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Diversity and dynamics of weeds as influenced by flucetosulfuron 10 % WG in direct seeded rice and its residual effect on succeeding crop green gram

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ABSTRACT

Weed management in direct seeded rice through flucetosulfuron 10 % WG and its residual effect on succeeding green gram was identified in the field experiment at College of Agriculture, Navile, Shivamoga, the University of Agricultural and Horticultural Sciences, Shivamogga, during kharif 2013- 2014 and rabi 2014-2015. Weed control treatments consisting flucetosulfuron at different doses (15 to 30 g a.i. ha^{-1}) and other herbicides bispyribac sodium 10%SC 20 g a.i. ha^{-1}, azimsulfuron 50% DF 35 g a.i. ha^{-1}and hand weeding.Dominant weed flora observed in the experimental field among grasses Echinochloacolonum, E. crusgalli and Leptochloachinensis among sedges Cyperusdifformis and C. iria whereas in case of broadleaf weeds (BLW) Ludwigiaparviflora, Ecliptaprostrata, Alternantherasessilis, Fimbristylismiliacea and Marseliaquadrifolia were dominated weeds. Application flucetosulfuron10 % WG @ 25g a.i. ha^{-1}registered consistently good control of all category of weeds, i.e., grasses, sedges and broad leaved weeds and was on par with flucetosulfuron10 % WG @ 30g a.i. ha^{-1} dose and these herbicides did not cause any phytotoxicity symptoms on preceding crop direct seeded rice as well as succeeding crop green gram and recorded significantly higher grain yield in direct seeded rice.

***Keywords*:** Bioefficacy, direct seeded rice, green gram and herbicide

Rice is a principal source of food in India and cultivated on about 44 million hectare area, occupying 30per cent of the total cultivated area (Anon., 2016). Rice is predominantly grown by transplanting seedlings into puddled (conventional wet-tillage) soil and kept flooded for the most of the growing season. The puddled soil ensures good crop establishment, weed control with standing water, and reduces deeppercolation losses. However, the conventional method of rice crop establishment requires a significant amount of water, labour, and energy, which are gradually becoming scarce and more expensive.Scarcity of water and the non-uniform distribution of rainfall during monsoon, the acreage under transplanted rice is shrinking continuously. Moreover, growing rice by transplanting in puddled soil requires the massive amount of labour in the growing of nursery, uprooting of seedlings, puddling field and seedling transplanting in fields. The alternative option for puddling and transplanting could be direct seeding as it does not require the massive amount of labour and huge capital input initially and also crop matures earlier than the transplanted crop, allowing timely planting of succeeding crop. But the rice farming through the direct-seeded method is not profitable on account of severe weed infestation, a major constraint in improving its profitability and sustainability. Severe crop weed competition in this system reduces the yield by 20-95 per cent (Gogoi, 1996). Therefore, effective and timely management of weeds plays pivotal for successful adoption of the direct seeded method of establishment of rice crop. Some newly developed herbicides are available to facilitate post-emergence application to manage late emerged weeds in direct seeded rice. Use of these herbicides at low concentrations can ensure good control weeds in direct seeded rice resulting higher uptake of nutrients by the crop to produce higher grain yields and economic return to the farmers. On the other hand, high doses of herbicides can cause substantial crop injury, especially on soils low in clay content. There is an urgent need to optimize the use of these herbicides to minimize possible adverse effects on the environment. Information available on these new broad-spectrum low dose post emergence herbicides is meager.Sulfonyl urea group of herbicides are low dose high efficacy herbicides having acetolactase synthase (ALS) inhibition as mode of action in plants, and are safe for mammals. Flucetosulfuron is such a new generation, pyrimidinyl sulfonylurea, broad spectrum herbicide, odourless white solid, soluble in water, acetone, ethyl alcohol, ethyl acetate, n-hexane and methanol. Even though new generation herbicides are required in smaller quantities, their persistence and safety to the succeeding crop in the herbicide applied field must be analysed thoroughly. The phytotoxic activity of the herbicide molecule can be measured by bioassay method which is cost-effective and do not require expensive equipments like High Performance Liquid Chromatograph (HPLC). Bioassays or biological tests applied to the study of herbicides, are based on the response of different species, chosen as controls, to the application of the herbicide under study (Horowitz, 1976).Bioassay is the simplest and direct method of residue assessment. It possesses several

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advantages over mechanical or chemical methods of residue assessment like determination of both active or biologically active substance and possible degradation products of the herbicide; being based on the observation of the response of the plants to herbicide, it provides more practical information and materials involved and the methodology is simple with high reproducibility (Günther *et al*., 1993). Keeping these in mind, the present investigation on diversity and dynamics of weeds as influenced by flucetosulfuron in direct seeded rice and its residual effect on succeeding greengram was carried out.

MATERIALS AND METHODS

The field experiment was carried out during *kharif* 2013-14 and *Rabi* 2013-14 and 2014-15 on sandy loam soil in the research farm of the University of Agricultural and Horticultural Science, Shimoga, Karnataka. The experiment was laid out in Randomized Complete Block Design and replicated thrice with a plot size of 6.0 × 5.0 m. The treatments consisted of flucetosulfuron 10 % WG in different doses (15 to 30g *a.i.*ha^{-1}), bispyribac sodium 10SC @ 20g *a.i.*ha^{-1}, azimsulfuron 50DF @ 35g *a.i.* ha^{-1} and hand weeding. Uniform application of herbicides was done by spraying with the help of knapsack sprayer fitted with Water Foam Nozzle. For the application of the herbicides, a water volume of 350 liters ha^{-1} was used. Hand weeding was done at 20th and 60th day after transplanting (DAT).Species-wiseobservations were recorded for bio-efficacy of different herbicides. Weed count was recorded at 7, 15, 30 and 45 days after application (DAA) of herbicides. A quadrate of 0.25m^2 size was thrown randomly at five spots in each treatment and count for specieswise weed was recorded and data presented as species-wise weeds m^{-2}. The data on the dry weight of weeds was recorded at 60 days after transplanting (DAT). Grain yield, plant height and panicle number per m^2 were also recorded at the time of harvest. The data were analyzed statistically using a suitable transformation like the square root of (X+1) depending on the extent of variations. For the calculation of weed index formula of Gill and Kumar (1966) was used as follow-

$$\text{Weed index (\%)} = \frac{\text{Yield from hand weeded plot - Yield from the treatment plot}}{\text{Yield from hand weeded plot}} \times 100$$

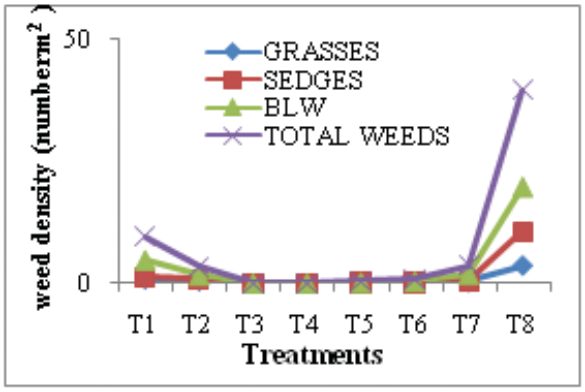
Phytotoxicity effect of flucetosulfuron 10%WGon paddy plants was observed at 1, 3, 5, 7 and 10 days after application as per the protocol of Central Insecticide Board and Registration Committee (CIB&RC) for the phototoxic symptoms like; a) leaf tip injury, b) wilting, c) vein clearing, d) necrosis, e.) epinasty and f.) hyponasty and bioassay studies were made to study the residual effect of herbicides on succeeding crop green gram in the net plot area. Immediately after the harvest of the main crop, green gram was sown in each treatment by opening the furrows at 30cm apart manually. The crop was supplemented with the recommended dose of fertilizer at the time of sowing and irrigated to ensure uniform crop growth. At 30 DAS plant population and 60 days after sowing the plant height was recorded and yield of the green gram was taken at harvest. The phytotoxicity on the succeeding crop was assessed in all the treatments of the herbicide flucetosulfuron applied @ 15, 20 and 25g *a.i.* ha^{-1} along with standards and untreated check applied indirect seeded rice. The observations on leaf epinasty, hyponasty, necrosis, wilting and vein clearing were recorded at 10, 20 and 30 DAS. A visual assessment estimated the level of phytotoxicity on phytotoxicity rating scale (PRS), where 0 = no crop injury, 10 = heavy injuries or complete destruction of the green gram plants (Anon., 1981).

RESULTS AND DISCUSSION

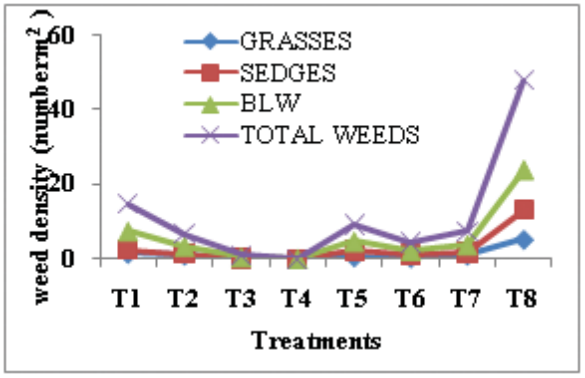
During *kharif* 2013 and 2014 dominant weed flora observed in the experimental plots. Among grasses *Echinochloa colonum* and *E. crusgalli*, among sedges *Cyperus iria*, *C. difformis* whereas in case of broad leaf weeds BLW) *Ludwigia parviflora*, *Eclipta prostrata*, *Ammania baccifera* and *Spilanthes acmella* were dominated weeds.

Observations on weed density after different days of application of herbicides indicate that herbicidal treatment was better than untreated control condition in reducing all categories of weeds (grasses, sedges, BLW and the total number of weeds). Data (Fig.1) indicated the efficacy of different herbicides at 7 days after application.Flucetosulfuron10WG @ 25 g *a.i.* ha^{-1} and @ 30 g *a.i.* ha^{-1} as post-emergence gave good control of all categories (grasses, sedges and BLW) of weeds being, 0.0m^{-2} during both the seasons as compared to the un-weeded control. Data on weed density after 15 days of application of herbicides is presented in the fig.- 1 also indicates the superiority of flucetosulfuron10WG @ 30g *a.i.*ha^{-1} and was followed by flucetosulfuron10WG @ 25 g *a.i.* ha^{-1}. In flucetosulfuron10WG @ 30g *a.i.*ha^{-1}, density of grasses, sedges, BLW and total weed number recorded zero during both the seasons; while application of flucetosulfuron10 WG @ 25 g *a.i.*ha^{-1} recorded density of grasses (0.07, 0.10 m^{-2}), sedges (0.03, 0.27m^{-2}) and

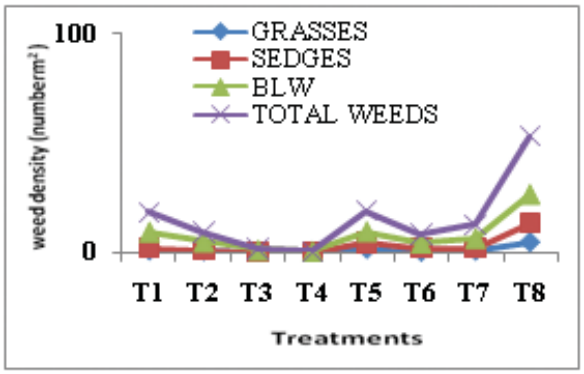
BLW (0.20,0.57m^{-2}) with a total weed population of 0.3 and 0.93m^{-2} during first and second season, respectively. That was followed by bispyribac sodium 10SC @ 20g *a.i.*ha^{-1}, hand weeding, flucetosulfuron10WG @ 20g *a.i.*ha^{-1}, azimsulfuron 50DF @ 35 g *a.i.*ha^{-1} and flucetosulfuron10WG @ 15g *a.i.*ha^{-1}. Observation data for 30 and 45 days after the application of herbicides represented in (Fig. 1) indicated a similar trend of weed control as on 15 days after the application of herbicides during both the seasons. Whereas,flucetosulfuron 10WG @ 30g *a.i.* ha^{-1}was giving best control of all category of weeds with a total weed population 0.00 m^{-2} and 0.30 m^{-2} at 30 and 45 days after application, respectively during first season and 0.10m^{-2}and 0.90m^{-2}at 30 and 45 days after application respectively during the second season and application of flucetosulfuron @ 25g *a.i.* ha^{-1} recorded a total weed count of 0.47m^{-2} and 2.23m^{-2} at 30 and 45 days after application respectively during first season and during second season total weed count 1.70m^{-2}and 3.90m^{-2}at 30 and 45 days after application, respectively. Bispyribac sodium 10 SC @ 20g *a.i.*ha^{-1} recorded total weed population 2.20m^{-2} and 6.87m^{-2} at 30 and 45 days application, respectively during first season and 3.90m^{-2} and7.40m^{-2} at 30 and 45 days after application, respectively during second season. Flucetosulfuron 10WG @ 20g *a.i.*ha^{-1} recorded total weed count 5.30m^{-2} at 30 days after application and 9.83m^{-2}at 45 days after application, respectively during first season and total weed count 7.53m^{-2}at 30days after application and 12.17m^{-2} at 45 days after application during second season. Azimsulfuron 50DF @ 35 g *a.i.* ha^{-1} recorded total weed count 5.80 m^{-2} at 30 and 8.97 m^{-2} at 45 day during first season and 6.03m^{-2} at 30 and 9.77m^{-2} at 45 day after application during second season. Whereas, hand weeding recorded total weed count 3.23 m^{-2} at 30 days and 10.73m^{-2}at 45 days, respectively during the first season and total weed count 4.23 m^{-2} at 30 days and 9.17m^{-2}at 45 days, respectively during the second season. The treatments flucetosulfuron10WG @ 30g *a.i.*ha^{-1} and 25g *a.i.* ha^{-1} were at par with each other and statistically superior to other standard check herbicides during both the seasons. At 60 DAA of both season's trial similar pattern of weed control was observed with flucetosulfuron10 WG @ 25 and 30g *a.i.*ha^{-1}dose. These doses were superior to standard check chemicals *viz*., bispyribac sodium 10 SC @ 20g *a.i.*ha^{-1} and azimsulfuron 50DF @ 35g *a.i.* ha^{-1}. Single hand weeding was superior to flucetosulfuron10WG@ 20 g *a.i.*ha^{-1}dose for controlling different categories of weed.



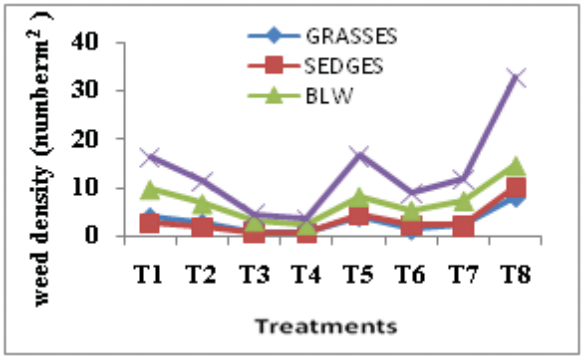
7 days after herbicide application



14 days after herbicide application



30 days after herbicide application



45 days after herbicide application

Fig. 1:Weed density in direct seeded rice at different interval of herbicides application

Table 1: Efficacy of flucetosulfuron 10 WG on total weed population in direct seeded rice at 60 days after application during *kharif*, 2013 -14

Treatments	Total weed count (number m^{-2}) at 60 DAT							
	First season				Second season			
	Grasses	Sedges	BLW	Total	Grasses	Sedges	BLW	Total
T_1:Flucetosulfuron 10WG @ 15g *a.i.* ha^{-1}	6.10 (2.57)	7.73 (2.87)	7.93 (2.90)	21.77 (4.72)	4.00 (2.12)	10.37 (3.30)	13.90 (3.79)	28.27 (5.36)
T_2: Flucetosulfuron10WG @ 20g *a.i.* ha^{-1}	4.87 (2.32)	3.63 (2.03)	6.30 (2.61)	14.80 (3.91)	2.80 (1.82)	3.57 (2.02)	11.00 (3.39)	17.37 (4.23)
T_3: Flucetosulfuron10WG @ 25g *a.i.* ha^{-1}	0.63 (1.06)	0.83 (1.15)	1.83 (1.53)	3.30 (1.95)	1.43 (1.39)	2.33 (1.68)	4.10 (2.14)	7.87 (2.89)
T_4: Flucetosulfuron10 WG @ 30g *a.i.* ha^{-1}	0.53 (1.01)	0.73 (1.11)	1.30 (1.34)	2.57 (1.75)	1.53 (1.42)	1.73 (1.49)	1.20 (1.30)	4.47 (2.23)
T_5: Hand weeding	3.53 (2.01)	3.17 (1.92)	6.20 (2.59)	12.90 (3.66)	1.00 (1.22)	3.90 (2.10)	7.97 (2.91)	12.87 (3.66)
T_6: Bispyribac sodium 10SC @ 20g *a.i.* ha^{-1}	3.13 (1.91)	2.73 (1.80)	3.60 (2.02)	9.47 (3.16)	1.60 (1.45)	2.53 (1.74)	6.70 (2.68)	10.83 (3.37)
T_7: Azimsulfuron 50DF @ 35g *a.i.* ha^{-1}	3.97 (2.11)	3.40 (1.97)	5.07 (2.36)	12.43 (3.60)	1.77 (1.51)	2.97 (1.86)	7.27 (2.79)	12.00 (3.53)
T_8 Control	12.80 (3.65)	19.23 (4.44)	25.03 (5.05)	57.07 (7.59)	7.83 (2.89)	16.83 (4.16)	23.83 (4.93)	48.50 (7.00)
SEm (±)	**0.14**	**0.11**	**0.17**	**0.13**	**0.06**	**0.10**	**0.09**	**0.22**
LSD(0.05)	**0.42**	**0.33**	**0.53**	**0.40**	**0.19**	**0.30**	**0.28**	**0.67**

Note: Values in the parenthesis indicate the square root transformed values ("x+1)

Table 2: Efficacy of flucetosulfuron10 WG on total number of weeds and weed dry weight at 60 days after application during *kharif*, 2013-14

Treatments	Weed dry weight (g m^{-2}) at 60 DAT							
	First season				Second season			
	Grasses	Sedges	BLW	Total weeds	Grasses	Sedges	BLW	Total weeds
T_1:Flucetosulfuron 10WG @ 15g *a.i.* ha^{-1}	36.60	30.93	39.67	107.20	24.00	41.47	69.50	134.97
T_2: Flucetosulfuron10WG @ 20g *a.i.* ha^{-1}	29.20	14.53	31.50	75.23	16.80	14.27	55.00	86.07
T_3: Flucetosulfuron10WG @ 25g *a.i.* ha^{-1}	3.80	3.33	9.17	16.30	8.60	9.33	20.50	38.43
T_4: Flucetosulfuron10 WG @ 30g *a.i.* ha^{-1}	3.20	2.93	6.50	12.63	9.20	6.93	6.00	22.13
T_5: Hand weeding	21.20	12.67	31.00	64.87	6.00	15.60	39.83	61.43
T_6: Bispyribac sodium 10SC @ 20g *a.i.* ha^{-1}	18.80	10.93	18.00	47.73	9.60	10.13	33.50	53.23
T_7: Azimsulfuron 50DF @ 35g *a.i.* ha^{-1}	23.80	13.60	25.33	62.73	10.60	11.87	36.33	58.80
T_8 Control	76.80	76.93	125.17	278.90	47.00	67.33	119.17	233.50
SEm (±)	**0.36**	**0.24**	**0.42**	**0.27**	**0.16**	**0.23**	**0.21**	**0.48**
LSD(0.05)	**1.10**	**0.73**	**1.26**	**0.83**	**0.50**	**0.64**	**0.64**	**1.45**

Table 3: Efficacy of flucetosulfuron10WG on plant height, number of panicles, grain yield and weed index in direct seeded rice during *kharif*, 2013 -14

Treatments	Plant height (cm)		Number of panicle m^{-2}		Grain yield(kg ha^{-1})		Weed index (%)	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
T_1:Flucetosulfuron 10WG @ 15g *a.i.* ha^{-1}	95.57	96.93	163.33	176.67	8166.67	7873.33	17.21	10.06
T_2: Flucetosulfuron10WG @ 20g *a.i.* ha^{-1}	96.17	96.77	174.67	179.33	8733.33	8006.67	11.46	8.55
T_3: Flucetosulfuron10WG @ 25g *a.i.* ha^{-1}	95.13	96.43	186.00	196.33	9300.00	8306.67	5.74	5.11
T_4: Flucetosulfuron10 WG @ 30g *a.i.* ha^{-1}	95.17	100.37	193.67	198.67	9683.33	8376.67	1.87	4.31
T_5: Hand weeding	96.03	103.77	197.33	201.33	9866.67	8755.00	0.00	0.00
T_6: Bispyribac sodium 10SC @ 20g *a.i.* ha^{-1}	94.97	96.33	183.00	183.67	9150.00	8243.33	7.25	5.83
T_7: Azimsulfuron 50DF @ 35g *a.i.* ha^{-1}	95.37	96.90	179.33	181.33	8966.67	8434.33	9.12	3.67
T_8Control	98.27	101.50	157.67	147.67	7883.33	7283.33	20.12	16.79
SEm (±)	**0.03**	**0.07**	**0.16**	**0.23**	**1.17**	**0.48**	**0.31**	**0.20**
LSD(0.05)	**0.10**	**0.22**	**0.49**	**0.69**	**3.52**	**1.45**	**0.95**	**0.62**

Table 4: Phytotoxicity ratings recorded at different days after spraying of herbicides on direct seeded rice and green gram crop as influenced by weed control treatments

Treatments	*Kharif* (2013-2014)					*Rabi* (2013-14 and 2014-2015)			
	Days after herbicide application					Days after sowing			
	1	3	5	7	10	30	10	20	30
T_1:Flucetosulfuron 10WG @ 15g *a.i.* ha^{-1}	0	0	0	0	0	0	0	0	0
T_2: Flucetosulfuron 10WG @ 20g *a.i.* ha^{-1}	0	0	0	0	0	0	0	0	0
T_3: Flucetosulfuron 10WG @ 25g *a.i.* ha^{-1}	0	0	0	0	0	0	0	0	0
T_4: Flucetosulfuron 10 WG @ 30g *a.i.* ha^{-1}	0	0	0	0	0	0	0	0	0
T_5: Hand weeding	0	0	0	0	0	0	0	0	0
T_6: Bispyribac sodium 10SC @ 20g *a.i.* ha^{-1}	0	0	0	0	0	0	0	0	0
T_7: Azimsulfuron 50DF @ 35g *a.i.* ha^{-1}	0	0	0	0	0	0	0	0	0
T_8Control	0	0	0	0	0	0	0	0	0

Table 5: Effect of herbicidal treatments on germination, plant stand, plant height and yield of the succeeding green gram crop

Treatments	Germination (%)		Plat population at 30 DAS		Plant height at 60 DAS (cm)		Yield at harvest (kg ha^{-1})	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
T_1	89.30	88.30 (30.99)	959.90 (30.68)	940.70	55.85	53.96	885.67	883.64
T_2	91.30	89.20 (31.03)	962.60 (30.72)	943.35	56.68	54.13	892.39	890.40
T_3	91.01	89.01 (31.11)	967.06 (30.79)	947.72	55.30	55.18	911.35	895.86
T_4	91.23	88.70 (30.99)	960.06 (30.68)	940.86	55.64	54.89	968.27	889.27
T_5	88.00	89.60 (31.10)	966.64 (30.79)	947.31	56.96	55.31	844.63	899.63
T_6	91.33	88.13 (31.02)	962.00 (30.71)	942.76	56.89	55.46	845.36	887.66
T_7	90.80	89.23 (30.92)	955.32 (30.61)	936.21	55.68	53.94	784.56	874.56
T_8	92.80	91.30 (31.32)	980.23 (30.95)	957.35	57.23	56.35	974.23	910.25
SEm (±)	**1.84**	**1.64**	**1.25**	**1.21**	**0.31**	**0.31**	**0.56**	**0.37**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Note: Values in the parenthesis indicate the square root transformed values ("x+1)

The dry weight of total weed population was recorded at 60 DAA (Table 2). Among treatments, flucetosulfuron 10WG @ 30 g *a.i.*ha^{-1}and @ 25 g *a.i.*ha^{-1} recorded minimum dry weight of total weeds *i.e.*,12.63 and 16.30 gm^{-2}, respectively during first season and 22.13 and 38.43 gm^{-2}, respectively during second season and are significantly on par with each other and superior over standard check herbicides.

At harvest, maximum grain yields were observed in flucetosulfuron10WG @ 30 g *a.i.*ha^{-1} (9683.33 and 8376.67 kg ha^{-1}) during first and second season, respectively and flucetosulfuron10WG @ 25g *a.i.*ha^{-1} treated plots recorded grain yields of (9300.00 and 8306.67 kg ha^{-1}) during first and second season, respectively and they were significantly on par with each other. This was followed by bispyribac sodium 10SC @ 20 g a.i.ha^{-1} with (9150 and 8243.33 kg ha^{-1}) during the first and second season, respectively and Flucetosulfuron10% WG @ 20g *a.i.*ha^{-1} recorded 8733.33, 8006.67 kg ha^{-1} yield during the first and second season, respectively. New herbicide flucetosulfuron 10WG @ 25g *a.i.*ha^{-1} was superior to standard treated check bispyribac sodium 10SC @ 20g *a.i.*ha^{-1} and azimsulfuron 50DF @ 35g *a.i.* ha^{-1} in achieving grain yield (Table 3).

Observation on plant height, weed index and a total number of panicles m^{-2} was also recorded and represented in the table 3 which also indicates the superiority of flucetosulfuron@ 25-30 g *a.i.*ha^{-1} doses during both the seasons.

Phytotoxicity study of new herbicide, flucetosulfuron 10 % WG at all the doses tested *i.e.*, 15, 20, 25 and 30 g *a.i.* ha^{-1} did not cause any phytotoxic symptoms such as no epinasty or hyponasty, necrosis, wilting and vein clearing at 1, 3, 5, 7 and 10 days after application of herbicides to direct seeded rice during *kharif* and in succeeding crop green gram during *rabi* at 10, 20 and 30 days after sowing (DAS) did not cause any adverse effect on germination percentage, plant population, plant height and yield of the succeeding crop, *i.e.*, green gram (Table 4, 5).

Based on two seasons' study on bio-efficacy and phytotoxicity of flucetosulfuron 10WG during *kharif* 2013 and 2014 on direct seeded rice and their residual effect on succeeding crop greengram during *rabi*, flucetosulfuron 10WG @ 25g *a.i.* ha^{-1} gave consistently good control of all category of weeds. Flucetosulfuron acts as enzyme acetolactate synthase (ALS) inhibitor, which is essential for the synthesis of branched-chain amino acids valine, leucine, and isoleucine. Inhibition of amino acid production subsequently inhibits cell division and causes death of susceptible plants (Kim *et al*., 2006; Pal *et al*., 2009; Singh *et al*., 2010 and Vijay, 2016). Flucetosulfuron10 % WG can be recommended

safely @ 25 g *a.i.* ha^{-1} against weed complex in direct seeded rice. This herbicidal treatment achieved maximum grain yield and did not show any phytotoxicity on both rice and green gram during the study period.

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