy check and 75% lower than farmers' practice. The different knocking dates of *Sesbania* had not influenced the total weed density and weed density of individual categories. Knocking down of *Sesbania* at 21 to 42 DAS had reduced the weed density by 59.15% and 72.73% as compared to farmer's practice and weedy check respectively. These findings are in conformity with Singh *et al*. (2009) i.e. broadcasting of *Sesbania* along with rice seeding and killing *Sesbania* by spraying 2,4-D around 30 days after seeding reduced the weed density by 37-42 per cent compared to the rice crop without brown manuring.

There was observed non-significant effect of different seed rates and knocking down days of *Sesbania* on weed density at 60 DAS (Table 3). With increasing seed rate and delaying knocking down decreased weed density. Comparatively higher weed density of all categories of weeds recorded on knocking down at 21 DAS. The weed density with different seed rates and knocking down days of *Sesbania* had 60 and 85% lower as compared to farmer's practice and weedy check respectively.

Table 1: Description of narrow leaf weeds, broad leaf weeds and Sedges recorded at different growth stages of DDSR at AFU, Rampur, Chitwan, 2014

Scientific name	Local name	Common name	family	Class	Habit	Time of appearance 30 DAS	60 DAS	90 DAS
Narrow leaf weeds								
Cyanodon dactylon	Dubo	Bermuda grass	Poaceae	M	PH	+	+	+
Setaria glauca	Bandarghas	Bulrush millet	Poaceae	M	PH	-	+	+
Echinochloa colana	Sawa	Jungle-rice	Poaceae	M	PH	-	+	+
Paspalum scrobiculatum	Kode jhar	Kodo millet	Poaceae	M	AH	-	+	+
Digitaria ciliaris	Bonso	Crab grass	Poaceae	M	AH	+	+	+
Panicum repens			Poaceae	M	AH	-	-	+
Para grass			Poaceae	M	PH	+	+	+
Caesulia axillaris		Pink node flower	Asteraceae	M		+	-	-
Eleuscine indica	Kode jhar	Goose grass	Poaceae	M	AH	+	-	-
Broad leaf weeds								
Melochia corchorifolia	Ban Patey		Sterculiaceae	D	AS	+	+	+
Aeschynomene indica	Armale		Fabaceae	D	PH	+	+	+
Polygonum hydropiper	Pire	Water pepper	Asteraceae	D		+	-	-
Commelina diffusa	Kane Jhar	Day flower	Asteraceae	M	PH	-	-	-
Sedges								
Cyperus iria	Motha		Cyperaceae	M	AH	+	+	+
Fimbristylis miliacea	Jwane		Cyperaceae	M	PH	+	-	+

+, presence of weeds; -, absence of weeds; A, annual; P, perennial; H, herb; M, monocot; D, dicot; DAS, days after sowing

Table 2: Weed density influenced by seed rates and knocking down days of *Sesbania* in Rice-*Sesbania* co- culture practices at 30 DAS at Agronomy Farm, AFU, Rampur, Chitwan, Nepal, 2014

Treatments	Weed density (no. of weeds m^{-2}) at 30 DAS Grasses	Broad Leaf Weeds	Sedges	Total
Seed rates of *Sesbania*				
60 kg ha^{-1}	8.79 (82.92)	5.24 (32.50)	8.09 (70.00)	13.42^a (185.42)
80 kg ha^{-1}	8.68 (79.58)	4.62 (25.83)	7.53 (71.67)	12.80^a (177.08)
100 kg ha^{-1}	6.76 (50.42)	3.68 (15.00)	4.49 (27.50)	9.34^b (92.92)
SEm ±	0.59	0.62	0.78	0.65
$LSD_{0.05}$	ns	ns	ns	2.54
Knocking down days				
21 DAS	7.81 (62.78)	4.91 (27.78)	5.99 (47.78)	11.51 (138.33)
28 DAS	8.06 (73.33)	4.18 (23.89)	7.20 (67.78)	12.09 (165.00)
35 DAS	8.48 (78.89)	4.49 (22.22)	6.96 (57.22)	12.16 (158.33)
42 DAS	7.95 (68.89)	4.45 (23.89)	6.66 (52.78)	11.67 (145.56)
SEm ±	0.52	0.28	0.81	0.63
$LSD_{0.05}$	ns	ns	ns	ns
CV, %	31.4	33.30	53.1	28.8
Grand mean	8.08	4.51	6.7	11.85
Weedy check	216.67	53.33	286.67	556.67
Farmers' practice	160.00	61.67	151.67	371.67

Note: Data subjected to square-root ($\sqrt{X+0.5}$) transformation; figures in parentheses are original value; Mean separated by DMRT and columns represented with same letter (s) are non-significant at 5% level of significance. DAS, days after sowing; BLW, broad leaf weeds

The density of grasses, sedges and total weed density had significantly influenced by varying seed rates of *Sesbania* at 90 DAS but broad leaf weeds were similar among all seed rates (Table 4). Significantly lowest total weed density was recorded with the seed rate of 100 kg ha^{-1} which was statistically lower than recorded on seed rate of 80 kg ha^{-1} and higher than seed rate of 60 kg ha^{-1}. Similar trend was observed with density of grasses but in case of sedges, lowest density was observed on 80 kg ha^{-1} seed rate of *Sesbania* followed by 100 and 60 kg ha^{-1}. But, the density of sedges with 100 kg ha^{-1} was statistically similar to the weed density observed with lower seed rates of *Sesbania*. The seed rate of 100 kg ha^{-1} had reduced the number of weeds by 51.51% than farmers' practice and by 75% as compared to weedy check. At 90 DAS, there was observed non-significant effect of different knocking down days of *Sesbania* on density of all weed categories. The weed densities had reduced by 42.68 and 70.44 % in farmer's practice and weedy check respectively when knocked down the *Sesbania* from 21 to 42 DAS.

Brown manuring acted as cover crop in suppressing weed growth effectively at the initial growth stage. Angadi *et al.*(1993), Sharma and Ghosh (2000) and Yadav (2004) also reported similar results. Gupta *et al.*(2006) reported that co-culture of Sesbania in rice and its subsequent knock down by 2,4-D reduced the weed population by nearly half without any adverse effect on rice yield.

Table 3: Weed densities influenced by seed rate and knocking down days of *Sesbania* in Rice-*Sesbania* co- culture practices at 60 DAS at Agronomy Farm, AFU, Rampur, Chitwan, Nepal, 2014

Treatments	**Weed density (no. of weeds m^{-2}) at 60 DAS**			
	Grasses	**BLW**	**Sedges**	**Total**
Seed rates of *Sesbania*				
60 kg ha^{-1}	9.63 (100.00)	2.57 (10.00)	2.80 (15.00)	10.80 (125.00)
80 kg ha^{-1}	8.89 (83.33)	2.39 (7.92)	2.11 (9.58)	9.85 (100.83)
100 kg ha^{-1}	8.03 (68.75)	2.22 (7.08)	2.04 (8.75)	8.91 (84.58)
SEm ±	0.74	0.29	0.43	0.75
$LSD_{0.05}$	ns	ns	ns	ns
Knocking down days				
21 DAS	9.29 (90.00)	2.60 (9.44)	2.65 (15.56)	10.49 (115.00)
28 DAS	8.71 (81.67)	2.19 (6.67)	2.49 (14.44)	9.69 (102.78)
35 DAS	9.04 (87.78)	2.43 (9.44)	1.48 (3.89)	9.80 (101.11)
42 DAS	8.35 (76.67)	2.35 (7.78)	2.65 (10.56)	9.44 (95.00)
SEm ±	0.69	0.52	0.82	0.71
$LSD_{0.05}$	ns	ns	ns	ns
CV, %	32.7	96.7	121.1	27.8
Grand mean	8.85	2.39	2.32	9.86
Weedy check	333.33	73.33	273.33	680.00
Farmers' practice	178.33	3.33	75.00	255.00

Note: Data subjected to square-root ($\sqrt{X+0.5}$) transformation; figures in parentheses are original value; Mean separated by DMRT and columns represented with same letter (s) are non-significant at 5% level of significance. DAS, days after sowing; BLW, broad leaf weeds.

Table 4: Weed densities influenced by seed rate and knocking down days of *Sesbania* in Rice-*Sesbania* co- culture practices at 90 DAS at Agronomy Farm, AFU, Rampur, Chitwan, Nepal, 2014

Treatments	**Weed density (no. of weeds m^{-2}) at 90 DAS**			
	Grasses	**BLW**	**Sedges**	**Total**
Seed rates of *Sesbania*				
60 kg ha^{-1}	8.82^{a} (80.42)	1.55 (3.33)	2.25^{a} (11.25)	9.57^{a} (95.00)
80 kg ha^{-1}	7.88^{ab} (64.58)	1.78 (5.83)	1.33^{b} (3.33)	8.40^{ab} (73.75)
100 kg ha^{-1}	7.56^{b} (59.58)	0.91 (0.83)	1.72^{ab} (5.83)	7.90^{b} (66.25)
SEm ±	0.29	0.34	0.16	0.29
$LSD_{0.05}$	1.14	ns	0.63	1.17
Knocking down days				
21 DAS	7.18 (54.44)	1.73 (3.89)	2.07 (11.11)	8.04 (69.44)
28 DAS	7.84 (64.44)	1.06 (1.67)	0.71 (0.00)	7.95 (66.11)
35 DAS	8.52 (73.89)	1.33 (4.44)	2.01 (6.11)	9.03 (84.44)
42 DAS	8.80 (80.00)	1.53 (3.33)	2.29 (10.00)	9.47 (93.33)
SEm ±	0.62	0.41	0.65	0.61
$LSD_{0.05}$	ns	ns	ns	ns
CV, %	20.7	96.5	140	27.4
Grand mean	8.09	1.41	1.77	8.62
Weedy check	80.00	156.67	28.33	265.00
Farmers' practice	43.33	61.67	31.67	136.67

Note: Data subjected to square-root ($\sqrt{X+0.5}$) transformation; figures in parentheses are original value; Mean separated by DMRT and columns represented with same letter (s) are non-significant at 5% level of significance. DAS, days after sowing; BLW, broad leaf weeds; ns, non-significance.

Grain Yield, Straw Yield, Above Ground Biomass and Harvest Index

The average grain yield in the experiment was 3671 kg ha^{-1} and it was not significantly influenced by both seed rates and knocking down days of *Sesbania* (Table 5). However, 100 kg ha^{-1} of *Sesbania* seed rate produced the highest grain yield (3956.63 kg ha^{-1}) and lowest (3392.52 kg ha^{-1}) with the seed rate of 60 kg ha^{-1}. The trend of yield was in increasing rate with increased seed rate of *Sesbania*. Higher grain yield in case of *Sesbania* 100 kg ha^{-1} may be attributed by release of more amount of nitrogen producing more number of productive tillers, more number of filled grains per panicle and less sterile spikelets. These results are in affirmation to those reported by Gopal *et al.* (2010) who reported brown manuring in direct seeded rice reduced weed population by nearly half without any adverse effect on rice yield and also, *Sesbania* surface mulch decomposed very fast to supply N and other re-cycle nutrients.

In case of knocking down days, knocking down of *Sesbania* at 28 DAS produced highest grain yield (3944.20 kg ha^{-1}) as compared to other days of knocking down. Early knocking down of *Sesbania* (21 DAS) had lowest grain yield (3452.53 kg ha^{-1}) because it produced less biomass of *Sesbania* and has less amount of nitrogen released contributing less to yield attributes as compared to delay knocking down.

Straw Yield

Both the seed rates and knocking down days of *Sesbania* had also non-significant effects on straw yield (Table 5). However, the highest straw yield (5152.77 kg ha^{-1}) was recorded with the seed rate of 80 kg ha^{-1} whereas the lowest straw yield (4902.97 kg ha^{-1}) was with the seed rate of 60 kg ha^{-1}. In case of knocking down days, knocking down at 21 DAS produced highest straw yield (5247.08 kg ha^{-1}) followed by knocking down at 28 and 42 DAS respectively. The lowest straw yield (4814.23 kg ha^{-1}) was observed with the knocking down day of 35 DAS.

Above Ground Biomass

There was also non-significant effect of both seed rates and knocking down days of *Sesbania* on above ground biomass (Table 5). The lowest above ground biomass (7820.54 kg ha^{-1}) was recorded with the *Sesbania* seed rate of 60 kg ha^{-1} and it was increased with increasing seed rate of *Sesbania* and highest was recorded with *Sesbania* seed rate of 100 kg ha^{-1} (8328.11 kg ha^{-1}). Knocking down of *Sesbania* at 28 DAS had produced highest above ground biomass (8392.73 kg ha^{-1}) which was decreasing with delaying knocking down and lowest (7963.90 kg ha^{-1}) was found when knocked down *Sesbania* at 42 DAS. Early knocking down of *Sesbania* (21 DAS) had also produced lower above ground biomass as compared to 28 DAS.

Table 5: Grain yield, Straw yield, above ground biomass and Harvest index as influenced by seed rate and knocking down days of *Sesbania* in Rice-*Sesbania* co- culture practices at AFU Agronomy Farm, Rampur, Chitwan, Nepal, 2014

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Above ground biomass (kg ha^{-1})	Harvest index
Seed rates of *Sesbania*				
60 kg ha^{-1}	3392.52	4902.97	7820.54	0.37^{b}
80 kg ha^{-1}	3664.59	5152.77	8304.31	0.38^{b}
100 kg ha^{-1}	3956.63	4925.41	8328.11	0.41^{a}
SEm ±	135.8	104.8	218.10	0.004
$LSD_{0.05}$	ns	ns	ns	0.02
Knocking down days				
21 DAS	3452.53	5247.08	8216.25	0.36^{c}
28 DAS	3944.20	5000.72	8392.73	0.40^{a}
35 DAS	3740.51	4814.23	8031.07	0.40^{a}
42 DAS	3547.75	4912.83	7963.90	0.38^{b}
SEm ±	172.00	228.30	368.70	0.004
$LSD_{0.05}$	ns	ns	ns	0.01
CV, %	12.20	11.00	8.90	9.9
Grand mean	3671	4994.00	8151.00	0.39
Farmers' practice	4112.16	6502.44	10038.90	0.35
Weed free	4823.27	6764.17	10654.18	0.37
Weedy check	440.96	999.47	1378.70	0.76

Note: Mean separated by DMRT and columns represented with same letter (s) are non-significant at 5% level of significance. DAS, days after sowing; ns, non-significant.

Harvest Index (HI)

The average harvest index was observed 0.39. There was significant effect of both the seed rates and knocking down days of *Sesbania* on harvest index (Table 5). The harvest index was found significantly lower (0.37) with lower *Sesbania* seed rate (60 kg ha^{-1}) than *Sesbania* seed rate of 100 kg ha^{-1} and statistically similar with *Sesbania* 80 kg ha^{-1}. Significantly, knocking down of *Sesbania* at 28 and 35

DAS had produced similar harvest index (0.40) which were significantly higher than early and delay knocking down days and lowest (0.36) harvest index was recorded with 21 DAS knocking down.

Optimum Seed Rate and Knocking Down Date of Sesbania

The relationship of seed rate of *Sesbania* in rice- *Sesbania* co-culture and grain yield follow a quadratic response with coefficient of determination of 0.79 (R^2=0.79) and this association was highly significant (r=0.89**). Similarly the relationship of knocking down dates of *Sesbania* in rice-*Sesbania* co-culture and grain yield follow a quadratic response with coefficient of determination of 0.79 (R^2=0.12) and this association was significant (r=0.35*). The optimum seed rate of *Sesbania* in rice- *Sesbania* co-culture of 102.28 kg ha^{-1} (102 kg ha^{-1}) was found with optimum knocking down days of 31.67 days (32 DAS) of sowing with selective herbicide (Table 5).

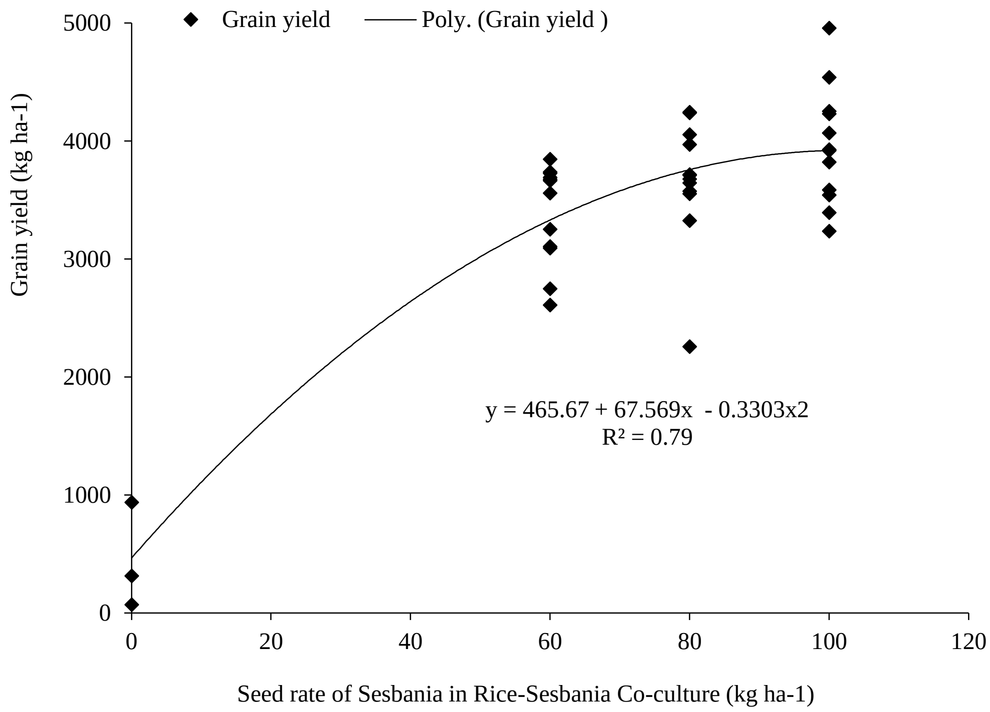

Fig. 1: Response Seed rate of Sesbania in rice-Sesbania co-culture (kg ha^{-1}) on grain yield of rice (kg ha^{-1}) in Rice-Sesbania co- culture practices at Agronomy Farm, AFU, Rampur, Chitwan, Nepal, 2014

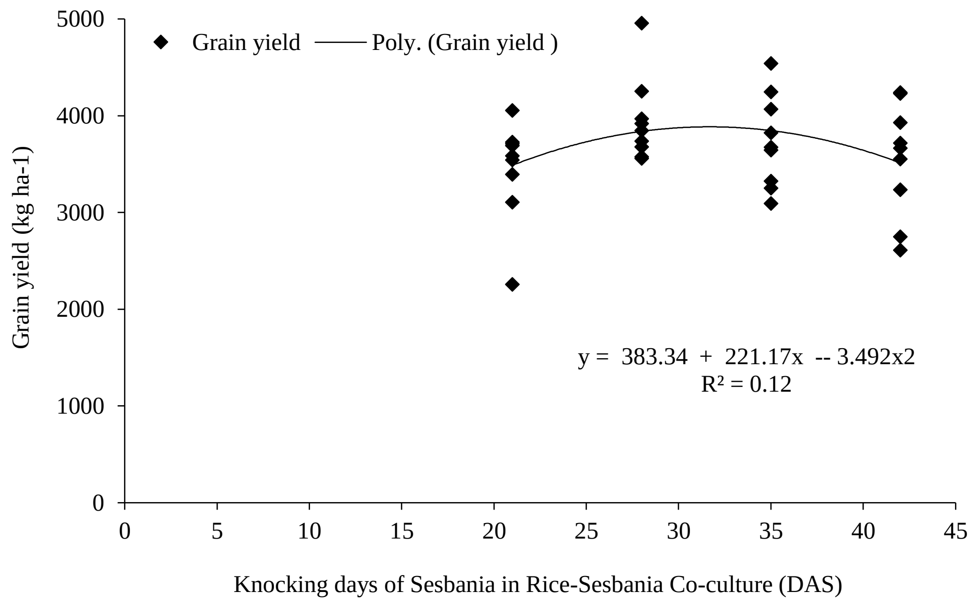

Fig. 2: Response knocking down of Sesbania (DAS) in rice-Sesbania co-culture on grain yield of rice (kg ha^{-1}) in Rice-Sesbania co- culture practices at Agronomy Farm, AFU, Rampur, Chitwan, Nepal, 2014

Conclusion

It was concluded that the growing of *Sesbania* with 100 kg seeds ha^{-1} along with its knocked down at 28 days was the best weed management practices which produced yield similar with farmers' practice. The optimum seed rate and knocking down days of *Sesbania* were 102.28 kg ha^{-1} (102 kg ha^{-1}) and 31.67 DAS (32 DAS) respectively which was found suitable for controlling weeds and produced higher grain yield with higher economic return and being a good weed management practices for dry-DSR.

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