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Effect of non-chemical weed management and planting geometry on weed density, weed biomass, grain yield and nutrient removal by weed in dry direct seeded rice (*Oryza sativa* L.) cultivars

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Abstract
Field studies were carried out from 2015 and 2016 at Agricultural Research Farm, Banaras Hindu University Varanasi, Uttar Pradesh, India to evaluate the effect of non-chemical weed management and planting geometry on weed density, weed biomass, grain yieldand nutrient removal by weed in dry direct seeded rice (*Oryza sativa* L.) cultivars. The experiment consisted of two planting geometry (Seed drill sown crop and square planting), two cultivars (Arize 6444 and PHB 71) and five non-chemical weed management treatment *viz*., weedy, one hoeing at 12 DAS *fb* hand weeding at 30 DAS, one hoeing at 12 DAS *fb Sesbania* co-culture and incorporated at 45 DAS, one hoeing at 12 DAS *fb* straw mulching 4 t/ha *fb* hand weeding at 40 DAS, one hoeing at 12 DAS *fb* straw mulching 6 t/ha. The dominant weed flora of experimental field were *Cynodon dactylon*, *Echinochloa colona* and *Echinochloa crus* Galli among the grasses, *Cyperus iria*, *Cyperus difformis* and *Fimbristylis miliacea* among sedges and *Ammannia baccifera*, *Caesulia axillaris* and *Phyllanthus fraternus* among broad-leaved weeds during both the years. The result revealed that square planting, Arize 6444 cultivar and one hoeing at 12 DAS *fb* hand weeding at 30 DAS had significantly lower weed density, weed biomass and nutrient removal by weed at 90 DAS and higher grain yield during both years.

Keywords: *Sesbania* co-culture, square planting, seed drill sown crop, cultivars, non-chemical weed management

Introduction

Rice is the staple food for more than half of the world's population and playing a crucial role in livelihood and food security of India. Rice (*Oryza sativa* L.) crop suffers more from weed competition unlike other cereal crops. Actual yield losses due to pests have been estimated ~ 40%, of which weeds caused the highest loss (32%), worldwide (Rao *et al*., 2007) [21]. Weeds compete with crop plants for moisture, nutrients, light, space and other growth factors and in the absence of an effective control measures, remove considerable quantity of applied nutrients resulting in a significant yield losses. Weed infestation is one of the major biotic constraints in rice production. About 350 species have been reported as weeds of rice, of which grasses are ranked as first posing serious problem followed by sedges and broad-leaf weeds causing major losses to rice production worldwide (Singh *et al*., 2016) [23]. Crop-weed competition is more severe in DSR than in transplanted rice. The severity of competition depends not only on competing species but also on its density, duration and the fertility status of the soil (Raj and Syriac, 2017) [20]. Since weeds are a major constraint to dry-seeded rice cultivation, the success of dry-seeded rice warrants the intensive use of herbicides. In DSR production environments, cultivars are targeted that are semi-tall, have low tillering ability but high biomass at early stages, have early canopy closure, and provide crop-weed competition in favour of the crop. These cultivars must have tolerance for lodging under high-fertility conditions (Rodenburg and Johnson, 2009) [22]. Direct dryseeded rice requires specially bred cultivars having good mechanical strength in the coleoptiles to facilitate early emergence of the seedlings under crust conditions (generally formed after light rains), early seedling vigour for weed competitiveness (Zhao *et al*. 2006a) [26]., efficient root system for anchorage and to tap soil moisture from lower layers in peak evaporative demands (Pantuwan *et al.* 2002) [17] and yield stability over planting times are desirable traits for DSR. Hybrids usually have better vigor than inbreds; therefore, when possible, hybrids can also be used in direct seeded systems.

However, hybrids are used at low seeding rates (e.g., 15 to 20 kg/ha) because of their expensive seeds (Chauhan, 2012) [3].The crop should be sown preferably in rows either by dibbling or drilling instead of broadcasting to facilitate interculture and other operations (Longchar *et al*., 2002) [12]. Changes in planting geometry and seeding rates may affect weed dynamics and resource use in crops (Khan *et al*., 2009) [10]. The optimum spacing ensures the plant to grow in their both aerial and underground parts through efficient utilization of solar radiation and nutrients (Khan *et al.*, 2005) [11]. Herbicides have been proven effective in many cases, but intensive herbicide use can cause environmental contamination and induce herbicide resistance in weeds (Heap, 2018) [6]. Effective weed management strategies are required to sustain rice production. So, it was planned to study the effect of non-chemical weed management and planting geometry on weed density, weed biomass, grain yield and nutrient removal by weed in dry direct seeded rice cultivars.

Material and Methods

The field experiment was carried out in rice during *kharif* seasons of 2015-16 and 2016-17 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh (India) situated at 25º 18’ N latitude, 83 º 03’ longitudes and at altitude of 128.93m above the mean sea level. The site was well drained and soil sandy clay loam, non-saline (EC 0.21 and 0.20 dsm^{-1}) with pH 7.49 and 7.52 (1:2.5 soil: water) and contained 0.46% and 0.48% organic carbon, 180.21 and 182.67 Kg/ha N (Alkaline permanganate Method, Subbiah and Assja, 1956) [24], 22.12 and 22.85 Kg/ha available P (Olsen’s methods 0.5 M $NaHCO_3$ extractable, Olsen *et al.,* 1954) [16] and 216.5 and 218.86 Kg/ha available K (Flame photometer, Jackson, 1973) [8] during 2015 and 2016 respectively. The weekly mean maximum temperature, during the period of crop growth of both year ranges from 24.6^0C to 42.6^0C (2015) and 25.4^0C to 41.0^0C (2016), respectively. The weekly mean minimum temperature varies from 29.8^0C to 16.2^0C (2015) and 29.9^0C to 11. 7^0C (2016), during both the year, respectively. The experiment was laid out in a split plot design consisting of 20 treatments. Two spacing [S_1-18.5 (seed drill sown crop), S_2-25 cm×25 cm (Square planting)] and two cultivars [V_1-Arize 6444, V_2-PHB71] were assigned in main plot and 5 non-chemical weed management treatments viz.,W_1- Weedy, W_2-One hoeing at 12 DAS *fb* hand weeding at 30 DAS, W_3- One hoeing at 12 DAS *fb Sesbania* co-culture and incorporated at 45 DAS, W_4- One hoeing at 12 DAS *fb* straw mulching 4 t/ha *fb* hand weeding at 40 DAS, W_5 - One hoeing at 12 DAS *fb* straw mulching 6 t/ha were taken in sub-plot replicated thrice. The square quadrat measuring 1 m×1 m was thrown randomly at two spots in the plot and number of weed was counted. The weed biomass was recorded from the total biomass scraped in quadrat (1 m ×1m) from two randomly selected spots in each plot. The samples were first sun dried and then dried in oven at 60^0C samples obtained constant weight.The weed data were recorded as weed density (number/m^2) and weed biomass (g/m^2). Weed density and weed biomass data was subjected to square root transformation ($\sqrt{x+0.5}$) before statistical analysis.Crops from each net plot were threshed separately and grain yield recorded in kg/plot. This was finally converted in to grain yield q/ha.Nitrogen, phosphorus, potassium, content in weeds were analysed as per standard procedurefor nitrogen content estimation by micro kjeldahl method (Piper, 1966) [18]., phosphorus by vanadomolybdate yellow colour method (Jackson, 1958) [7] and potassium by flame photometer method (Jackson, 1958) [7]. Nutrient uptake by weeds were calculated in kg/ha by using the following formula.

$$\text{Nutrient Uptake (kg/ha)} = \frac{\text{Nutrient content (\%)} \times \text{Weed biomass}}{100}$$

Collected data were statistically analyzed as per standard (Gomez and Gomez, 1984) [5] procedure to draw a valid conclusion.

Result and Discussion

Effect on weed density and weed biomass

Total weed density and weed biomass recorded significantly lower in square planting treatment as compared to seed drill sown crop (Table 1). Weed growth suppressed in square planting because of rice crop performed satisfactorily in uniform plant to plant and row to row spacing and reduced crop weed competition. Colbach *et al*. (2014) [4] also reported that weed-competition decreases with increasing uniformity of arrangements of plants *i.e* inter- and intra-row spacing are more or less same. In this situation crop draw and take up larger share of the natural resources and applied inputs in comparison to weeds. (Nichols *et al*., 2009) [15].

Arize 6444 cultivar was more competitive than PHB71 in respect of reducing weed density and weed biomass. This might be due to higher germination and faster seedling emergence with more vigorous seedlings under dry direct-seeded conditions (Azhiri-Sigari *et al*., 2005) [1]. The use of cultivars with early vegetative vigour facilitating good crop establishment and better competitive ability with weeds stabilizes the yield of dry direct-seeded rice

The weed density and weed biomass under present study was significantly reduced under different non-chemical weed management treatments as compared to weedy check. Amongst weed management methods, one hoeing at 12 DAS *fb* hand weeding at 30 DAS was most effective weed management method in reducing weed density and weed biomass at 90 DAS during both the years. This might be due initial 30 days lesser crop weed competition maintained which help to attain maximum crop growth and ultimately suppressed weed growth. Johnson *et al*. (2004) [9] also reported similar findings in field trials of dry-seeded irrigated rice where higher rice yield was obtained by controlling weeds until 38 DAS in wet season and until 32 DAS in the dry season.

Effect on grain yield

The grain yield was significantly higher at square planting than the seed drill sown crop (Table 1). The higher yield in wider plant spacing might be due to lower weed competition. The result was in accordance of Mahajan and Chauhan (2011a) [13].

Grain yield was significantly higher in Arize 6444 cultivar than PHB 71.and proved more competitive against weeds than PHB 71.Similar findings were also reported by Toung *et al*. (2000) [25].

Among weed management treatment, one hoeing at 12 DAS *fb* hand weeding at 30 DASrecorded the maximum grain yield which was significantly superior to rest of the weed management treatment except one hoeing at 12 DAS *fb Sesbania* incorporated at 45 DAS during both the years. Weedy check recorded significantly minimum grain yield among all weed management treatments during both the years of experimentation. Similar finding was reported by Mewada *et al*. (2016) [14].

Interaction effect of planting geometry and non-chemical weed management treatments on grain yield

Square planting and one hoeing at 12 DAS *fb* hand weeding at 30 DAS treatment combination recorded the maximum grain yield which remained on par with rest of the treatment combinations except seed drill sown crop and one hoeing at 12 DAS *fb* hand weeding at 30 DAS and square planting and one hoeing at 12 DAS *fb Sesbania* incorporated at 45 DAS during both the years (Table 2). Uniform planting geometry performed better along with one hoeing at 12 DAS *fb* hand weeding at 30 DAS and it proved more efficient in reducing weed growth and increased grain yield. Among all treatments combinations seed drill sown crop and weedy check recorded minimum grain yield.

Interaction effect of cultivars and non-chemical weed management treatments on grain yield

The maximum grain yield was recorded in Arize 6444 and one hoeing at 12 DAS *fb* hand weeding at 30 DAS interactions and remained on par with Arize 6444 and one hoeing at 12 DAS *fb Sesbania* incorporated at 45 DAS, but was significantly superior to the rest of the cultivars and weed management treatments (Table 3). This might be due to early canopy development of Arize 6444 cultivar and more competitiveness against weed along with one hoeing at 12 DAS *fb* hand weeding at 30 DAS and one hoeing at 12 DAS *fb Sesbania* incorporated at 45 DAS weed management treatments. Weeding at 30 DAS proved to be effective in reducing weed density and encourage the growth and development of Arize 6444 cutivar.

Effect on nutrient removal by weeds

Nutrient removal by weeds was significantly influenced due to planting geometry, cultivar and non-chemical weed management methods (Table 4). Square planting recorded significantly lower nutrient removal by weed as compared to seed drill sown crop. This might be due to lesser weed density and lower weed biomass which significantly reduced nutrient removal by weed Similar findings were reported by Nichols *et al*., 2009 [15]. Arize 6444 cultivar significantly reduced nutrient removal by weed as compared to PHB 71. Arize 6444 cultivar suppressed weed growth and reduced weed biomass and subsequent nutrient removal. Similar findings were reported by Chauhan and Johnson, (2010a) [2].

The removal of N, P and K by weeds was maximum under weedy. All the weed management methods significantly brought down N, P and K removal by weed as compared to weedy check during both the years. Amongst the weed management, the removal of nutrients by weeds was lowest in W_2 (One hoeing at 12 DAS *fb* hand weeding at 30 DAS) treatment. The nutrient removal is dependent on dry matter accumulation of weeds and weed management methods which observed lower weed biomass had minimum nutrient (N, P and K) removal. This fact is in conformity with the findings of Puniya *et al*. (2007) [19].

Interaction effect of planting geometry and non-chemical weed management on nutrient (N, P and K) removal

Square planting and one hoeing at 12 DAS *fb* hand weeding at 30 DAS treatment combination recorded minimum nutrient (N, P and K) removal by weed which remained significantly superior over rest of the treatments during both the years (Table 5, 7 and 9). Amongst all treatment combinations normal drill sown crop and weedy check treatment combination recorded maximum nutrient removal by weed during both the years. This might be due to lower weed biomass and consequently lesser removal of nutrient by weed in this treatment combination.

Interaction effect of cultivar and non-chemical weed management on nutrient (N and P) removal

The minimum nutrient (N and P) removal by weed was recorded in treatment combination of Arize 6444 and one hoeing at 12 DAS *fb* hand weeding at 30 DASand remained significantly superior in reducing nutrient removal than the rest of the interaction effects during both the years (Table 6 and 8). This might be due to lower weed biomass and consequently lesser removal of nutrients in these treatment combinations.

Conclusion

On the basis of result it can be concluded that square planting and Arize 6444 cultivar withone hoeing at 12 DAS *fb* hand weeding at 30 DAS was found to be most effective in minimizing weed density, weed biomass and nutrient removal by weed and enhancing yield during both the year of experimentation.

Table 1: Effect of non-chemical weed management and planting geometry on weed density (No. /m^2) weed biomass (g/m^2) and grain yield (q/ha) at 90 DAS in dry direct seeded rice cultivars.

Treatment	90 DAS				Grain yield (q/ha)	
	Weed density		Weed biomass			
	2015	2016	2015	2016	2015	2016
Planting geometry						
18.5 cm (R-R)	12.41(156.69)	11.88(143.39)	21.76(485.61)	21.31(465.20)	37.84	40.01
25×25 cm (Square planting)	11.01(123.42)	10.34(108.73)	20.25(422.10)	19.62(396.80)	40.80	42.93
SEm±	0.07	0.07	0.09	0.11	0.72	0.70
CD (P=0.05)	0.23	0.24	0.30	0.40	2.51	2.41
Cultivar						
Arize 6444	11.29(130.17)	10.68(116.43)	20.59(436.45)	19.95(410.24)	41.31	43.57
PHB71	12.13(149.94)	11.54(135.68)	21.41(471.26)	20.98(451.75)	37.33	39.37
SEm±	0.07	0.07	0.09	0.11	0.72	0.70
CD (P=0.05)	0.23	0.24	0.30	0.40	2.51	2.41
Weed management						
Weedy	14.37(207.09)	13.43(180.89)	27.30(745.41)	26.31(692.17)	20.51	22.66
Hoeing at 12 DAS *fb* hand weeding at 30 DAS	9.76(95.18)	9.19(84.61)	16.87(284.49)	16.17(261.90)	47.58	49.34
Hoeing at 12 DAS *fbSesbania* incorporated at 45 DAS	10.48(109.98)	9.93(99.07)	19.05(363.20)	18.47(341.84)	45.90	47.75
Hoeing at 12 DAS *fb* straw mulching 4 t/ha *fb* hand weeding at 40DAS	12.59(158.62)	12.15147.84)	21.70(471.24)	21.49(462.52)	39.36	41.69

Hoeing at 12 DAS *fb* straw mulching 6 t/ha	11.37(129.42)	10.84(117.88)	20.11(404.92)	19.90(396.56)	43.25	45.89
SEm±	0.06	0.05	0.07	0.09	0.62	0.56
CD (P=0.05)	0.17	0.15	0.21	0.25	1.77	1.62

Table 2: Interaction effect of planting geometry and non-chemical weed management on grain yield of dry direct seeded rice cultivars during 2015 and 2016

Weed management	**Planting geometry**			
	2015		**2016**	
	S_1-18.5 cm (R-R)	**S_2-25x25 cm (Square planting)**	**S_1-18.5 cm (R-R)**	**S_2-25x25 cm (Square planting)**
W_1-Weedy	17.21	23.80	19.63	25.70
W_2-Hoeing at 12 DAS *fb* hand weeding at 30 DAS	46.63	48.52	48.20	50.47
W_3-Hoeing at 12 DAS *fb Sesbania* incorporated at 45 DAS	44.77	47.04	46.99	48.51
W_4-Hoeing at 12 DAS *fb* straw mulching 4 t/ha *fb* hand weeding at 40DAS	38.72	39.99	40.12	43.27
W_5-Hoeing at 12 DAS *fb* straw mulching 6 t/ha	41.87	44.64	45.10	46.68
	2015		2016	
	SEm±	CD at 5%	SEm±	CD at 5%
W at same levels of S	0.87	2.51	0.80	2.29
S at same or different levels of W	1.06	3.35	0.99	3.15

Table 3: Interaction effects of cultivar and non-chemical weed management on grain yield of dry direct seeded rice during 2015

Weed management	**Planting geometry**			
	2015		**2016**	
	V_1-Arize6444	**V_2-PHB71**	**V_1-Arize6444**	**V_2-PHB71**
W_1-Weedy	21.79	19.22	23.51	48.80
W_2-Hoeing at 12 DAS *fb* hand weeding at 30 DAS	50.55	44.61	52.02	46.66
W_3-Hoeing at 12 DAS *fb Sesbania* incorporated at 45 DAS	48.79	43.01	50.46	45.04
W_4-Hoeing at 12 DAS *fb* straw mulching 4 t/ha *fb* hand weeding at 40DAS	39.99	38.72	43.06	40.33
W_5-Hoeing at 12 DAS *fb* straw mulching 6 t/ha	45.42	41.09	48.80	42.98
	2015		2016	
	SEm±	CD at 5%	SEm±	CD at 5%
W at same levels of S	0.87	2.51	0.80	2.29
S at same or different levels of W	1.06	3.35	0.99	3.15

Table 4: Effect of planting geometry and non-chemical weed management on nutrient removal by weed in dry direct seeded rice cultivars at 90 DAS

Treatment	**Nutrient removal by weed**					
	N removal		**P removal**		**K removal**	
	2015	**2016**	**2015**	**2016**	**2015**	**2016**
Planting geometry						
18.5 cm (R-R)	35.16	33.34	7.33	6.95	34.44	32.65
25×25 cm (Square planting)	28.41	26.58	5.92	5.53	27.88	26.07
SEm±	0.22	0.23	0.08	0.08	0.29	0.31
CD (P=0.05)	0.75	0.81	0.27	0.27	1.02	1.09
Cultivars						
Arize 6444	29.97	28.16	6.25	5.87	29.43	27.63
PHB71	33.60	31.76	7.00	6.61	32.90	31.09
SEm±	0.22	0.23	0.08	0.08	0.29	0.31
CD (P=0.05)	0.75	0.81	0.27	0.27	1.02	1.09
Weed management						
Weedy	63.08	60.92	12.83	12.39	60.64	58.57
Hoeing at 12 DAS *fb* hand weeding at 30 DAS	16.67	15.06	3.66	3.30	17.17	15.51
Hoeing at 12 DAS *fb Sesbania* co-culture sown at 12 DAS and incorporated at 45 DAS	21.44	19.70	4.56	4.19	21.39	19.66
Hoeing at 12 DAS *fb* straw mulching 4 t/ha *fb* hand weeding at 40DAS	32.68	30.88	6.80	6.43	31.95	30.19
Hoeing at 12 DAS *fb* straw mulching 6 t/ha	25.06	23.23	5.29	4.90	24.66	22.86
SEm±	0.28	0.28	0.06	0.06	0.34	0.34
CD (P=0.05)	0.80	0.80	0.18	0.18	0.97	0.98

Table 5: Interaction effect of planting geometry and non-chemical weed management on N removal by weed (kg/ha) in dry direct seeded rice cultivars at 90 DAS during 2015 and 2016

Weed management	**Planting geometry**			
	2015		**2016**	
	S_1-18.5 cm (R-R)	**S_2-25x25 cm (Square planting)**	**S_1-18.5 cm (R-R)**	**S_2-25x25 cm (Square planting)**
W_1-Weedy	67.40	58.76	65.28	56.56
W_2-Hoeing at 12 DAS *fb* hand weeding at 30 DAS	18.94	14.40	17.33	12.79
W_3-Hoeing at 12 DAS *fb Sesbania* incorporated at 45 DAS	24.57	18.30	22.82	16.58

W_4-Hoeing at 12 DAS *fb* straw mulching 4 t/ha *fb* hand weeding at 40DAS	36.49	28.87	34.70	27.07
W_5-Hoeing at 12 DAS *fb* straw mulching 6 t/ha	28.40	21.72	26.56	19.90
	2015		2016	
	SEm±	CD at 5%	SEm±	CD at 5%
W at same levels of S	0.39	1.13	0.39	1.13
S at same or different levels of W	0.41	1.25	0.42	1.29

Table 6: Interaction effect of cultivar and non-chemical weed management on N removal by weed (kg/ha) in dry direct seeded rice cultivars at 90 DAS during 2015 and 2016

Weed management	Planting geometry			
	2015		2016	
	V_1-Arize 6444	**V_2-PHB71**	**V_1-Arize6444**	**V_2-PHB71**
W_1-Weedy	60.53	65.62	58.39	63.46
W_2-Hoeing at 12 DAS *fb* hand weeding at 30 DAS	15.55	17.79	13.89	16.23
W_3-Hoeing at 12 DAS *fb* *Sesbania* incorporated at 45 DAS	19.82	23.06	18.10	21.30
W_4-Hoeing at 12 DAS *fb* straw mulching 4 t/ha *fb* hand weeding at 40DAS	30.59	34.78	28.80	32.97
W_5-Hoeing at 12 DAS *fb* straw mulching 6 t/ha	23.38	26.74	21.61	24.85
	2015		2016	
	SEm±	CD at 5%	SEm±	CD at 5%
W at same levels of S	0.39	1.13	0.39	1.13
S at same or different levels of W	0.41	1.25	0.42	1.29

Table 7: Interaction effect of planting geometry and non-chemical weed management on P removal by weed (kg/ha) in dry direct seeded rice cultivars at 90 DAS during 2015 and 2016

Weed management	Planting geometry			
	2015		2016	
	S_1-18.5 cm (R-R)	**S_2-25x25 cm (Square planting)**	**S_1-18.5 cm (R-R)**	**S_2-25x25 cm (Square planting)**
W_1-Weedy	13.79	11.86	13.36	11.42
W_2-Hoeing at 12 DAS *fb* hand weeding at 30 DAS	4.19	3.12	3.84	2.77
W_3-Hoeing at 12 DAS *fb* *Sesbania* incorporated at 45 DAS	5.18	3.94	4.81	3.57
W_4-Hoeing at 12 DAS *fb* straw mulching 4 t/ha *fb* hand weeding at 40DAS	7.54	6.06	7.17	5.68
W_5-Hoeing at 12 DAS *fb* straw mulching 6 t/ha	5.96	4.62	5.57	4.23
	2015		2016	
	SEm±	**CD at 5%**	**SEm±**	**CD at 5%**
W at same levels of S	0.09	0.26	0.09	0.26
S at same or different levels of W	0.11	0.35	0.11	0.36

Table 8: Interaction effect of cultivar and non-chemical weed management on P removal by weed (kg/ha) in dry direct seeded rice cultivars at 90 DAS during 2015 and 2016

Weed management	Planting geometry			
	2015		2016	
	V_1-Arize 6444	**V_2-PHB71**	**V_1-Arize6444**	**V_2-PHB71**
W_1-Weedy	12.27	13.38	11.83	12.94
W_2-Hoeing at 12 DAS *fb* hand weeding at 30 DAS	3.40	3.91	3.04	3.57
W_3-Hoeing at 12 DAS *fb* *Sesbania* incorporated at 45 DAS	4.26	4.86	3.89	4.49
W_4-Hoeing at 12 DAS *fb* straw mulching 4 t/ha *fb* hand weeding at 40DAS	6.37	7.23	6.00	6.85
W_5-Hoeing at 12 DAS *fb* straw mulching 6 t/ha	4.95	5.62	4.58	5.22
	2015		2016	
	SEm±	**CD at 5%**	**SEm±**	**CD at 5%**
W at same levels of S	0.09	0.26	0.09	0.26
S at same or different levels of W	0.11	0.35	0.11	0.36

Table 9: Interaction effect of planting geometry and non-chemical weed management on K removal by weed (kg/ha) in dry direct seeded rice cultivars at 90 DAS during 2015 and 2016

Weed management	Planting geometry			
	2015		2016	
	S_1-18.5 cm (R-R)	**S_2-25×25 cm (Square planting)**	**S_1-18.5 cm (R-R)**	**S_2-25××25 cm (Square planting)**
W_1-Weedy	65.09	56.20	63.04	54.09
W_2-Hoeing at 12 DAS *fb* hand weeding at 30 DAS	19.57	14.77	17.91	13.11
W_3-Hoeing at 12 DAS *fb* *Sesbania* incorporated at 45 DAS	24.40	18.38	22.66	16.65
W_4-Hoeing at 12 DAS *fb* straw mulching 4 t/ha *fb* hand weeding at 40DAS	35.41	28.49	33.67	26.71
W_5-Hoeing at 12 DAS *fb* straw mulching 6 t/ha	27.75	21.57	25.96	19.76
	2015		2016	
	SEm±	**CD at 5%**	**SEm±**	**CD at 5%**
W at same levels of S	0.48	1.38	0.48	1.38
S at same or different levels of W	0.52	1.59	0.53	1.64

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