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Management of complex weed flora in transplanted rice by different herbicides and green manuring

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ABSTRACT

A field study was conducted at Dr. Balasdaheb Sawant Konkan Krishi Vidyapeeth, Dapoli (Maharashtra) during *Kharif* seasons (2011 to 2014) on rice crop to evaluate the effect of green manuring with *Sesbania rostrata* and different herbicides on complex weed flora in transplanted rice. The experimental field was infested with *Ludwigia octovalis*, *Cloem viscosa*, *Cyperus iria, Amaranthus sessils, Isachne globosa* and *Eriocaulon hexangularis*. Application of pre-emergence fixed herbicide and pre-emergence and post-emergence rotational herbicides reduced the complex weed flora. Pre-emergence application of pretilachlor-S at the rate of 0.75 kg/ha at 3-7 days after treatment (DAT) recorded the highest weed control efficiency, rice grain yield and net returns during all years is the best ways of controlling complex weed flora and enhancing productivity and profitability from transplanted rice.

Introduction

Rice (*Oryza sativa* L.) is cultivated as a strategic crop in many countries of the world. This crop is a remarkable source of food for a large population, especially in India. In India, rice occupies an area of 43.39 million ha with production and productivity of 104.32 million tons and 2.4 t/ha, respectively (Mahajan et al. 2017). India should add 1.7 million tons of additional rice every year to

ensure national food security (Das and Chandra 2013). Though, India has the largest area under rice in the world but its productivity is very low. This might be due to several constraints. Among them weeds pose a major threat for rice production and yield. Uncontrolled weed growth causes 33-45% reduction in grain yield of transplanted rice (Singh et al. 2007, Manhas et al. 2012). Antralina et al (2015) found that chemical control method using Bispyribac sodium and 2.4 D + Methyl metsulfuron has significant effects on weed population and rice yield in the SOBARI. The composition of weed flora in agro ecosystems is depends on different factors including crop type, irrigation regimes, herbicides application history, and climate condition. Hosoya and Sugiyama (2016) found that two dominant weed species, including *Monochoria vaginalis* and Cyperaceae, accounted for 84% of the total weed biomass in the rice field in japan. Akter et al. (2018) reported five most dominant weed species in rice crop in Bangladesh under in situ condition including *Eleocharis atroperpurea*, *Cyperus difformis*, *Alternanthera philoxeroides*, *Azolla pinnata* and *Echinochloa crusgalli*.

The scope of incorporation of legume green manuring crop in rice is more because of its efficiency to control weeds by way of smothering during the early period of weed emergence and increasing crop yield and reduce the weed crop competition during early period of crop growth by application of pre emergence herbicide. Therefore the present investigation was carried out to study the influence of green manure and weed control measures in transplanted rice.

Materials and Methods

A field experiment was conducted during 2011 to 2014 at Dr. Balasdaheb Sawant Konkan Krishi Vidyapeeth, Dapoli (Maharashtra). The experimental site was located at west coast 250 meter height from mean sea level having annual average rainfall 3500 mm with 95 to 100 rainy days throughout *Kharif* season. The experiment was conducted in strip plot design with three replications. The two main plot treatment comprised: application of green manuring and without green manuring and four subplot treatments including fixed herbicide (pretilachlor-S 0.75 kg/ha at 3-7 DAT), rotational herbicide (pyrazosulfuron 0.030 kg/ha at 8-10 DAT (I yr)**,** fenoxaprop -p-ethyl 0.056 kg/ha at 25-30 DAT (IIyr)**,** oxadiargyl 0.100 kg/ha at 0-5 DAT (IIIyr), weed free check (2 Hand Weeding (HW) at 20 and 40 Days After Transplanting(DAT)) and weedy check. The soil of the experimental plot was sandy clay loam in texture, acidic in pH and medium in organic carbon content. It was low in available nitrogen (282 kg/ha), medium in available phosphorus (10.8 kg/ha) and high in available potassium (236 kg/ha). The gross main plot size was 10.0 x 10.0 m. and net plot size 2.30 x 10 m. The seed of rice variety *'Ratnagiri-24'* was treated with thiram at the rate of 3 g/kg of seed used for sowing. Sowing was done by opening small furrows of about 3 cm depth in

nursery. The rice seedlings were transplanted in puddled field 21 days after sowing (DAS). The recommended dose of fertilizer (100:50:50 N, P_2O_5, and K_2O kg/ha) was applied to all the plots. Half dose of nitrogen and full dose of phosphorus and potassium was applied at the time of puddling while remaining half dose of nitrogen was applied at 30 DAT. The uniform representative samples of crop as well as weeds were randomly collected from each plot. Data were analyzed (pooled analysis) statistically by using standard methods of Panse and Sukhatme (1984). The significant differences between treatments were compared by critical difference at 5% level of probability. The data on weed density and biomass were subjected to square root transformation for comparison.

Results and discussion

The major weed flora observed during the experimentation were, *viz*. *Ludwigia octovalis*, *Cleome viscosa*, *Cyperus iria, Amaranthus sessils, Isachne globosa, Eriocaulon hexangularis Cyperus rotundus, Eleusine indica, Echinochloa colona, Ischemum rugosum, Mimosa pudica, Physalis minima,* and *Celosia argentea.*

Weed density of monocots and broad leaved weeds in rice at 30 and 50 DAT did not significantly influence during the individual years and in pooled results due to green manuring (Table 1 and 2). However, less number of weeds was observed in green manuring than without green manuring during all the years of observations as well as in pooled results. These results are in line with the findings of Gnanavel and Kathiresan, (2002) who reported that raising green manure *Sesbania aculeata* in the preceding off-season and ploughing in situ before puddling reduced the weed counts and increased the weed control index in the succeeding rice crops due to smothering effect of green manure on the emergence and growth of weeds. In rice-wheat cropping systems, inclusion of *Sesbania aculeata* in summer resulted in least grasses and sedges in the succeeding crops (Singh et al. 2008).

Effect of weed control measures

Weed control measures tried did not significantly influence weed density of monocots and broad leaved weeds at 30 DAS during all the individual years and also in pooled results except during the year 2014 (Table 1) and pooled results in respect of BLWs. Weed free check significantly reduced the weed density of monocots and broad leaved weeds over weedy check and application of rotational herbicide (pyrazosulfuron 0.030 kg/ha at 8-10 DAT (I yr)**,** fenoxaprop -p-ethyl 0.056 kg / ha at 25-30 DAT (IIyr)**,** oxadiargyl 0.100 kg/ha at 0-5 DAT (IIIyr) but it was at par with application of pretilachlor-S herbicide during 2014, While it was at par with all the weed control measures and reduced significantly the density of broad leaved weeds than weedy check during pooled results.

In *Kharif* rice, weed free check reduced significantly the density of monocots and broad leaved weeds during the year 2014 and in pooled results over weedy check and rotational herbicide but it was at par with application of pretilachlor-S herbicide at 50 DAT (Table 2) and application of pretilachlor-S herbicide and remained at par with rotational herbicide (pyrazosulfuron 0.030 kg/ha at 8-10 DAT (I yr), fenoxaprop -p-ethyl 0.056 kg / ha at 25-30 DAT (IIyr), oxadiargyl 0.100 kg/ha at 0-5 DAT (IIIyr). Higher weed control efficiency was observed in weed free check followed by application of pretilachlor-S herbicide during both the observations. Duary *et al.* (2015) also reported similar results.

Effects of green manuring on weed dry matter

Four year pooled data revealed that green manuring did not influence significantly the dry matter of monocots and broad leaved weeds at all the stages of observation during all the years of experimentation (Table 3). However, least weed dry matter was observed in green manuring than without green manuring during all the years of observations as well as in pooled results. These results were in line with the findings of Mathew and Alexander (1995) who reported that intercropping with *Sesbania aculeata* and manual incorporation of the same at 35 DAS in semi-dry rice recorded the lowest weed dry matter compared with sole paddy crop. Similar results were recorded by Nalini et al. (2008).

Effect of weed control measures

Weed free check significantly reduced the weed dry matter of monocots and broad leaved weeds at 30 DAT during the year 2014 and in pooled results over all other weed control measures (Table 3), however it was at par with the use of application of pretilachlor-S herbicide during the year 2014 and in pooled results while it was significantly higher over rest of the treatments in broad leaved weeds during 2014.

Significantly lowest dry matter of monocots was recorded due to weed free check over weedy check and rotational herbicide (pyrazosulfuron 0.030 kg/ha at 8-10 DAT (I yr), fenoxaprop -p-ethyl 0.056 kg / ha at 25-30 DAT (IIyr), oxadiargyl 0.100 kg/ha at 0-5 DAT (IIIyr) and was at par with application of pretilachlor-S herbicide during the year 2014 at 50 DAT (Table 4) and in pooled results. Among the herbicides tried, pretilachlor-S herbicide reduced weed dry matter of monocots than application of rotational herbicide (pyrazosulfuron 0.030 kg/ha at 8-10 DAT (I yr), fenoxaprop -p-ethyl 0.056 kg / ha at 25-30 DAT (IIyr), oxadiargyl 0.100 kg/ha at 0-5 DAT (IIIyr). However dry matter of broad leaved weeds did not significantly influence due to various weed control measures

tried during individual years as well as in pooled analysis. Higher weed control efficiency was observed in weed free check followed by application of pretilachlor-S herbicide during both the observations. Similar results were reported by Duary et al. (2015).

Effects of green manuring on grain and straw yield of rice

Green manuring significantly influenced the grain and straw yield of rice and produced significantly higher grain and straw yield as compared to without green manuring during the year 2011, 2012 and in pooled results (Table 5). This was due to effective suppression of weeds, restricting the nutrient drain by weeds and nutrient addition due to incorporation of green manuring crop. Apart from better weed control, mineralization of nutrients from incorporated green manuring might have resulted in higher grain yield (Matiwade and Sheelavantar, 1994) and Nalini et al. (2008).

Effect of weed control measures

Weed control measures significantly influence the grain yield of rice during individual years as well as in pooled results except during the year 2013 (Table 5). Weed free check produced significantly highest grain yield of rice over use of both (application of pretilachlor-S and rotational herbicides (pyrazosulfuron 0.030 kg/ha at 8-10 DAT (I yr)**,** fenoxaprop -p-ethyl 0.056 kg / ha at 25-30 DAT (IIyr)**,** oxadiargyl 0.100 kg/ha at 0-5 DAT (IIIyr) herbicide and weedy check during the year 2014 and in pooled results while, it was at par with application of pretilachlor-S and rotational herbicides during the year 2011 and during the year 2012 with rotational herbicide. Various weed control measures did not influence significantly the straw yield of rice during the year 2012, 2013 and in pooled analysis. Pooled result revealed that compared to best treatment of weed free check, the percent reduction in grain yield in terms of weed control efficiency was found to be the least in case of use of pretilachlor-S (8.41%) followed by application of rotational herbicide (pyrazosulfuron 0.030 kg/ha at 8-10 DAT (I yr)**,** fenoxaprop -p-ethyl 0.056 kg / ha at 25-30 DAT (IIyr)**,** oxadiargyl 0.100 kg/ha at 0-5 DAT (IIIyr) (12.39%). Similar finding was also reported earlier by Teja et al. (2016).

Conclusion

From four years study, it can be concluded that**,** incorporation of green manure and application of fixed herbicide pretilachlor-S to *kharif* rice reduced weed growth with increase in yield of the rice under Konkan region of Maharashtra.

Conflict of interest

Authors declare no conflict of interest.

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Table 1. Effects of green manuring and weed control measures on weed density in rice at 30 DAT (No/m²). (Four years pooled mean)

Treatments	Grasses and sedges					Broad leaved weeds					Weed control efficiency				
	2011	2012	2013	2014	Pooled	2011	2012	2013	2014	Pooled	2011	2012	2013	2014	Pooled
Green manuring															
Green manuring	10.48 (3.04)	11.67 (3.28)	23.67 (4.65)	22.33 (4.72)	17.70 (4.20)	2.65 (1.48)	1.33 (1.08)	1.00 (0.94)	8.33 (2.87)	3.50 (1.96)		-	-	-	
Without green manuring	13.47 (3.45)	23.33 (4.31)	22.00 (4.27)	25.00 (5.01)	20.28 (4.49)	2.33 (1.29)	2.33 (1.43)	1.00 (1.01)	10.33 (3.22)	3.83 (2.06)		-	-	-	
Sem ±	- (0.02)	(0.30)	- (0.62)	- (0.13)	- (0.08)	- (0.09)	- (0.28)	- (0.19)	- (0.20)	- (0.16)		-	-	-	
LSD (p=0.05)	- (N.S)	- (N.S)	(N.S)	- (N.S)	- (N.S.)	- (N.S.)	- (N.S.)	- (N.S.)	- (N.S.)	- (N.S.)	-	-	-	-	
Weed control measures															
Fixed.herbicide – Pretilachlor-S (PE)	10.65 (3.09)	12.00 (3.19)	20.67 (4.49)	19.33 (4.44)	18.91 (4.32)	2.66 (1.41)	1.33 (1.08)	0.00 (0.71)	8.00 (2.86)	3.50 (1.98)	46.63	56.54	32.61	42.27	17.97
Rotational herbicide	12.96 (3.12)	18.67 (4.00)	26.67 (4.84)	22.00 (4.66)	21.74 (4.63)	2.66 (1.27)	2.00 (1.31)	0.00 (0.71)	9.33 (3.08)	3.34 (1.93)	37.37	32.61	13.04	33.82	8.20
Weed free check	4.00 (1.64)	11.33 (3.29)	17.33 (4.09)	16.67 (4.13)	13.17 (3.67)	0.00 (0.71)	1.33 (1.08)	0.00 (0.71)	5.33 (2.39)	2.67 (1.76)	83.96	58.72	43.50	53.53	42.02
Weedy check	20.30 (3.93)	28.00 (4.71)	26.67 (4.41)	32.67 (5.75)	22.16 (4.75)	4.64 (2.14)	2.67 (1.55)	4.00 (1.78)	14.67 (3.86)	5.16 (2.36)	-	-	-	-	-
Sem ±	- (0.85)	- (0.85)	- (0.87)	1.44 (0.14)	- (0.28)	- (0.41)	- (0.37)	- (0.29)	1.28 (0.21)	0.50 (0.12)	-	-	-	-	-
LSD (p=0.05)	- (N.S)	- (N.S)	- (N.S)	4.44 (0.44)	- (N.S.)	- (N.S.)	- (N.S.)	- (N.S.)	3.93 (0.64)	1.54 (0.37)	-	-	-	-	-

Note: Interaction between green manuring and weed control measures were non-significant during all the stages of observations. Figures in parentheses indicate square root transformations $\sqrt{x + 0.5}$.

Table 2. Effects of green manuring and weed control measures on weed density in rice at 50 DAT (No/m²) (four years pooled mean).

Treatments	Grasses and sedges					Broad leaved weeds					Weed control efficiency				
	2011	2012	2013	2014	Pooled	2011	2012	2013	2014	Pooled	2011	2012	2013	2014	Pooled
Green manuring															
Green manuring	18.80 (3.62)	5.00 (2.15)	26.67 (5.09)	29.33 (5.38)	24.28 (4.90)	0.02 (0.72)	3.00 (1.45)	8.33 (2.49)	22.33 (4.73)	8.42 (2.92)		-	-	-	-
Without green manuring	39.83 (5.39)	8.33 (2.69)	44.00 (6.56)	28.33 (5.25)	25.79 (4.98)	1.34 (1.13)	4.00 (1.83)	7.33 (2.35)	19.67 (4.44)	8.08 (2.88)		-	-	-	-
Sem ±	- (0.55)	- (0.16)	- (0.33)	- (0.09)	- (0.15)	- (0.05)	- (0.15)	- (0.30)	- (0.26)	- (0.07)		-	-	-	-
LSD (p=0.05)	- (NS)	- (NS)	- (NS)	- (NS)	- (NS)	- (0.29)	- (NS)	- (NS)	- (NS)	- (NS)					
Weed control measures															
Fixed.herbicide – Pretilachlor-S (PE)	23.32 (3.95)	7.33 (2.58)	36.00 (5.88)	22.00 (4.70)	23.00 (4.72)	1.33 (1.18)	2.67 (1.41)	8.67 (2.73)	20.00 (4.49)	6.34 (2.57)	53.42	37.50	16.24	40.57	38.53
Rotational herbicide	36.35 (5.25)	7.33 (2.44)	39.33 (6.17)	33.33 (5.80)	28.25 (5.30)	0.02 (0.72)	3.33 (1.68)	10.00 (2.95)	20.67 (4.56)	8.50 (2.98)	31.27	33.38	7.50	23.59	23.00
Weed free check	6.01 (1.89)	4.67 (2.02)	24.67 (4.91)	17.33 (4.20)	13.17 (3.68)	0.02 (0.72)	1.33 (1.18)	0.67 (0.94)	15.33 (3.96)	6.17 (2.55)	88.61	62.50	52.48	53.79	59.48
Weedy check	51.58 (6.94)	9.33 (3.35)	41.33 (6.33)	42.67 (6.56)	35.73 (6.00)	1.34 (1.08)	6.67 (2.29)	12.00 (3.06)	28.00 (5.32)	12.00 (3.49)	-	-	-	-	-
Sem ±	- (1.13)	- (0.60)	- (0.48)	- (0.23)	- (0.34)	- (0.25)	- (0.51)	- (0.65)	- (0.17)	- (0.21)	-	-	-	-	-
LSD (p=0.05)	- (NS)	- (NS)	- (NS)	- (0.72)	- (1.05)	- (NS)	- (NS)	- (NS)	- (0.53)	- (0.66)	-	-	-	-	-

Note: Interaction between green manuring and weed control measures were non-significant during all the stages of observations Figures in parentheses indicate square root transformations $\sqrt{x + 0.5}$

Table 3. Effects of green manuring and weed control measures on weed dry matter in rice at 30 DAT (No/m²) (four years pooled mean)

Treatments	Grasses and sedges					Broad leaved weeds					Weed control efficiency				
	2011	2012	2013	2014	Pooled	2011	2012	2013	2014	Pooled	2011	2012	2013	2014	Pooled
Green manuring															
Green manuring	3.99 (1.83)	5.10 (2.19)	3.36 (1.77)	4.54 (2.24)	4.76 (2.27)	2.34 (1.30)	0.70 (0.95)	0.04 (0.73)	2.17 (1.62)	1.56 (1.37)		-	-	-	-
Without green manuring	5.99 (2.32)	10.83 (3.09)	8.56 (2.84)	4.58 (2.25)	6.98 (2.69)	3.34 (1.57)	2.51 (1.44)	0.04 (0.73)	1.63 (1.44)	1.63 (1.38)		-	-	-	-
Sem ±	- (0.14)	- (0.37)	- (0.12)	- (0.02)	- (0.11)	- (0.13)	- (0.28)	- (0.01)	- (0.07)	- (0.05)		-	-	-	-
LSD (p=0.05)	- (N.S)	- (N.S)	- (N.S)	- (N.S)	- (N.S)	- (N.S)	- (N.S)	- (N.S)	- (N.S)	- (N.S)					
Weed control measures															
Fixed.herbicide – Pretilachlor-S (PE)	4.64 (2.15)	7.06 (2.57)	6.58 (2.46)	4.41 (2.21)	5.66 (2.49)	2.00 (1.32)	1.16 (1.10)	0.00 (0.71)	1.87 (1.52)	1.26 (1.29)	56.66	46.03	6.40	20.51	36.40
Rotational herbicide	7.30 (2.72)	9.46 (3.10)	6.65 (2.38)	4.67 (2.27)	7.05 (2.78)	2.01 (1.19)	1.52 (1.11)	0.00 (0.71)	1.25 (1.39)	1.79 (1.48)	39.23	27.91	5.41	25.06	18.75
Weed free check	0.02 (0.72)	3.43 (1.79)	3.72 (1.98)	3.94 (2.11)	5.00 (2.30)	0.02 (0.72)	0.64 (0.94)	0.00 (0.71)	1.03 (1.23)	0.46 (0.96)	99.74	73.28	47.08	37.09	49.82
Weedy check	7.99 (2.72)	11.91 (3.12)	6.89 (2.40)	5.23 (2.39)	8.00 (2.98)	7.33 (2.52)	3.32 (1.97)	0.14 (0.80)	2.67 (1.77)	2.88 (1.78)	-	-	-	-	-
Sem ±	- (0.34)	- (0.46)	- (0.44)	- 0.03	- (0.12)	- (0.46)	- (0.35)	- (0.02)	- 0.07	- (0.17)	-	-	-	-	-
LSD (p=0.05)	- (N.S)	- (N.S)	- (N.S)	- (0.11)	- (0.39)	- (N.S)	- (N.S)	- (N.S)	- (0.21)	- (0.51)	-	-	-	-	-

Note: Interaction between green manuring and weed control measures were non-significant during all the stages of observations. Figures in parentheses indicate square root transformations $\sqrt{x + 0.5}$

Table 4. Effects of green manuring and weed control measures on weed dry matter in rice at 50 DAT(No/m²).

Treatments	Grasses and sedges					Broad leaved weeds					Weed control efficiency				
	2011	2012	2013	2014	Pooled	2011	2012	2013	2014	Pooled	2011	2012	2013	2014	Pooled
Green manuring															
Green manuring	5.06 (2.00)	5.00 (2.15)	26.67 (5.09)	29.33 (5.38)	17.51 (4.31)	0.02 (0.72)	3.04 (1.40)	0.55 (0.96)	3.01 (1.86)	1.65 (1.39)		-	-	-	-
Without green manuring	12.40 (3.06)	8.33 (2.69)	44.00 (6.56)	28.33 (5.25)	25.79 (4.98)	2.68 (1.35)	5.71 (1.99)	0.49 (0.95)	2.57 (1.74)	2.86 (1.67)		-	-	-	-
Sem ±	- 0.38	- (0.16)	- (0.33)	- (0.09)	- (0.15)	- (0.10)	- (0.31)	- (0.08)	- (0.09)	- (0.12)		-	-	-	-
LSD (p=0.05)	- (N.S.)	- (N.S.)	- (N.S.)	- (N.S.)	- (N.S.)	- (N.S.)	- (N.S.)	- (N.S.)	- (N.S.)	- (N.S.)					
Weed control measures															
Fixed.herbicide – Pretilachlor-S (PE)	7.67 (2.12)	7.33 (2.58)	36.00 5.88	22.00 (4.70)	18.25 (4.30)	2.54 (1.41)	3.72 (1.53)	0.01 (0.72)	2.87 1.83	2.29 (1.53)	40.22	40.72	14.28	45.46	48.18
Rotational herbicide	11.45 (3.03)	7.33 (2.44)	39.33 6.17	33.33 (5.80)	23.00 (4.77)	0.02 (0.72)	3.40 (1.62)	0.92 (1.13)	3.15 1.89	1.87 (1.49)	32.85	42.44	4.19	20.00	37.26
Weed free check	1.53 (1.23)	4.67 (2.02)	24.67 4.91	17.33 (4.20)	13.17 (3.68)	0.02 (0.72)	1.17 (1.13)	0.47 (0.96)	2.20 1.64	0.96 (1.19)	90.93	68.67	40.16	57.17	64.35
Weedy check	14.26 (3.73)	9.44 (3.05)	41.33 6.33	42.67 (6.56)	35.73 (6.00)	2.82 (1.29)	9.20 (2.49)	0.68 (1.02)	2.93 1.85	3.91 (1.89)	-	-	-	-	-
Sem ±	(0.67)	(0.60)	(0.48)	(0.23)	(0.34)	(0.39)	(0.65)	(0.12)	(0.06)	(0.30)	-	-	-	-	-
LSD (p=0.05)	(N.S.)	(N.S.)	(N.S.)	(0.72)	(1.05)	(N.S.)	(N.S.)	(N.S.)	(N.S.)	(N.S.)	-	-	-	-	-

Note: Interaction between green manuring and weed control measures were non-significant during all the stages of observations. Figures in parentheses indicate square root. transformations $\sqrt{x + 0.5}$.

Table 5. Effects of green manuring and weed control measures on yield of rice

Treatments	Grain (t/ha)				Pooled	*Straw (t/ha)*				Pooled	Weed Index %				Pooled
	2011	2012	2013	2014		2011	2012	2013	2014		2011	2012	2013	2014	
Green manuring															
Green manuring	3.77	4.87	3.07	3.13	3.86	3.83	4.89	3.62	3.74	3.87	-	-	-	-	
Without green manuring	2.44	3.65	2.97	3.00	3.17	2.10	3.77	3.04	3.60	2.98	-	-	-	-	
Sem ±	0.08	0.09	0.02	0.03	0.03	0.04	0.11	0.14	0.02	0.07	-	-	-	-	
LSD (p=0.05)	0.48	0.57	N.S	N.S	0.21	0.24	0.67	N.S	N.S	0.43	-	-	-	-	
Weed control measures															
Fixed.herbicide – Pretilachlor-S (PE)	3.43	4.33	3.18	3.14	3.54	3.32	4.46	3.36	3.61	3.50	3.57	4.56	0.46	14.77	6.38
Rotational herbicide	3.15	4.18	2.89	2.87	3.44	2.78	4.17	3.33	3.39	3.42	15.29	9.34	5.33	20.96	8.78
Weed free check	3.65	4.61	3.20	3.49	3.92	3.35	4.60	3.37	4.43	3.60	-	-	-	-	
Weedy check	2.19	4.03	2.82	2.27	3.16	2.41	4.09	3.27	2.83	3.18	34.29	11.83	7.31	35.61	15.69
Sem ±	0.21	0.12	0.15	0.06	0.10	0.15	0.16	0.38	0.07	0.12	-	-	-	-	
LSD (p=0.05)	0.64	0.37	N.S	0.18	0.30	0.45	N.S	N.S	0.22	N.S.	-	-	-	-	

Note: Interaction between green manuring and weed control measures were non-significant during all the stages of observations