Original Research Article

Influence of Various Nitrogen Levels and Herbicides Application on Nutrient Uptake and Quality Parameters of Rice (*Oryza sativa* L.)

ABSTRACT

Afield experiment was conducted during *Kharif* season 2022 and 2023 at Agronomy research farm, Acharya Narendra Deva University of Agriculture and Technology Kumarganj,Ayodhya Uttar Pradesh, (India), which consisted of three levels of nitrogen 80, 120 and 160 Kg/ha in main plot and five weed management practices Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DAT, Bispyribac sodium 10 % SC @ 25g a.i/ha (PoE) at 25 DAT, Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DAT *fb*Bispyribac sodium 10 % SC @ 25g a.i/ha (PoE) at 25 DAT, Weed free and Weedy check in subplot thereby, making fifteen treatment combinations and replicated thrice in split plot design.Results indicated thatprotein content and protein yield, N, P and Kcontent in grain and straw and their uptake after harvest were maximumrecorded with the application of 160 Kg N $ha^{-1}$and Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DAT *fb*Bispyribac sodium 10 % SC @ 25g a.i/ha (PoE) at 25 DAT which was comparable to weed free during both the years of investigation on transplanting rice.

***Keyword**:*Protein content, Protein yield, NPK uptake, Nitrogen levels, Herbicides and Transplanted rice

1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most major cereal food grain crops of the *kharif* season and is a member of the Poaceae family.About 90 % of all rice grown in theworldisproducedandconsumedintheAsianregion.Tomeetthefoodandnutritional requirements in these densely populated and rice dominant regions, theprojected demand for rice by 2030 has been estimated at 904 mt for the world and824 mt for Asian region. Indiaalone wouldrequire about 156 mt of rice by theyear2030(ICAR,2010)atanannualincrementof3mtinthecurrentriceproduction (Dass *et al*., 2016).

Nitrogen management is also a major component of soil and crop management system in rice**.** Knowing the required nutrients for all stages of growth and understanding the soil's ability to supply them is critical to profitable crop production**.** Among major nutrients like NPK, nitrogen is a key nutrient of rice production and requires proper application management (Nedunchezhiyan and Laxminarayan, 2011).

Bispyribac-sodium, a pyrimidinylcarboxy herbicide, is effective to control many annual and perennial grasses, sedges and broad-leaved weeds in rice fields (Yun *et al*., 2005) Combinations of herbicides bispyribac sodium + pyrozosulfuron offer several advantages over the use of a single herbicide, including reduction in cost of cultivation by saving time and labour, reduction in soil compaction by eliminating multiple field operations, increase in the spectrum or range of weeds controlled or an extension of weed control over a longer period of time, improvement in crop safety by using minimum doses of selected herbicides applied in combination rather than a single high dose of one herbicide, reduction in crop or soil residues of persistent herbicides by using minimum doses of such herbicides and delay in the appearance of resistant weed species to selected herbicides(Mitra *et al*., 2022).

2. MATERIALS AND METHODS

Afield experiment was conducted during *Kharif* season 2022 and 2023 at Agronomy research farm, Acharya Narendra Deva University of Agriculture and Technology Kumarganj,Ayodhya Uttar Pradesh, (India), located at latitude of $24.4^{0\prime}$North and longitude of $82.12^{0\prime}$ East with an elevation of 113 meters above the mean sea level. The Ayodhya area lies in the heart of Eastern Utter Pradesh and has sub humid climate. The experimental site has an even topography with good drainage facilities system in farm. The area receives mean annual rainfall of 1013 mm, of which90 per cent is received from June to September.The experiment was layout in split plot design (SPD) with thrice replications taken three nitrogen levels 80 Kg/ha, 120 Kg/ha and 160 Kg/hain main plot and five weed management practices Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DAT, Bispyribac sodium 10 % SC @ 25g a.i/ha (PoE) at 25 DAT, Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DAT*fb*Bispyribac sodium 10 % SC @ 25g a.i/ha (PoE) at 25 DAT, Weed free and Weedy checkin subplot.The soil of the experimental field was silty loam in texture and slightly alkaline in reaction. The soil was medium in available phosphorus and available potassium but low in organic carbon and available nitrogen.The rice varietySarjoo-52 was manually transplanted in*kharif* season during both year on 01st July 2022 and 12thJuly2023 respectively.

2.1NPK content in grainand straw:

Nitrogen content in grain and strawwas analyzed by modified micro-Kjeldahl method (Jackson, 1973) by digesting samples in sulphuric acid in a micro-Kjeldhal flask (digestion tube) on a hot plate. The distillation process was carried out using Nitrogen Analyzer (Gerhart) and titration was carried out using digital burette.

Phosphorus content in grain and straw was estimated by Vanadomolybdo phosphoric acid yellow colour method (Jackson, 1973) and the intensity of yellow colour was read with Spectro-photometer at 420 nm and the contents were expressed in terms of percentage phosphorus.

Estimation of potassium content in grainand straw by flame emission photometry method (Jackson, 1973) was used in di-acid digested samples and reported as percent potassium.

2.2 NPK uptake:

The nitrogen content in plant was determined by Kjeldahl's method. The grain andstraw were separated and then grinded. The grinded material was digested in concentrated sulphuric acid using copper sulphate and potassium sulphate mixture as catalyst. The digested material was then distilled with 40 per cent sodium hydroxide and distillate was collected in boric acid

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containing the mixed indicator. The content was estimated by titrating the distillate against N/20 sulphuric acid. The nitrogen uptake was calculated by multiplying the dry weight with nitrogen content. In order to get total uptake of nitrogen, the uptake values for grain and straw were added together.

Phosphorus uptake was determined in the extract by Vando molybdate yellow color method. The optical density (OD) was measured with photoelectric colorimeter at 470nm. The content was estimated with calibration curve. The phosphorous uptake by grain and straw per hectare was calculated with the help of per cent value of phosphorus and yield of grain and straw. In order to get uptake of phosphorous,the uptake value for grain and straw were added together plot wise.

The potassium content was determined with the help of flame photometer (Jackson, 1973) and was estimated with calibration curve. Uptake of potassium by rice grain and straw was calculated by multiplying their relative contents with yield and values were added to know the uptake of potassium in kg/ha.

Grain uptake (kg/ha) = Grain yield (q/ha) × Nutrient content (%) in grain

Straw uptake (kg/ha) = Straw yield (q/ha) × Nutrient content (%) in straw

2.3 Protein content in grain (%):

Protein content in rice grains was estimated separately by multiplying the nitrogen content of grain as determined by modified Nessler's reagent method. The nitrogen content was multiplied by a factor 6.25.

2.4 Protein yield (Kg/ha):

Protein yield of rice was calculated by multiplying the respective grain yield (kg/ha) with their protein content in grains divided by 100

3. RESULTS AND DISCUSSION

3.1Nitrogen content in grain and straw of rice (%)

Data given Table 1clearly indicated that nitrogen and weed management practices had non-significant effect on nitrogen content in grain whereas in straw significantly effected during both the years of experiment.

Nitrogen content in straw significantly influenced by nitrogen and weed management practices during both years. Data further revealed that maximum nitrogen content in straw 0.43 and 0.45, during 2022 and 2023 respectively recorded under 160 Kg N/ha, which was statistically at par with 120 Kg N/ha while significantly higher than 80 Kg N/ha. This might be due to better supply of nitrogen to the plant resulted in higher growth and development responsible for higher nitrogen content in straw.The results are supported by the Kamruzzaman*et al.* (2013)**.**

Among the weed management practices weed free recorded maximum nitrogen content in straw in rice 0.43 and 0.46% during 2022 and 2023 respectively which was at par with the application of Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DAT *fb*Bispyribac sodium 10 % SC @ 25g a.i/ha (PoE) at 25 DAT during both years.This might be due effective

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control of weed, reduces crop weed competition and enhance more supply nitrogen to the crop.Similar results were also reported byNagarjuna *et al.*(2021).

3.2Nitrogen uptake by grain and straw of rice (kg ha^{-1})

Data given Table 1,clearly indicated that nitrogen and weed management practices had significant effect on nitrogen uptake by grain and straw in rice during both the years of experimentation.

Data further revealed that maximum nitrogen uptake by grain and straw 61.96 and 64.63, 32.17 and 34.74 kg during 2022 and 2023 respectively recorded under 160 Kg N/ha which was significantly higher than rest of the treatments. Nitrogen treatment affected the significant effects on uptake of nitrogen through grain and straw of rice crop. The maximum nitrogen uptake was recorded under 160 Kg N/ha. It was due to the fact that in 160 Kg N/ha increased root volume and root weight which might have enabled more absorption area, responsible for better growth and yield resulted in higher uptake of nitrogen. Similar result was also found by Laxminarayana (2003) and Sandhya. (2012).

Among the weed management practices weed free recorded maximum nitrogen uptake by grain and straw in rice 66.72 and 68.60, 34.29 and 36.49 kg during 2022 and 2023 respectively which was at parwithPyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DA *fb*Bispyribac sodium 10 % SC @ 25g a.i/ha (PoE) at 25 DAT while significantly higher than rest of the weed management practices during both years.The maximum nitrogen uptake through grain and straw was recorded under suchtreatment which was mainly due to efficient weed control higher availability of nutrients to crop and higher yield. Weedy check recorded the lowest nitrogen uptake through grain and straw was associated with higher weeds growth. The results are in close proximity of Yadav *et al.* (2009).

3.3Phosphoruscontentingrainandstrawofrice(%)

Data given Table 2clearly indicated thatnitrogen levels andweedmanagementpracticeshadnon-significanteffectonphosphoruscontentingrainandstrawinriceduringboththe yearsofexperiment.Phosphoruscontentingrainandstrawinricenon-significantlyinfluencedbynitrogen and weed management practices during both years. However,maximumphosphoruscontentingrainandstrawinrice(0.348 and 0.351%,0.100 and 0.102 % during 2022 and 2023 respectively recorded under 160 Kg N/ha.

Weed management practices also had non-significant effect. However maximumphosphoruscontentingrainandstrawinrice(0.356 and 0.358 %, 0.102 and 0.103%weed free recordedduring2022and2023respectively.

Phosphorus content in grain and straw as affected by different nitrogen and weed management practices were found to be non-significant during both the years of experimentation. This might be due to same amount of phosphorus used in all treatments. Nagarjuna *et al.*(2021) also reported the similar type of responses.

3.4Phosphorusuptakebygrain andstrawofrice(kgha^{-1})

Data given Table 2clearly indicated

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thatnitrogenandweedmanagementpracticeshadsignificanteffectonphosphorusuptakebygrainandstr aw inriceduringboththeyearsofexperiment. Data further revealed that maximum phosphorus uptake by grain and straw in rice17.46 and 18.11 kg, 7.42 and 7.81 kg during 2022 and 2023 respectively recorded under160 Kg N/ha which was statistically at par with 120 Kg N/ha while significantly higher than 80 Kg N/ha.The maximum phosphorus uptake was recorded under 160 Kg N/ha. This might be due to continuous supply of optimum phosphorus which Improve the availability of nutrient to plant, responsible for higher yield resulted in higher phosphorus uptake.Similar result was also found by Rawat *et al.* (2013).

Among the weed management practices weed free recordedmaximum phosphorus uptake by grain and straw in 19.09 and 19.50 kg 8.01 and 8.24 kg during 2022 and 2023 respectively. Which was at par with application of Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DA *fb*Bispyribac sodium 10 % SC @ 25g a.i/ha (PoE) at 25 DAT while significantly higher than the rest of the weed management practices during both years.Themaximum phosphorus uptake through grain and straw was recorded underweed free treatment which was mainly due to efficient weed controlhigher availability of nutrients to crop and higher yield. Weedy check recorded the lowestphosphorus uptake through grain and straw was associated with higher weeds growth. TheresultsareincloseproximityofThimmegowda*et al*. (2009).

3.5Potassiumcontentingrainandstrawofrice(%)

Data given Table 3clearly indicate thatnitrogen and weedmanagementpracticeshadnon-significanteffectonpotassiumcontentingrainandstrawinriceduringboththe yearsofexperiment. However, maximumpotassiumcontentingrainandstrawinrice0.328 and 0.331 %, 1.560 and 1.564 % during 2022 and 2023 respectively recorded under 160 Kg N/ha.

Among the weed management practices weed free recordedmaximumpotassiumcontentingrainandstrawinrice0.335 and 0.338 % , 1.571 and 1.574%during2022and2023respectivelyfollowedbyapplicationofPyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DA *fb*Bispyribac sodium 10 % SC @ 25g a.i/ha (PoE) at 25 DAT during both years.This might be due to same amount of potassium used in all treatments. Laxminarayana (2003) also reported the similar type of responses.

3.6Potassiumuptakebygrain andstrawofrice(kgha^{-1})

Data given Table 3clearly indicated thatnitrogenandweedmanagementpracticeshadsignificanteffectonphosphorusuptakebygrainandstr aw inriceduringboththeyearsofexperiment.Data further revealed that maximum potassium uptake by grain and straw 16.49 and 17.05, 115.40 and 118.42 kg during 2022 and 2023 respectively recorded under 160 Kg N/ha which was significantly higher than rest of the treatments. Nitrogen treatment affected significantly uptake of potassium through grain and straw of rice crop. The maximum nitrogen uptake was recorded under 160 Kg N/ha. It was due to the fact that in 160 Kg N/ha increased root volume and root weight which might have enabled more absorption area responsible for better yield resulted in maximum uptake of potassium. Similar result was also found by Laxminarayana (2003) and Sandhya. (2012).

Among the weed management practices weed free recorded maximum potassium uptake

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by grain and straw in rice 17.99 and 18.36, 123.83 and 129.53 kg during 2022 and 2023 respectively which was at parwith Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DA *fb*Bispyribac sodium 10 % SC @ 25g a.i/ha (PoE) at 25 DAT while significantly higher than rest of the weed management practices during both years.The maximum potassium uptake through grain and straw was recorded under weed free treatment which was mainly due to efficient weed control higher availability of nutrients to crop and higher yield. Weedy check recorded the lowest potassium uptake through grain and straw was associated with higher weeds growth. The results are in close proximity of Yadav *et al.* (2009).

3.7Protein content in grain (%)

Data given Table 4clearly indicated that nitrogen levels and weedmanagement practices had non-significant effect on protein content in grain during boththe years of experiment. However, maximum protein content in grain 7.71 and 7.84%recorded under 160 Kg N/haduring 2022 and 2023 respectively.This might be due to better supply of nitrogen to the resulted in higher protein content. The results are in close proximity of Jahan *et al*. (2014).

Among the weed management practices weed free recordedmaximum protein content in grain 7.75 and 7.88during 2022 and 2023 respectively followed by application of Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DAT *fb*Bispyribac sodium 10 % SC @ 25g a.i/ha (PoE) at 25 DAT during both years.

This might be due to effective control of weeds reduce the crop weed competition, increase maximum availability of moisture, nutrient, space and light. To the plant resulted in higher crop growth and development of crop resulted in higherprotein content in grain. Shekara*et al.* (2011)also reported the similar type of responses.

3.8 Protein yield (kg ha^{-1})

Data given Table 4clearly indicated that nitrogen levels and weed management practices had significant effect on protein yield in grain during boththe years of experiment.

Data further revealed that maximum protein yield of rice 387.23 and 403.95kg during 2022 and 2023 respectively recorded under 160 Kg N/ha which was significantlyhigher than rest of the treatments. This might be due to better supply of nitrogen to the crop, resulted in higher protein yields. The results are in close proximity of Jahan *et al*. (2014).

Among weed management practices weed free recorded maximum protein yields 417.03 and 428.77 kg during 2022 and 2023 respectively, which was at par with application of Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DAT *fb*Bispyribac sodium 10 % SC @ 25g a.i/ha (PoE) at 25 DAT. While significantly higher than the rest of the weed management practices during both years. This might be due to effective control of weeds reduce the crop weed competition, increased maximum availability of moisture, nutrient, space and light, to the plant resulted in higher crop growth and protein yield.Shekara*et al.* (2011) also reported the similar type of responses

4. CONCLUSIONS

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From the above study it may be concluded that application 160 Kg N/ha and Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DAT*fb*Bispyribac sodium 10 % SC @ 25g a.i/ha (PoE) at 25 DAT for weed management practices was better forquality and nutrient content anduptake.

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Table 1Nitrogen content (%) andNitrogen uptake (kg/ha)of rice as influenced by nitrogen levels and weed management practices.

Treatments	**Nitrogen content (%)**				**Nitrogen uptake (kg/ha)**			
	Grain		**Straw**		**Grain**		**Straw**	
	2022	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
Nitrogen Levels								
N_1 : 80 Kg/ha	1.17	1.19	0.36	0.38	46.40	48.94	21.92	23.75
N_2: 120 Kg/ha	1.21	1.23	0.40	0.42	54.68	57.59	27.05	29.18
N_3 : 160 Kg/ha	1.23	1.25	0.43	0.45	61.96	64.63	32.17	34.74
SEm±	0.018	0.017	0.006	0.004	0.755	0.794	1.304	1.260
CD at 5%	**NS**	**NS**	**0.03**	**0.02**	**3.04**	**3.20**	**5.01**	**5.08**
WeedManagementPractices								
W_1: Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DAT	1.19	1.21	0.38	0.40	45.46	48.26	21.67	23.82
W_2 : Bispyribacsodium10 % SC @ 25g a.i/ha (PoE)at25 DAT	1.20	1.22	0.40	0.43	57.65	60.59	29.12	31.44
W_3: Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DA*fb*Bispyribacsodium10 % SC @ 25g a.i/ha (PoE) at 25 DAT	1.23	1.25	0.42	0.44	63.72	66.79	31.91	33.98
W_4 : Weedfree	1.24	1.26	0.43	0.46	66.72	68.60	34.29	36.49
W_5 :Weedy check	1.16	1.19	0.34	0.36	38.19	41.04	18.23	20.38
SEm±	0.028	0.026	0.009	0.008	1.263	1.318	1.481	1.541
CD at 5%	**NS**	**NS**	**0.02**	**0.02**	**3.69**	**3.85**	**4.32**	**4.50**

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Table 2Phosphorus content (%) and Phosphorus uptake (kg/ha) of rice as influenced by nitrogen levels and weed management practices

Treatments	Phosphorus content (%)				Phosphorus uptake (kg/ha)			
	Grain		Straw		Grain		Straw	
	2022	2023	2022	2023	2022	2023	2022	2023
Nitrogen Levels								
N_1 : 80 Kg/ha	0.335	0.337	0.097	0.098	13.35	13.87	5.82	6.02
N_2: 120 Kg/ha	0.343	0.345	0.099	0.100	15.58	16.27	6.71	6.93
N_3 : 160 Kg/ha	0.348	0.351	0.100	0.102	17.46	18.11	7.42	7.81
SEm±	0.003	0.004	0.001	0.001	0.53	0.67	0.32	0.31
CD at 5%	**NS**	**NS**	**NS**	**NS**	2.14	2.68	1.28	1.26
WeedManagementPractices								
W_1: Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DAT	0.339	0.341	0.097	0.098	12.99	13.65	5.56	5.87
W_2 : Bispyribacsodium10 % SC @ 25g a.i/ha (PoE)at25 DAT	0.343	0.345	0.098	0.099	16.54	17.21	7.00	7.28
W_3: Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DA*fb*Bispyribacsodium10 % SC @ 25g a.i/ha (PoE) at 25 DAT	0.347	0.349	0.101	0.102	18.02	18.75	7.72	7.93
W_4 : Weedfree	0.356	0.358	0.102	0.103	19.09	19.50	8.01	8.24
W_5 :Weedy check	0.327	0.329	0.095	0.096	10.68	11.32	4.96	5.28
SEm±	0.007	0.006	0.002	0.003	0.67	0.66	0.35	0.37
CD at 5%	**NS**	**NS**	**NS**	**NS**	**1.95**	**1.92**	**1.02**	**1.07**

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Table 3Potassium content (%) and Potassium uptake (kg/ha) of rice as influenced by nitrogen levels and weed management practices

Treatments	Potassium content (%)				Potassium uptake (kg/ha)			
	Grain		Straw		Grain		Straw	
	2022	2023	2022	2023	2022	2023	2022	2023
Nitrogen Levels								
N_1 : 80 Kg/ha	0.324	0.326	1.538	1.540	12.86	13.38	92.21	93.17
N_2: 120 Kg/ha	0.325	0.327	1.543	1.546	14.75	15.36	105.06	109.67
N_3 : 160 Kg/ha	0.328	0.331	1.560	1.564	16.49	17.05	115.40	118.42
SEm±	0.004	0.003	0.021	0.022	0.20	0.21	1.43	1.49
CD at 5%	NS	NS	NS	NS	0.82	0.85	5.76	5.99
WeedManagementPractices								
W_1: Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DAT	0.318	0.320	1.553	1.555	12.16	12.76	88.94	91.28
W_2 : Bispyribacsodium10 % SC @ 25g a.i/ha (PoE)at25 DAT	0.329	0.332	1.560	1.564	15.86	16.52	111.54	117.74
W_3: Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DA*fb*Bispyribacsodium10 % SC @ 25g a.i/ha (PoE) at 25 DAT	0.332	0.334	1.564	1.567	17.22	17.88	119.58	117.23
W_4 : Weedfree	0.335	0.338	1.571	1.574	17.99	18.36	123.83	129.53
W_5 :Weedy check	0.315	0.316	1.486	1.489	10.28	10.78	77.22	79.65
SEm±	0.007	0.006	0.033	0.034	0.34	0.35	2.38	2.44
CD at 5%	NS	NS	NS	NS	0.99	1.03	6.95	7.12

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Table 4Protein content in grain (%)and Protein yield(Kg/ha)of rice as influenced by nitrogen levels and weed management practices.

Treatments	**Protein content in grain (%)**		**Protein yield (Kg/ha)**	
	2022	**2023**	**2022**	**2023**
Nitrogen Levels				
N_1 : 80 Kg/ha	7.29	7.46	290.03	305.90
N_2: 120 Kg/ha	7.54	7.67	341.78	359.92
N_3 : 160 Kg/ha	7.71	7.84	387.23	403.95
SEm±	0.103	0.142	4.72	4.96
CD at 5%	NS	NS	19.02	20.00
WeedManagementPractices				
W_1: Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DAT	7.44	7.58	284.14	301.61
W_2 : Bispyribacsodium10 % SC @ 25g a.i/ha (PoE)at25 DAT	7.48	7.60	360.34	378.68
W_3: Pyrazosulfuron ethyl 10 % WP @ 20g a.i/ha (PE) at 0-3 DAT*fb*Bispyribacsodium10 % SC @ 25g a.i/ha (PoE) at 25 DAT	7.67	7.79	398.22	417.41
W_4 : Weedfree	7.75	7.88	417.03	428.77
W_5 :Weedy check	7.24	7.42	238.66	256.49
SEm±	0.162	0.165	7.89	8.24
CD at 5%	NS	NS	23.04	24.05

UNDER PEER REVIEW

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