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Impact of Mulch, Cover Crop and Herbicides on Growth, Yield and Nutrient Uptake in Direct Seeded Rice (*Oryza sativa* L.)

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ABSTRACT

Background: Direct seeded rice is very much prone for weed infestation in eastern Uttar Pradesh. The aim of this trial is to find out appropriate option for improving rice growth and yields besides increasing nutrient uptake.

Methods: A field investigation was conducted during the *Kharif* season of 2014 and 2015 at Varanasi, Uttar Pradesh. Rice variety MTU-7029 was sown with *Sesbania* and sunhemp cover crop bispyribac Na 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS and 2, 4 -D 0.5 kg ha^{-1} at 30 DAS were applied to find out best weed control practice for enhancing growth, yields and nutrient uptake in direct seeded rice.

Result: *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS markedly improved plant height, dry matter accumulation, leaf area index, chlorophyll content. Consequently, *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS influenced statistically grain and straw yields. *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS recorded significantly lower nutrients (NPK and Zn) depletion by weeds and higher nutrients (NPK and Zn) uptake as compared to hand weeding at 15 and 35 DAS in rice.

Key words: Azimsulfuron, Bispyribac Na, Direct seeded rice, *Sesbania*, Sunhemp.

INTRODUCTION

India stand second in rice (*Oryza sativa* L.) production (163 Mt) after China, while first in its import (13 Mt) and 42nd in average yield (3.76 t ha^{-1}), indicating very low rice yield per hectare (Sanodiya and Singh (2019). Rice is grown under diverse ecologies ranging from irrigated to rainfed upland, lowland and deep water. Direct seeded rice is becoming more popular as an alternative to transplanted rice, as it is more remunerative if the crop managed properly (Sharma *et al.,* 2007). Aerobic edaphic conditions under non flooded conditions in DSR stimulate germination of diverse weed species. Sunil *et al*. (2010) reported that season-long weed competition in direct-seeded rice may cause yield reduction up to 80%. Raj *et al.* (2013) found 72% reduction in grain yield due to the infestation of non-grassy, broad-leaved weeds and sedges in direct-seeded rice. Growing cover crops, have potential as an important component of a system oriented ecological weed management strategy for sustainable agriculture (Kruidhof *et al.,* 2008), because it conserve soil and moisture, enhancing soil nutrient status (Malviya and Singh, 2007), total biomass production. The inclusion of cover crops in the rotation at a time when land might otherwise lie uncropped will suppress weed development, yet maintain soil fertility and prevent erosion (Liebman and Davis, 2000). *Sesbania* cover crop followed by (fb) bispyribac 25 g/ha + azimsulfuron 30 g/ha at 15 DAS reduced weed density of various weeds and dry weight than sunnhemp (*Crotalaria juncea* L.) cover crop fb bispyribac 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 (Sanodiya and Singh, 2018). Through allelopathic (Kruidhof *et al.,* 2008b) and mechanical effects (Den Hollander *et al.,* 2007a) and the competition between the cover crops and the weeds for limited resources such as light, water and nutrients (Kruidhof *et al.,* 2008a). According to Singh *et al.,* (2006) amongst the weed control treatments, broadcasting of *Sesbania* knocked down by the application of 2, 4-D at 30 days after sowing recorded lowest weed dry weight. Co-culture of *Sesbania*in rice and its subsequent knock down by 2, 4-D ester reduced the weed population by nearly half without any adverse effect on rice yield (Gupta *et al*., 2006). Weed problem in direct seeded rice can be managed in Gangetic plains by integrated various control measures. 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 integrated weed management practices for minimizing nutrient uptake by weeds and maximizing by crop yield and nutrient uptake. Therefore, keeping these points in view, the present study was taken up, to assess the efficacy of different herbicides along with growing cover crops and live mulches and to study the impact of integrated weed management on

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growth, yield and nutrient uptake by weeds and crop in direct seeded rice.

METHODS AND MATERIALS

A field experiment was conducted during *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, compried of treatments, *viz*. *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 gha^{-1}at 15 DAS, sunhemp cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS, *Sesbania* cover crop *fb Sesbania* coculture *fb* 2, 4 D 0.5 kg ha^{-1} at 30 DAS, sunhemp cover crop *fb* sunhemp coculture *fb* 2, 4 D 0.5 kg ha^{-1} at 30 DAS, *Sesbania* coculture *fb* 2, 4 -D 0.5 kg ha^{-1} at 30 DAS, sunhemp coculture *fb* 2, 4- D 0.5 kg ha^{-1} at 30 DAS, bispyribac Na 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS, hand weeding at 15 and 35 DAS and weedy check during both the years and replicated thrice. Rice variety MTU-7029 was sown by zero till drill during the last week of June in the both the years following the seed rate of 30 kg/ha and 20 cm row-row spacing. A recommended dose of fertilizer (150 kg N, 60 kg P_2O_5 and 60 kg K_2O) was applied through inorganic sources *viz* urea, single super phosphate and muriate of potash during both the years of experimentation. Full dose of phosphorus and potash were applied as basal application while nitrogen was applied half as basal and remaining half at two equal parts at tillering and panicle initiation stage of rice. Application of alone and tank mixed post emergence herbicides was done according to the treatments using knap-sack sprayer fitted with flat-fan nozzle. The spray volume of post emergence herbicides was 600 litres/ha. The crop was raised under irrigated condition under the recommended package of practices. Five plants from each experimental plot were selected randomly and tagged. Plant height (cm) of the rice was recorded with the help of meter scale from base of the plant to the tip of upper most leaf of the plant before panicle emergence and upto the tip of panicle after heading, then averaged and expressed in cm. The leaf area index (LAI) is the area of leaf surface per unit area of land surface. Leaf area index was measured by using portable plant canopy analyzer at five randomly selected sites in each plot at 90 DAS. Dry matter accumulation was measured from two randomly selected places in plot and then cut one plant row near ground level of one meter length from each plot at different stages of crop growth from either side leaving two rows. Samples were first dried in sun and then oven dried at 65^0C till the constant weight was achieved. After drying, the samples were weighed for recording dry weight and expressed in g/mrow length. The data was analyzed statistically using Duncan multiple range test (DMRT) for valid conclusion of research.

Nutrient uptake by grain and straw of rice crop was calculated by multiplying yields of grain or straw with its nutrient contents (Black *et al*. 1965).

Nutrient uptake (kg ha^{-1}) =

$$\frac{\text{Nutrient content (\%) in grain or straw}}{\text{Grain/Straw yield (kg ha}^{-1}\text{)}} \times 100$$

Nutrient (N, P, K and Zn) removal by weeds (kg ha^{-1} and g ha^{-1})
Nutrient (N, P, K and Zn) removal by weeds was calculated as per the following formula.

Nutrient removal by weeds (kg ha^{-1}) =

$$\frac{\text{Nutrient content (\%) in weed}}{\text{Weed dry matter (kg ha}^{-1}\text{)}} \times 100$$

RESULTS AND DISCUSSION

Growth attributes

Amongst the integrated weed management treatments, *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS resulted higher plant height, dry matter accumulation (g/m), leaf area index and chlorophyll content at 90 DAS in comparison to sunhemp cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS and both treatments were statistically similar to each other during field experimentation years (Table 1). However, bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS recorded significantly higher plant height, dry matter accumulation (g/m), leaf area index and chlorophyll content at 90 DAS as compared to *Sesbania* cover crop *fb Sesbania* coculture *fb* 2,-4 D 0.5 kg ha^{-1} at 30 DAS, sunhemp cover crop *fb* sunhemp coculture *fb* 2, 4 D 0.5 kg ha^{-1}at 30 DAS, *Sesbania* coculture *fb* 2, 4 -D 0.5 kg ha^{-1} at 30 DAS and sunhemp coculture *fb* 2, 4 D 0.5 kg ha^{-1} at 30 DAS (Table 1). Majhi *et al*, (2009) also expressed similar views in direct seeded rice.Amongst the integrated weed management treatments, *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS recorded higher plant height, dry matter accumulation g/m, LAI and chlorophyll content at 90 DAS in comparison to sunhemp cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS. This could be attributed to higher weed control efficiency under these treatments as a result of which crop confronted minimum competition from weeds for growth factors like moisture, nutrient, light and space. The weeds were controlled at initial stage due to cover crops. Mechanical weeding to kill the cover crop and leave a thick evenly distributed layer of weed suppressing mulch. This surface mulch may limit further weed development through its effect on light transmittance, soil temperature and soil moisture. The mulch also provides a protective habitat for seed predators which helps to reduce *viz.* dry matter accumulation finally weed seed numbers. These resultsalso supported by Majhi *et al.,* (2009), Reader, (1991) and Teasdale, (1993). The tank mixed application of bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS was found effective to control the second flush of weeds. Similar findings were recorded by Singh *et al.,* (2014).

Table 1: Effect of integrated weed management on growth attributes at 90 DAS and yields of direct seeded rice (average of 2 years).

Treatment	Plant height (cm)	Dry matter accumulation (gm^{-1})	LAI (Leaf area index)	Chlorophyll content (SPAD value)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1: *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS	87.33	111.25	3.86	43.61	48.31	59.91
T_2: Sunhemp cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS	87.12	110.63	3.85	42.92	47.62	57.79
T_3: *Sesbania* cover crop *fb Sesbania* coculture *fb* 2, 4 D 0.5 kg ha^{-1} at 30 DAS	85.51	109.97	3.83	42.21	46.52	57.05
T_4: Sunhemp cover crop *fb* Sunhemp coculture *fb* 2, 4 D 0.5 kg ha^{-1} at 30 DAS	85.18	109.37	3.82	42.12	45.96	56.83
T_5: *Sesbania* coculture *fb* 2, 4 -D 0.5 kg ha^{-1} at 30 DAS	85.09	108.95	3.81	41.86	45.50	56.01
T_6: Sunhemp coculture *fb* 2, 4- D 0.5 kg ha^{-1} at 30 DAS	84.78	108.61	3.80	41.71	45.03	55.47
T_7: Bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS	86.05	110.35	3.84	42.59	47.07	57.83
T_8: Hand weeding at 15 and 35 DAS	89.78	117.19	4.04	44.50	57.47	70.88
T_9: Weedy	69.04	75.20	2.02	36.80	23.52	33.67
SEm±	0.90	0.87	0.06	0.12	0.08	2.02
CD (5%)	2.70*	2.60*	0.18*	0.42*	2.41*	6.06*

*Significant at P≤0.05; NS- Non significant at P>0.05.

Grain and straw yields

The increase in grain yield under *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS and sunhemp cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS was 105.39% and 102.46% over weedy. Similarly, 77.93% and 71.63% higher straw yield under treatments *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS and sunhemp cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS over weedy, respectively, were recorded. These findings are confronted by Sanodiya and Singh (2017) who reported that *Sesbania* cover crop fb bispyribac 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. This was due to *Sesbania* might have supplied sufficient nutrients in soil after decomposition coupled with smothering effect on weeds during initial stages which resulted in increased growth and yield attributes. Similar findings were also reported by Majhi *et al.,* (2009). These treatments provided almost weed free condition during period of crop-weed competition. The favourable effect of these treatments allowed the crop plants to utilize the moisture, nutrient, light and space more efficiently, resulting in to better growth and yield attributes as compared to other integrated weed management treatments. This result could be attributed to higher weed control efficiency and lower weed index, increased dry matter accumulation and improved yield attributing characters. The minimum grain and straw yields were recorded under weedy due to more weed infestation and their dry matter accumulation and lower values of yield attributing characters. These results are in accordance with findings of Chongtham *et al.,* (2016).

Available nutrients in soil

After harvesting of crop, soil was analyzed for available soil nutrient and data was analyzed and tabulated in (Table 2). Amongst integrated weed management treatments, *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS recorded significantly higher available nutrients (NPK) in comparison to sunhemp cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS, *Sesbania* cover crop *fb Sesbania* coculture *fb* 2, 4 D 0.5 kg ha^{-1} at 30 DAS, sunhemp cover crop *fb* sunhemp coculture *fb* 2, 4 D 0.5 kg ha^{-1} at 30 DAS, *Sesbania* coculture *fb* 2, 4 -D 0.5 kg ha^{-1} at 30 DAS, sunhemp coculture *fb* 2, 4- D 0.5 kg ha^{-1} at 30 DAS, bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS (Table 2). Similar findings reported by Sanodiya and Singh (2018) that repeated hand weedings in direct seeded rice recorded minimum nitrogen losses due to weeds. Amongst integrated weed management treatments, *Sesbania* cover crop *fb* bispyribac 25 gha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS recorded significantly higher available nutrients (NPK) in comparison to sunhemp cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS, *Sesbania* cover crop *fb Sesbania* coculture *fb* 2, 4 D 0.5 kg ha^{-1} at 30 DAS, sunhemp cover crop *fb* sunhemp coculture *fb* 2, 4 D 0.5 kg ha^{-1} at 30 DAS, *Sesbania* coculture *fb* 2, 4 -D 0.5 kg ha^{-1} at 30 DAS, sunhempcoculture *fb* 2, 4-D 0.5 kg ha^{-1} at 30 DAS, bispyribac Na 25 gha^{-1}+ azimsulfuron 30 g ha^{-1} at 15 DAS. This could be found due to less germination of weeds occurred in cover crop treated at initial growth of rice followed by bispyribac Na + azimsulfuron at later stage. Coculture technology followed by 2, 4-D reduced weed growth and less uptake by weeds. Similar findings also reported by Sanodiya and Singh (2018) that repeated hand weedings in direct seeded rice recorded minimum nitrogen losses due to weeds.

Nutrient depletion by weeds

Amongst the integrated weed management treatments, *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS recorded significantly lesser nutrients (NPKZn) depletion by weeds as compared to sunhemp cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS, *Sesbania* cover crop *fb Sesbania* coculture *fb* 2, 4 D 0.5 kg ha^{-1} at 30 DAS, sunhemp cover crop *fb* sunhempcoculture *fb* 2, 4 -D 0.5 kg ha^{-1} at 30 DAS, *Sesbania* coculture *fb* 2, 4 -D 0.5 kg ha^{-1} at 30 DAS, sunhemp coculture *fb* 2, 4- D 0.5 kg ha^{-1} at 30 DAS, bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS during averaged 2 years (Table 3). Our results support the findings of Brar and Bhullar (2013) that the weeds in herbicidal plot removed significantly higher amount of nitrogen, phosphorous and potassium as compared to three hand weedings. The nutrient removal by weeds was directly related to the weed dry matter accumulation under different treatments. Amongst the

Table 2: Effect of integrated weed management on soil organic carbon (%), pH, EC, available nutrients in direct seeded rice (average of 2 years).

Treatment	Organic carbon (%)	Soil pH	EC	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1: *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS	0.40	7.45	0.21	173.83	18.87	188.08
T_2: Sunhemp cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS	0.40	7.44	0.21	173.00	18.85	187.57
T_3: *Sesbania* cover crop *fb Sesbania* coculture *fb*2, 4 D 0.5 kg ha^{-1} at 30 DAS	0.39	7.43	0.21	171.67	18.81	187.19
T_4: Sunhemp cover crop *fb* Sunhemp coculture *fb* 2, 4 D 0.5 kg ha^{-1} at 30 DAS	0.39	7.42	0.21	171.17	18.78	187.01
T_5: *Sesbania* coculture *fb* 2, 4 -D 0.5 k gha^{-1} at 30 DAS	0.39	7.41	0.21	170.33	18.77	186.83
T_6: Sunhemp coculture *fb* 2, 4- D 0. kg ha^{-1} at 30 DAS	0.39	7.41	0.21	169.00	18.74	186.65
T_7: Bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS	0.39	7.44	0.21	172.00	18.84	187.54
T_8: Hand weeding at 15 and 35 DAS	0.39	7.43	0.22	170.67	18.65	185.83
T_9: Weedy	0.38	7.41	0.21	176.17	19.27	189.17
SEm±	0.00	0.00	0.00	0.23	0.01	0.14
CD (5%)	0.00	0.01	0.00	0.68*	0.02	0.43*

*Significant at P≤0.05; NS- Non significant at P>0.05.

Table 3: Effect of integrated weed management on N, P, K (kg ha^{-1}) and Zn (g ha^{-1}) depletion by weeds and uptake by crop at harvest in direct seeded rice (average of 2 years).

Treatment	Nutrient depletion by weeds at harvest				Nutrient uptake by crop at harvest			
	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Zn (g ha^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Zn (g ha^{-1})
T_1: *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS	0.7	0.4	0.8	28.3	76.8	21.2	113.4	3997.1
T_2: Sunhemp cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS	0.9	0.5	1.0	30.3	74.2	19.7	108.2	3829.1
T_3: *Sesbania* cover crop *fb Sesbania* coculture *fb* 2, 4 D 0.5 kg ha^{-1} at 30 DAS	1.2	0.7	1.3	37.4	70.8	17.8	104.8	3704.6
T_4: Sunhemp cover crop *fb* Sunhemp coculture *fb* 2, 4 D 0.5 kg ha^{-1} at 30 DAS	1.3	0.8	1.4	39.9	69.3	16.8	103.1	3640.8
T_5: *Sesbania* coculture *fb* 2, 4 -D 0.5 kg ha^{-1} at 30 DAS	1.4	0.8	1.5	41.8	67.5	15.7	100.5	3530.8
T_6: Sunhemp coculture *fb* 2, 4- D 0.5 kg ha^{-1} at 30 DAS	1.5	0.9	1.6	44.0	65.8	15.1	98.0	3427.1
T_7: Bispyribac 25 g ha^{-1} + azimsulfuron 30 gha^{-1} at 15 DAS	1.1	0.6	1.1	34.2	72.6	19.1	107.2	3793.0
T_8: Hand weeding at 15 and 35 DAS	0.2	0.2	0.2	16.4	92.4	27.3	139.2	5037.8
T_9: Weedy	8.1	3.7	9.5	158.0	38.0	7.8	58.1	1761.0
SEm±	0.04	0.03	0.05	1.12	1.68	0.42	3.16	91.57
CD (5%)	0.12*	0.08*	0.14*	3.36*	5.05*	1.25*	9.48*	274.54*

*Significant at P≤0.05; NS- Non significant at P>0.05.

integrated weed management treatments, *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS recorded higher nutrient content while minimum depletion of nutrients by weeds as compared to all other integrated weed management treatments except hand weeding at 15 and 35 DAS. *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS reduced nutrients depletion by weeds as weed infestation and their dry matter accumulation in these treatments were statistically lower than all other integrated weed management treatments except hand weeding at 15 and 35 DAS. Similar findings reported by Sanodiya and Singh (2018) that weed management practices in DSR reduced the nutrient depletion by weeds. Amongst the integrated weed management treatments, the highest N, P, K and Zn depletion by weeds was recorded under sunhemp coculture *fb* 2, 4- D 0.5 kg ha^{-1} at 30 DAS. It was due to higher weed dry matter under this treatment as compared to rest of the integrated weed management treatments except weedy and nutrient depletion is known to be positively correlated with weed dry matter accumulation. This is in agreement with the findings of Singh *et al*., (2014).

Nutrient uptake by crop

Mean data of 2 years showed that all integrated weed management treatments brought significant variation in nutrient uptake by rice compared with weedy (Table 3). Hand weeding at 15 and 35 DAS resulted in the highest nutrients (NPKZn) uptake by crop.*Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS recorded significantly higher nutrients (NPKZn) uptakein comparison to sunhemp cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS, *Sesbania* cover crop *fb Sesbania* coculture *fb* 2, 4 D 0.5 kg ha^{-1} at 30 DAS, sunhemp cover crop *fb* sunhemp coculture *fb* 2, 4 D 0.5 kg ha^{-1} at 30 DAS, *Sesbania* coculture *fb* 2, 4 -D 0.5 kg ha^{-1} at 30 DAS, sunhemp coculture *fb* 2, 4- D 0.5 kg ha^{-1} at 30 DAS, bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS. Sanodiya and Singh (2018) also showed that application of herbicides controlled weeds effectively and made available more nutrients to rice crop and consequently resulted in higher yield in direct seeded rice. At harvest stage, amongst the integrated weed management treatments, *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS recorded higher nutrient content and uptake by grain and straw as compared to all other integrated weed management treatments except hand weeding at 15 and 35 DAS. Amongst the integrated weed management treatments, the highest total N, P, K and Zn uptake was observed under *Sesbania* cover crop *fb* bispyribac 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS except hand weeding at 15 and 35 DAS. This is owing to lower nutrient depletion by weeds under these treatments (Table 3), whereas the lowest uptake of nutrients (N, P, K and Zn) by crop was recorded under weedy. Hence, it appears that competition for nutrients was more serious due to luxuriant weed growth in weedy which resulted in less availability of nutrient and uptake by crop. The results are in close proximity with findings of Sanodiya and Singh (2018) reported that N, P and K uptake by rice crop was inversely proportional to the N, P and K depletion by weeds. The highest N, P and K uptake by crop was observed in weed free plots. Sanodiya and Singh (2018) also suggested that weed control helped in better utilization of nutrients and was recorded to be the highest in weed free plots.

CONCLUSION

On basis of two years investigation it may be concluded that *Sesbania* cover crop *fb* bispyribac Na 25 g ha^{-1} + azimsulfuron 30 g ha^{-1} at 15 DAS should be undertaken for improved plant height, dry matter accumulation, LAI, chlorophyll content. Consequently this treatment reported lesser nutrients (NPK and Zn) depletion by weeds and higher nutrients (NPK and Zn) uptake by rice at harvest besides higher grain and straw yields in direct seeded rice.

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