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Effect of integrated weed management on growth, yields and nutrient balance in direct seeded rice (*Oryza sativa*)

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Abstract: **A field study was carried out during the rainy (*Kharif*) season of 2014 and 2015 at Varanasi, Uttar Pradesh, to study the effect of integrated weed management on growth, yields and nutrient balance in soil in direct seeded rice (*Oryza sativa* L.). Penoxsulam 35g/ha at 10 DAS *fb* 1 HW at 35 DAS significantly improved plant height, dry matter accumulation, leaf area index, chlorophyll content. Consequently, Penoxsulam 35g/ha at 10 DAS *fb* 1 HW at 35 DAS influenced statistically grain and straw yields. Penoxsulam 35g/ha at 10 DAS *fb* 1 HW at 35 DAS had lower nutrients (NPK and Zn) depletion by weeds and higher nutrients (NPK and Zn) uptake by crop in comparision of hand weeding at 15 and 35 DAS in rice during both the years of experimentation.**

Index Terms: **Azimsulfuron, bispyribac Na, direct seeded rice, chlorimuron ethyl + metsulfuron methyl and penoxsulam**

I. INTRODUCTION

Rice is grown not only in India but most part of the world since human civilization and used as a valuable grain for human diet. It is taken under diverse ecologies ranging from irrigated to rainfed upland, lowland and deep water as per ecological situations. From conventional era to modern farming, amongst growers, direct seeded upland 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). The critical period for weed control is defined as the time period in the crop growth cycle, during which weeds must be controlled to prevent unacceptable yield loss (Dogan *et al.*, 2004). Aerobic edaphic conditions under non flooded conditions in DSR stimulate germination of diverse weed species. The aim of integrated weed management is not to eliminate the use of herbicides but to improve their efficiency through their rational usage by combining with better crop management options and other methods which give an advantage to the crop (Duary *et al.*, 2015). Weed problem in direct seeded rice can be controlled by implementing inclusion of various weed management practices. However, weeds in direct seeded rice cannot be managed by growing of cover crops and incorporation of live mulches alone because of various flushes of weeds during rainy season in crop growth. It is imperative for identifying effective integrated weed management practices to minimize nutrient depletion by weeds and maximize by crop. Therefore, keeping these points in view, the present investigation was done to evaluate as well as assess the efficacy of different herbicides along with hand weeding and to identify best practice for suggesting farmers.

II. MATERIALS AND METHODS

A field study 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, comprising 10 treatments, viz. Bispyribac Na 25g/ha at 10 DAS *fb* 1 HW at 35 DAS, bispyribac Na 25g/ha at 20 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 10 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 20 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha +

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(chlorimuron ethyl + metsulfuron methyl) 2g/ha at 10 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha + (chlorimuron ethyl + metsulfuron methyl) 2g/ha at 20 DAS *fb* 1 HW at 35 DAS, penoxsulam 35g/ha at 10 DAS *fb* 1 HW at 35 DAS, penoxsulam 35g/ha at 20 DAS *fb* 1 HW at 35 DAS, hand weeding at 15 and 35 DAS and weedy during both the years and replicated thrice. Rice variety MTU-7029 was sown by zero till drill during the last week of June in 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 and sources were urea, single super phosphate and muriate of potash during both the years of investigation. 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 water for post emergence herbicides was 500 litres/ha. The crop was grown under irrigated condition under the recommended package of practices. Five plants from each experimental plot were selected randomly and marked with tag. 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/m row length. The data was analyzed statistically using Duncan multiple range test for valid conclusion of research.

Nutrient (N, P, K and Zn) uptake by crop (kg/ha)

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) = [Nutrient content (%) in grain or straw/100]
× Grain/Straw yield (kg/ha)

Nutrient (N, P, K and Zn) uptake by weeds (kg/ha)

Nutrient (N, P, K and Zn) uptake by weeds was calculated as per the following formula

Nutrient uptake by weeds (kg/ha) = [Nutrient content (%) in weed/ 100] × Weed dry matter (kg/ha)]

III. RESULTS AND DISCUSSION

Growth attributes

Amongst the integrated weed management treatments, Penoxsulam 35g/ha at 10 DAS *fb* 1 HW at 35 DAS resulted higher plant height, dry matter accumulation (g running/m), leaf area index and chlorophyll content in comparison to penoxsulam 35g/ha at 20 DAS *fb* 1 HW at 35 DAS and both treatments were statistically similar to each other during averaged 2 years. However, bispyribac Na 25g/ha at 10 DAS *fb* 1 HW at 35 DAS had higher plant height, dry matter accumulation (g running/m), leaf area index and chlorophyll content as compared to, bispyribac Na 25g/ha at 20 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 10 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 20 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha + (chlorimuron ethyl + metsulfuron methyl) 2g/ha at 10 DAS *fb* 1 HW at 35 DAS and bispyribac Na 12.5g/ha + (chlorimuron ethyl + metsulfuron methyl) 2g/ha at 20 DAS *fb* 1 HW at 35 DAS during both the years of investigation (Table 1). Sairamesh *et al.,* (2015) also expressed similar views in direct seeded rice.

Grain and straw yields

The increase in grain yields under penoxsulam 35g/ha at 10 DAS *fb* 1 HW at 35 DAS and penoxsulam 35g/ha at 20 DAS *fb* 1 HW at 35 DAS was 105.95% and 103.82% over weedy. Similarly, 83.08% and 83.97% higher straw yield under treatments penoxsulam 35g/ha at 10 DAS *fb* 1 HW at 35 DAS and penoxsulam 35g/ha at 20 DAS *fb* 1 HW at 35 DAS over weedy, respectively, was recorded. Khare *et al*., (2014) also supported the same findings in direct seeded rice and revealed that the higher grain yield (4.86 t/ha) were recorded under penoxsulam 25 g/ha applied at 10 DAS/DAT due to higher weed control efficiency (69.67%). The minimum grain and straw yields were recorded under weedy check due to more weed infestation and their dry matter accumulation and lower yield attributing characters (Table 1).

Organic carbon, pH and EC of soil

The data recorded on organic carbon, pH and electrical conductivity of soil indicated that these properties of soil were not affected by integrated weed management practices during 2 year study. (Table 2)

Available NPK in soil

Amongst integrated weed management treatments, Penoxsulam 35g/ha at 10 DAS *fb* 1 HW at 35 DAS showed significantly higher nutrients (NPK) availability in soil except 2 hand weedings at 15 and 35 DAS as compared to rest treatments; penoxsulam 35g/ha at 20 DAS *fb* 1 HW at 35 DAS, bispyribac Na 25g/ha at 10 DAS *fb* 1 HW at 35 DAS, bispyribac Na 25g/ha at 20 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 10 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 20 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha + (chlorimuron ethyl + metsulfuron methyl) 2g/ha at 10 DAS *fb* 1 HW at 35 DAS and bispyribac Na 12.5g/ha + (chlorimuron ethyl + metsulfuron methyl) 2g/ha at 20 DAS *fb* 1 HW at 35 DAS (Table 2).

Nutrient Uptake by crop

Average data of 2 years showed that all integrated weed management treatments brought significant variation in nutrient uptake by rice as compared to weedy (Table 3). Hand weeding at 15 and 35 DAS resulted in the highest nutrients (NPKZn) uptake by crop. Penoxsulam 35g/ha at 10 DAS *fb* 1 HW at 35 DAS recorded significantly higher nutrients (NPKZn) uptake in comparison to penoxsulam 35g/ha at 20 DAS *fb* 1 HW at 35 DAS, bispyribac Na 25g/ha at 10 DAS *fb* 1 HW at 35 DAS, bispyribac Na 25g/ha at 20 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 10 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 20 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha + (chlorimuron ethyl + metsulfuron methyl) 2g/ha at 10 DAS *fb* 1 HW at 35 DAS and bispyribac Na 12.5g/ha + (chlorimuron ethyl + metsulfuron methyl) 2g/ha at 20 DAS *fb* 1 HW at 35 DAS. The results are in close proximity with findings of Nanjappa and Krishnamurthy (1980) found that N, P and K uptake by rice crop was inversely proportional to the N, P and K depletion by weeds.

Nutrient depletion by weeds

Penoxsulam 35g/ha at 10 DAS *fb* 1 HW at 35 DAS recorded statistically lesser nutrients (NPKZn) depletion by weeds as compared to penoxsulam 35g/ha at 20 DAS *fb* 1 HW at 35 DAS, bispyribac Na 25g/ha at 10 DAS *fb* 1 HW at 35 DAS, bispyribac Na 25g/ha at 20 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 10 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 20 DAS *fb* 1 HW at 35 DAS, bispyribac Na 12.5g/ha + (chlorimuron ethyl + metsulfuron methyl) 2g/ha at 10 DAS *fb* 1 HW at 35 DAS and bispyribac Na 12.5g/ha + (chlorimuron ethyl + metsulfuron methyl) 2g/ha at 20 DAS *fb* 1 HW at 35 DAS during averaged 2 years (Table 3). Our results support the findings of Maity and Mukherjee (2008) also observed that weed management practices in DSR reduced the nutrient depletion by weeds and Kumar *et al.,* (2010) 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.

CONCLUSION

Based on 2 years study, it may be concluded that penoxsulam 35g/ha at 10 DAS *fb* 1 HW at 35 DAS should be suggested for maximizing plant height, dry matter accumulation, LAI, chlorophyll content. Consequently this treatment given lesser nutrients (NPK and Zn) depletion by weeds and higher nutrients (NPK and Zn) uptake by rice at harvest and to get higher yield in direct seeded rice.

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

Treatment	Plant height (cm) at harvest	Dry matter accumulation (g running/m) at harvest	LAI (Leaf area index) at 90 DAS	Chlorophyll content at 90 DAS (SPAD value)	Grain yield (t/ha)	Straw yield (t/ha)
Bispyribac Na 25g/ha at 10 DAS *fb* 1 HW at 35 DAS	85.8bc	110.6bc	3.8b	42.8c	47.3bcd	58.7b
Bispyribac Na 25g/ha at 20 DAS *fb* 1 HW at 35 DAS	85.5bc	110.2bc	3.8b	42.5cd	46.7bcde	60.7b
Bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 10 DAS *fb* 1 HW at 35 DAS	84.9bc	109.7bc	3.8b	42.1de	46.2bcde	60.8b
Bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 20 DAS *fb* 1 HW at 35 DAS	84.7bc	109.5bc	3.8b	41.9ef	45.7cde	60.7b
Bispyribac Na 12.5g/ha + (chlorimuron ethyl + metsulfuron methyl) 2g/ha at 10 DAS *fb* 1 HW at 35 DAS	83.4c	109.2bc	3.8b	41.7f	45.2de	60.7b
Bispyribac Na 12.5g/ha + (chlorimuron ethyl + metsulfuron methyl) 2g/ha at 20 DAS *fb* 1 HW at 35 DAS	83.1c	108.6c	3.8b	41.6f	44.9e	60.6b
Penoxsulam 35g/ha at 10 DAS *fb* 1 HW at 35 DAS	86.5b	111.4b	3.8b	43.5b	48.4b	61.7b
Penoxsulam 35g/ha at 20 DAS *fb* 1 HW at 35 DAS	86.3b	110.8bc	3.8b	42.8c	47.9bc	62.0b
Hand weeding at 15 and 35 DAS	89.8a	117.2a	4.0a	44.5a	57.5a	69.9a
Weedy	69.0d	75.2d	2.02c	36.8g	23.5f	33.7c

Table 2. Effect of integrated weed management on soil organic carbon (%), pH, EC, available N, P and K (kg/ha) in soil in direct seeded rice (average data of 2 years)

Treatment	Organic carbon (%)	Soil pH	EC	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Bispyribac Na 25g/ha at 10 DAS *fb* 1 HW at 35 DAS	0.388c	7.43b	0.21b	172.0d	18.8bc	187.5bcd
Bispyribac Na 25g/ha at 20 DAS *fb* 1 HW at 35 DAS	0.387d	7.42c	0.21c	171.7de	18.8c	187.5bcd
Bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 10 DAS *fb* 1 HW at 35 DAS	0.386de	7.41d	0.21d	171.2ef	18.8d	187.2cde
Bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 20 DAS *fb* 1 HW at 35 DAS	0.385e	7.41d	0.21e	170.3g	18.7e	187.0de
Bispyribac Na 12.5g/ha + (chlorimuron ethyl + metsulfuron methyl) 2g/ha at 10 DAS *fb* 1 HW at 35 DAS	0.384f	7.41d	0.21f	169.0h	18.7e	186.8e
Bispyribac Na 12.5g/ha + (chlorimuron ethyl + metsulfuron methyl) 2g/ha at 20 DAS *fb* 1 HW	0.383g	7.41d	0.21g	168.5h	18.7f	186.6e

at 35 DAS						
Penoxsulam 35g/ha at 10 DAS *fb* 1 HW at 35 DAS	0.389bc	7.45a	0.21df	173.8b	18.9b	188.1b
Penoxsulam 35g/ha at 20 DAS *fb* 1 HW at 35 DAS	0.389b	7.44ab	0.21e	173.0c	18.8e	187.6bc
Hand weeding at 15 and 35 DAS	0.391a	7.43b	0.22a	170.7fg	18.8e	185.8f
Weedy	0.382h	7.41d	0.21h	176.7a	19.3a	189.2a

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

Treatment	Nutrient depletion by weeds at harvest				Nutrient uptake by crop at harvest			
	N (kg/ha)	P (kg/ha)	K (kg/ha)	Zn (g/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Zn (g/ha)
Bispyribac Na 25g/ha at 10 DAS *fb* 1 HW at 35 DAS	0.9g	0.5g	0.9g	30.2ef	74.6bc	19.8c	110.1bc	3847.1bcd
Bispyribac Na 25g/ha at 20 DAS *fb* 1 HW at 35 DAS	1.0f	0.6f	1.1f	32.9e	73.5bcd	19.2c	109.5bc	3840.6bcd
Bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 10 DAS *fb* 1 HW at 35 DAS	1.1e	0.8e	1.2e	36.3d	72.3cde	17.8d	108.7bc	3789.3cd
Bispyribac Na 12.5g/ha + azimsulfuron 15g/ha at 20 DAS *fb* 1 HW at 35 DAS	1.3d	0.8d	1.4d	39.9c	70.9cde	16.8e	107.2bc	3703.3d
Bispyribac Na 12.5g/ha + (chlorimuron ethyl + metsulfuron methyl) 2g/ha at 10 DAS *fb* 1 HW at 35 DAS	1.4c	0.8c	1.5c	43.3b	69.3de	15.8f	106.1bc	3633.7d
Bispyribac Na 12.5g/ha + (chlorimuron ethyl + metsulfuron methyl) 2g/ha at 20 DAS *fb* 1 HW at 35 DAS	1.59b	0.9b	1.7b	45.7b	68.3e	16.6ef	104.9c	3567.2d
Penoxsulam 35g/ha at 10 DAS *fb* 1 HW at 35 DAS	0.6h	0.4h	0.7h	26.1g	78.3b	21.5b	116.3b	4082.7b
Penoxsulam 35g/ha at 20 DAS *fb* 1 HW at 35 DAS	0.7h	0.4h	0.8h	27.6fg	77.4b	21.3b	114.4bc	4057.9bc
Hand weeding at 15 and 35 DAS	0.2h	0.2i	0.2i	16.3h	91.9a	24.9a	137.6a	4992.9a
Weedy	8.2a	3.7a	9.5a	158.0a	37.9f	5.3g	57.9d	1761.9e

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