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Impact of live mulches, cover crops and herbicides on weeds, growth attributes and yield of direct seeded rice (*Oryza sativa* L.)

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Abstract

A field investigation was conducted during the rainy (*Kharif*) season of 2014 and 2015 at Varanasi, Uttar Pradesh, to study the impact of live mulches, cover crops and herbicides on weeds, growth attributes and yield in direct seeded rice (*Oryza sativa* L.). At 30, 60, 90 DAS and harvest, amongst the weed management treatments, *Sesbania* cover crop *fb* bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS reduced total weed density and dry weight than sunhemp cover crop *fb* bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS thus resulting in the lowest weed index except hand weeding at 15 and 35 DAS. At 90 DAS, *Sesbania* cover crop *fb* bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS markedly improved plant height, dry matter accumulation, leaf area index, chlorophyll content during both years. *Sesbania* cover crop *fb* bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS improved grain and straw yields during both years but higher harvest index in 2014 as compared to sunhemp cover crop *fb* bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS.

Keywords: azimsulfuron, bispyribac na, direct seeded rice, economics, *Sesbania*, sunhemp

Introduction

The area under direct-seeded rice systems is expected to increase in the future because of labor and water shortages. Weeds, however, are the major constraints to direct-seeded rice production. Sunil *et al.* (2010) [9] reported that season-long weed competition in direct-seeded rice may cause yield reduction up to 80%. Raj *et al.* (2013) [7] found 72% reduction in grain yield due to the infestation of non-grassy, broad-leaved weeds and sedges in direct-seeded rice. To minimize infestation of weeds, achieve effective, long-term and sustainable weed control in direct-seeded systems, there is need to integrate different weed management strategies, such as the use of cover crops, live mulches and appropriate herbicide mixtures, timing and doses. Weed problem in direct seeded rice can be managed by implementing integrated weed management. The incorporation of green manure crops with 2, 4-D significantly reduced weed population and weed dry weight compared to other incorporation method (Anitha *et al.*; 2009) [1]. Singh *et al.* (2007) [8] reported that *Sesbania* coculture reduced broadleaf and grass weed density by 76-83% and 20-33% respectively, and total weed biomass by 37-80 % compared with a sole rice crop. However, weeds in direct seeded rice cannot be controlled by incorporation of cover crops and live mulches alone because of various flushes of weeds during crop growth. It is imperative to identify effective weed management practices using live mulches and cover crops and to work out their feasibility. Therefore, keeping these points in view, the present study was taken up, to assess the efficacy of herbicides along cover crops and live mulches and to study the impact of integrated weed management on weeds and yield of direct seeded rice.

Materials and Methods

A field experiment was conducted during the rainy (*Kharif*) season of 2014 and 2015 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. The soil was sandy clay loam, with pH 7.40, low in available organic carbon (0.41%), available nitrogen (207.47 kg/ha), and medium in available phosphorous (23.85 kg/ha) and potassium (219.60 kg/ha). The experiment was laid out in a randomized block design replicated thrice, comprising 9 treatments, viz. *Sesbania* cover crop *fb* bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS, sunhemp cover crop *fb* bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS, *Sesbania* cover crop *fb* *Sesbania* coculture *fb* 2, 4 D 0.5 kg/ha at 30 DAS, sunhemp cover crop *fb* sunhemp coculture *fb* 2, 4 D 0.5 kg/ha at 30 DAS, *Sesbania* coculture *fb* 2, 4 D 0.5 kg/ha at 30 DAS, sunhemp coculture *fb* 2, 4 D 0.5 kg/ha at 30

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DAS, bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS, hand weeding at 15 and 35 DAS and weedy during both the years. Sowing of *Sesbania* and sunhemp as cover crops was done in plots allotted to cover crop before sowing of rice manually using seed rate of 25 kg/ha 15 days before sowing of rice. Co-culture was also sown along with sowing of rice by manually. In other experimental plots rice was also sown manually using seed rate of 30 kg/ha. In cover crops treated plot one week after sowing rice, cover crops were cut and placed as green mulch in between the two rows of rice. A recommended dose of fertilizer (150 kg N, 60 kg P₂O₅ and 60 kg K₂O) was applied through urea, single super phosphate and muriate of potash. Application of alone and tank mixed post emergence herbicides was done as per the treatments using knap-sack sprayer fitted with flat-fan nozzle. The spray volume of post emergence herbicides was 300 litres/ha. The crop was raised under irrigated condition under the recommended package of practices. Total weed density and their dry weight at 30, 60, 90 DAS and at harvest were measured by placing a quadrat of 0.50 m × 0.50 m randomly at 2 places in each plot. These were subjected to square root transformation before analysis. Weed control efficiency (Tripathi and Mishra, 1971) ^[11] and weed index (Gill and Kumar, 1969) ^[3] was also calculated at 30, 60, 90 DAS and at harvest. Biometric characters viz, growth attributes and yields (grain and straw) of crop were recorded. Duncan Multiple Range Test (DMRT) (Gomez and Gomez, 1984) ^[4] was used for comparing treatment means.

Results and Discussion

Density and dry weight of weeds

Total density of weeds and their dry weight varied significantly at 30, 60, 90 DAS and at harvest stages due to integrated weed management treatments during both the years (Table 1 & 2). At 30, 60, 90 DAS and at harvest stages, *Sesbania* cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS had significantly lower total weed density as compared to rest of the treatments except hand weeding at 15 and 35 DAS and it was comparable with sunhemp cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS. This might be due to effective suppression of weeds by *Sesbania* cover crop at the time of crop emergence as it covered the soil and did not allow weed seeds to germinate along with crop. Similar hypothesis had been also proposed by Nelson *et al.*, (1991) ^[6] who reported that rapid development of dense ground covering by the crop suppress weeds. At 30, 60 and 90 DAS, *Sesbania* cover crop fb *Sesbania* coculture fb 2, 4 D 0.5 kg/ha at 30 DAS had lesser weed density of total weeds as compared to sunhemp cover crop fb sunhemp coculture fb 2, 4 D 0.5 kg/ha at 30 DAS and both treatments were statistically similar to each other in the year of 2014 (Table 1). At 90 DAS and harvest, *Sesbania* cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS recorded lower total weed dry weight in comparison to sunhemp cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS and both treatments were statistically at par to each other. This might be due to sowing of *Sesbania* cover crop reduced dry matter accumulation of weeds prior to sowing and after sowing where as post-emergence herbicides bispyribac and azimsulfuron checked subsequent weed flushes at 15 DAS. These findings are in conformity with the result of Khaliq *et al.* (2012) ^[5]. *Sesbania* coculture fb 2, 4 D 0.5 kg/ha at 30 DAS had lesser total weed

dry weight as compared to sunhemp coculture fb 2, 4 D 0.5 kg/ha at 30 DAS and both treatments were statistically similar to each other at all the stages during both years (Table 2). The vigorous growth and better canopy coverage of live mulches suppressed the growth of weeds.

At 30, 60, 90 DAS and at harvest stages, *Sesbania* cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS recorded higher weed control efficiency as compared to sunhemp cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS, *Sesbania* cover crop fb *Sesbania* coculture fb 2, 4 D 0.5 kg/ha at 30 DAS, sunhemp cover crop fb sunhemp coculture fb 2, 4 D 0.5 kg/ha at 30 DAS, *Sesbania* coculture fb 2, 4 D 0.5 kg/ha at 30 DAS, sunhemp coculture fb 2, 4 D 0.5 kg/ha at 30 DAS, bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS during both years (Table 3). This might be due to lower weed dry matter accumulation under this treatment. Chongtham *et al.* (2016) ^[2] also reported similar findings in direct seeded rice.

Growth attributes

At 90 DAS, *Sesbania* cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS resulted higher plant height, dry matter accumulation (g/running m), leaf area index and chlorophyll content in comparison to sunhemp cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS and both treatments were statistically similar to each other except leaf area index and chlorophyll content in the year of 2015. *Sesbania* coculture fb 2, 4 D 0.5 kg/ha at 30 DAS had higher plant height, dry matter accumulation (g/runningm), leaf area index and chlorophyll content as compared to sunhemp coculture fb 2, 4 D 0.5 kg/ha at 30 DAS and both the treatments were statistically at par to each other except leaf area index in the year of 2015 (Table 4). The cover crops and live mulches might have controlled weeds at initial stage resulting in minimum competition from weeds for growth factors like moisture, nutrient, light and space (Table 1). Mechanical undercutting to kill the cover crop in *Sesbania* might have left a thick evenly distributed layer of weed suppressing mulch after one week of sowing rice. This surface mulch may limit further weed development through its effect on light transmittance, soil temperature and soil moisture (Teasdale, 1993) ^[10].

Yield

Weed management treatments resulted in lower weed index, which had significantly higher grain and straw yields over weedy (Table 3 & 4). *Sesbania* cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS had higher grain and straw yields in comparison to sunhemp cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS and both the treatments were statistically similar to each other in straw yield during both years. This could be due to significantly higher weed control efficiency and lower weed index as compared to all other treatments except hand weeding at 15 and 35 DAS. *Sesbania* cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS had highest harvest index in comparison to all integrated weed management treatments except hand weeding at 15 and 35 DAS. Due to effective suppression of weeds in cover crop treated plots (Table 1 and 2) and restricting the competition by weeds for growth resources which helped in improving yield attributes and yield.

Table 1: Effect of weed management on total density of weeds (/m²) at different stages of observation of direct seeded rice.

| Treatment | 30 DAS | | 60 DAS | | 90 DAS | | At harvest | |
|---|--------------------------|--------------------------|---------------------------|---------------------------|---------------------------|---------------------------|-------------------------|-------------------------|
| | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 |
| <i>Sesbania</i> cover crop <i>fb</i> bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS | 3.7 ^g (13.4) | 3.4 ^g (11.0) | 3.6 ^h (12.7) | 3.2 ^h (9.7) | 2.8 ^d (7.8) | 2.7 ^{de} (7.2) | 2.8 ^e (7.3) | 2.6 ^e (6.7) |
| Sunhemp cover crop <i>fb</i> bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS | 4.1 ^f (16.1) | 3.7 ⁱ (13.4) | 3.8 ^g (14.5) | 3.4 ^g (10.9) | 2.9 ^d (7.9) | 2.8 ^d (7.3) | 2.8 ^{de} (7.4) | 2.7 ^{de} (6.8) |
| <i>Sesbania</i> cover crop <i>fb</i> <i>Sesbania</i> coculture <i>fb</i> 2, 4 D 0.5 kg/ha at 30 DAS | 4.6 ^d (20.5) | 4.4 ^d (18.7) | 4.4 ^{de} (19.2) | 4.1 ^e (16.1) | 2.9 ^{bcd} (8.2) | 2.8 ^{cd} (7.5) | 2.8 ^d (7.6) | 2.7 ^d (7.0) |
| Sunhemp cover crop <i>fb</i> sunhemp coculture <i>fb</i> 2, 4 D 0.5 kg/ha at 30 DAS | 4.6 ^{cd} (21.4) | 4.5 ^{cd} (20.1) | 4.5 ^d (20.2) | 4.3 ^d (18.1) | 3.3 ^b (8.3) | 3.2 ^b (7.6) | 3.2 ^b (7.8) | 3.2 ^b (7.2) |
| <i>Sesbania</i> coculture <i>fb</i> 2, 4 -D 0.5 kg/ha at 30 DAS | 4.8 ^{bc} (22.8) | 4.6 ^{bc} (20.9) | 4.7 ^c (21.6) | 4.4 ^c (19.4) | 2.3 ^{cd} (8.5) | 2.8 ^c (7.7) | 2.9 ^{cd} (7.9) | 2.7 ^{cd} (7.2) |
| Sunhemp coculture <i>fb</i> 2, 4- D 0.5 kg/ha at 30 DAS | 5.1 ^b (25.2) | 4.7 ^b (22.3) | 4.9 ^b (23.6) | 4.6 ^b (20.6) | 3.1 ^{bc} (8.8) | 2.8 ^c (7.8) | 2.9 ^c (8.1) | 2.8 ^c (7.3) |
| Bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS | 4.4 ^e (19.4) | 4.1 ^e (16.5) | 4.3 ^f (18.0) | 3.7 ^f (13.2) | 2.9 ^{bcd} (8.1) | 2.8 ^d (7.4) | 2.8 ^d (7.5) | 2.7 ^d (6.9) |
| Hand weeding at 15 and 35 DAS | 0.7 ^h (0.0) | 0.7 ^h (0.0) | 0.7 ⁱ (0.0) | 0.7 ⁱ (0.0) | 0.7 ^e (0.0) | 0.7 ^e (0.0) | 0.7 ^f (0.0) | 0.7 ^f (0.0) |
| Weedy | 8.3 ^a (69.2) | 8.4 ^a (70.9) | 10.6 ^a (112.9) | 10.7 ^a (115.5) | 10.2 ^a (104.1) | 10.2 ^a (104.2) | 9.2 ^a (84.1) | 9.1 ^a (83.1) |
| CV (%) | 4.3 | 5.5 | 3.7 | 4.4 | 1.4 | 1.6 | 1.5 | 1.6 |

Data were subjected to square root ($\sqrt{X + 0.5}$) transformation; figures in parentheses are original values

Table 2: Effect of weed management on total dry weight of weeds (g/m²) at different stages of observation of direct seeded rice.

| Treatment | 30 DAS | | 60 DAS | | 90 DAS | | At harvest | |
|---|--------------------------|--------------------------|--------------------------|--------------------------|-------------------------|---------------------------|-------------------------|-------------------------|
| | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 |
| <i>Sesbania</i> cover crop <i>fb</i> bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS | 2.9 ^g (8.0) | 2.6 ^g (6.5) | 2.8 ^h (7.6) | 2.5 ^h (5.8) | 2.3 ^g (4.9) | 2.17 ^g (4.19) | 2.2 ^b (4.5) | 2.1 ^b (4.1) |
| Sunhemp cover crop <i>fb</i> bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS | 3.1 ^f (9.4) | 2.9 ^f (7.9) | 3.0 ^g (8.8) | 2.6 ^g (6.5) | 2.4 ^{fg} (5.2) | 2.20 ^{fg} (4.35) | 2.2 ^b (4.6) | 2.1 ^b (4.1) |
| <i>Sesbania</i> cover crop <i>fb</i> <i>Sesbania</i> coculture <i>fb</i> 2, 4 D 0.5 kg/ha at 30 DAS | 3.5 ^{de} (12.3) | 3.4 ^{de} (11.2) | 3.5 ^e (11.6) | 3.2 ^e (9.5) | 2.5 ^{de} (5.6) | 2.34 ^{de} (4.98) | 2.3 ^b (4.7) | 2.2 ^b (4.3) |
| Sunhemp cover crop <i>fb</i> sunhemp coculture <i>fb</i> 2, 4 D 0.5 kg/ha at 30 DAS | 3.6 ^d (12.8) | 3.5 ^d (12.1) | 3.5 ^d (12.2) | 3.3 ^d (10.8) | 2.5 ^{cd} (5.8) | 2.41 ^{cd} (5.30) | 2.3 ^b (4.7) | 2.2 ^b (4.3) |
| <i>Sesbania</i> coculture <i>fb</i> 2, 4 -D 0.5 kg/ha at 30 DAS | 3.7 ^{bc} (13.5) | 3.6 ^{bc} (12.5) | 3.6 ^{bc} (12.8) | 3.4 ^{bc} (11.4) | 2.5 ^{bc} (5.9) | 2.43 ^{bc} (5.39) | 2.3 ^b (4.8) | 2.2 ^b (4.4) |
| Sunhemp coculture <i>fb</i> 2, 4- D 0.5 kg/ha at 30 DAS | 3.9 ^b (15.1) | 3.7 ^b (13.4) | 3.8 ^b (14.3) | 3.5 ^b (12.3) | 2.6 ^b (6.5) | 2.46 ^b (5.53) | 2.3 ^b (4.9) | 2.2 ^b (4.5) |
| Bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS | 3.5 ^e (11.6) | 3.2 ^e (9.9) | 3.4 ^f (10.9) | 2.9 ^f (8.0) | 2.5 ^{ef} (5.8) | 2.27 ^{ef} (4.67) | 2.3 ^b (4.7) | 2.2 ^b (4.2) |
| Hand weeding at 15 and 35 DAS | 0.7 ^h (0.0) | 0.7 ^h (0.0) | 0.7 ⁱ (0.0) | 0.7 ⁱ (0.0) | 0.7 ^h (0.0) | 0.71 ^h (0.00) | 0.7 ^c (0.0) | 0.7 ^c (0.0) |
| Weedy | 6.5 ^a (41.4) | 6.6 ^a (43.2) | 8.5 ^a (72.4) | 8.6 ^a (73.1) | 7.9 ^a (62.1) | 7.78 ^a (59.96) | 7.5 ^a (56.6) | 7.2 ^a (51.3) |
| CV (%) | 4.8 | 5.3 | 3.9 | 4.1 | 1.5 | 1.4 | 2.2 | 1.5 |

Data were subjected to square root ($\sqrt{X + 0.5}$) transformation; figures in parentheses are original values

Table 3: Effect of weed management on weed control efficiency (%) and weed index (%) at different stages of observation of direct seeded rice.

| Treatment | Weed control efficiency (%) | | | | | | | | Weed index (%) | |
|---|-----------------------------|-------|--------|-------|--------|-------|------------|-------|----------------|------|
| | 30 DAS | | 60 DAS | | 90 DAS | | At harvest | | | |
| | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 |
| <i>Sesbania</i> cover crop <i>fb</i> bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS | 80.6 | 84.9 | 89.5 | 91.9 | 92.1 | 93.0 | 92.0 | 92.1 | 2.4 | 2.5 |
| Sunhemp cover crop <i>fb</i> bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS | 77.2 | 81.5 | 88.1 | 91.0 | 91.5 | 92.7 | 91.8 | 91.9 | 9.1 | 6.5 |
| <i>Sesbania</i> cover crop <i>fb</i> <i>Sesbania</i> coculture <i>fb</i> 2, 4 D 0.5 kg/ha at 30 DAS | 70.2 | 74.1 | 83.9 | 86.8 | 90.8 | 91.6 | 91.6 | 91.6 | 11.3 | 9.3 |
| Sunhemp cover crop <i>fb</i> sunhemp coculture <i>fb</i> 2, 4 D 0.5 kg/ha at 30 DAS | 68.8 | 72.0 | 83.2 | 85.2 | 90.6 | 91.1 | 91.5 | 91.5 | 11.8 | 10.9 |
| <i>Sesbania</i> coculture <i>fb</i> 2, 4 -D 0.5 kg/ha at 30 DAS | 67.4 | 71.1 | 82.3 | 84.3 | 90.4 | 91.0 | 91.4 | 91.4 | 12.5 | 12.0 |
| Sunhemp coculture <i>fb</i> 2, 4- D 0.5 kg/ha at 30 DAS | 63.5 | 68.8 | 80.2 | 83.1 | 89.5 | 90.7 | 91.2 | 91.3 | 13.3 | 13.0 |
| Bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS | 71.9 | 77.0 | 84.8 | 89.0 | 90.6 | 92.2 | 91.6 | 91.8 | 10.2 | 8.3 |
| Hand weeding at 15 and 35 DAS | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 0.0 | 0.0 |
| Weedy | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 56.5 | 52.8 |

Table 4: Effect of weed management on plant height (cm), dry matter accumulation (g/running m), leaf area index and chlorophyll content at 90 DAS in direct seeded rice.

| Treatment | 90 DAS | | | | | | | |
|---|-------------------|-------------------|---------------------------------------|-------------------|------------------|------------------|---------------------|--------------------|
| | Plant height (cm) | | Dry matter accumulation (g/running m) | | Leaf area index | | Chlorophyll content | |
| | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 |
| <i>Sesbania</i> cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS | 84.6 ^a | 84.8 ^a | 82.0 ^{ab} | 86.1 ^b | 3.8 ^a | 3.9 ^b | 42.9 ^b | 44.2 ^b |
| Sunhemp cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS | 84.5 ^a | 84.6 ^a | 81.5 ^{ab} | 85.8 ^b | 3.8 ^a | 3.9 ^c | 42.4 ^{bc} | 43.5 ^c |
| <i>Sesbania</i> cover crop fb <i>Sesbania</i> coculture fb 2, 4 D 0.5 kg/ha at 30 DAS | 82.8 ^a | 84.1 ^a | 81.0 ^b | 85.3 ^b | 3.7 ^a | 3.8 ^e | 41.0 ^{de} | 43.4 ^{cd} |
| Sunhemp cover crop fb sunhemp coculture fb 2, 4 D 0.5 kg/ha at 30 DAS | 82.5 ^a | 83.8 ^a | 80.2 ^b | 84.3 ^b | 3.7 ^a | 3.8 ^f | 40.8 ^{de} | 43.4 ^{cd} |
| <i>Sesbania</i> coculture fb 2, 4 -D 0.5 kg/ha at 30 DAS | 80.9 ^a | 83.7 ^a | 80.1 ^b | 84.2 ^b | 3.7 ^a | 3.8 ^f | 40.4 ^e | 43.3 ^{de} |
| Sunhemp coculture fb 2, 4- D 0.5 kg/ha at 30 DAS | 80.2 ^a | 83.5 ^a | 79.8 ^b | 83.7 ^b | 3.7 ^a | 3.8 ^g | 40.2 ^e | 43.2 ^e |
| Bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS | 83.3 ^a | 84.3 ^a | 81.3 ^{ab} | 85.5 ^b | 3.7 ^a | 3.8 ^d | 41.6 ^{cd} | 43.5 ^c |
| Hand weeding at 15 and 35 DAS | 84.9 ^a | 85.0 ^a | 88.4 ^a | 92.4 ^a | 3.9 ^a | 4.1 ^a | 43.8 ^a | 45.1 ^a |
| Weedy | 61.1 ^b | 66.5 ^b | 53.9 ^c | 57.3 ^c | 1.5 ^b | 2.5 ^h | 35.2 ^f | 38.3 ^f |
| CV (%) | 4.7 | 2.8 | 5.0 | 3.2 | 5.7 | 1.1 | 1.1 | 1.2 |

Table 5: Effect of weed management on grain yield (kg/ha), straw yield (kg/ha) and harvest index (%) in direct seeded rice.

| Treatment | Grain yield (kg/ha) | | Straw yield (kg/ha) | | Harvest index (%) | |
|---|---------------------|-----------------------|---------------------|---------------------|-------------------|-------------------|
| | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 |
| <i>Sesbania</i> cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS | 5041.6 ^a | 5075.0 ^{ab} | 5900.1 ^a | 6081.8 ^a | 46.1 ^a | 45.5 ^a |
| Sunhemp cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS | 4694.6 ^b | 4829.7 ^{bc} | 5779.0 ^a | 5779.0 ^a | 44.8 ^a | 45.7 ^a |
| <i>Sesbania</i> cover crop fb <i>Sesbania</i> coculture fb 2, 4 D 0.5 kg/ha at 30 DAS | 4583.1 ^b | 4720.7 ^{cde} | 5683.2 ^a | 5725.9 ^a | 44.6 ^a | 45.2 ^a |
| Sunhemp cover crop fb sunhemp coculture fb 2, 4 D 0.5 kg/ha at 30 DAS | 4556.0 ^b | 4636.4 ^{cde} | 5683.0 ^a | 5683.0 ^a | 44.5 ^a | 44.9 ^a |
| <i>Sesbania</i> coculture fb 2, 4 -D 0.5 kg/ha at 30 DAS | 4516.5 ^b | 4582.4 ^{de} | 5600.6 ^a | 5600.6 ^a | 44.6 ^a | 45.0 ^a |
| Sunhemp coculture fb 2, 4- D 0.5 kg/ha at 30 DAS | 4476.4 ^b | 4528.6 ^e | 5547.0 ^a | 5547.0 ^a | 44.6 ^a | 44.9 ^a |
| Bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS | 4639.5 ^b | 4775.1 ^{cd} | 5752.4 ^a | 5812.7 ^a | 44.6 ^a | 45.1 ^a |
| Hand weeding at 15 and 35 DAS | 5166.6 ^a | 5208.3 ^a | 6085.0 ^a | 6151.6 ^a | 45.9 ^a | 45.8 ^a |
| Weedy | 2248.5 ^b | 2456.1 ^f | 3313.2 ^b | 3420.5 ^b | 41.1 ^b | 42.2 ^b |
| CV (%) | 3.0 | 2.8 | 6.7 | 5.9 | 2.8 | 2.2 |

Conclusion

On the basis of above findings it may be concluded that *Sesbania* cover crop fb bispyribac Na 25 g/ha + azimsulfuron 30 g/ha at 15 DAS should be raised for minimizing weed growth and to obtain higher yield in direct seeded rice.

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