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Influence of herbicides on weed flora, yield and economics of direct-seeded rice (*Oryza sativa* L.)

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ABSTRACT

Effect of herbicides were evaluated on weed flora composition, grain and straw yield and economics of direct seeded rice during kharif 2017 and 2018. Based on the summed dominance ratio (SDR), grassy weed species Echinochloa colona (SDR of 39 in 2017 and 55 in 2018) was the most dominant species. Among the herbicide treatments, the application of bispyribac sodium 2% + 2, 4-D sodium salt 54.3% SP with adjuvant (30.0 + 814.5 g ha^{-1}) recorded the highest grain and straw yield, weed management index, highest net monetary return and B:C ratio and lowest total weed dry weight and weed index. In addition to this it recorded higher net monetary return by 76.86% and 98.16% as compared to the sole application of bispyribac sodium 10% SC @ 20 g a.i. ha^{-1} and 2, 4- D EE @ 850 g a.i. ha^{-1}, respectively.

Keywords: Direct-seeded rice, post–emergence herbicides and summed dominance ratio

Rice (*Oryza sativa* L.) is the most important and extensively grown crop in tropical and subtropical regions of the world as it is the staple food for more than 60% of the world population. India has the largest area among rice growing countries and stands second in production next to China, where it is grown in an area of 43.7 M ha annually with a production and productivity of 168 MT and 3.8 t ha^{-1}, respectively (Anon., 2017). The worldwide estimated loss in rice yield from weeds is around 10% of the total production (Oerke and Dehne, 2004) however in absence of proper weed control, rice yields are reduced by 35-100 percent in direct seeded rice (Kumar *et al.,*2008). The weeds reduce yield up to 30.2% (Singh *et al.*, 2012) and 17-24% if allowed to compete till 4 weeks after seeding (Chauhan and Johnson, 2011). In rice farming, herbicide-based weed management has become the smartest and most viable option (Anwar *et al.,* 2012). Though herbicides are effective and economical, the continuous use of same herbicide or herbicides with a similar mode of action will lead to the development of herbicide resistance and the shift in weed flora (Raj and Syriac, 2016). Use of herbicide mixtures or new herbicide with different mode of action is one of the ways to overcome the problem of herbicide resistance and the shift in weed flora (Fischer *et al.*, 2004; Damalas *et al.*, 2005). It also reduces the usage rate, herbicide injury to crops and broadens the spectrum of weed control in a single application and reduces the cost of application (Afrin *et al.*, 2015).

MATERIALS AND METHODS

A field experiment was conducted during *kharif* 2017 and 2018 to study the bio-efficiency of herbicides against weed flora and their effect on yield and economics of direct seeded rice under upland condition. The field study was conducted at the Instructional cum Research Farm, I.G.K.V, Raipur, Chhattisgarh. The soil was low in available nitrogen, medium in available phosphorous and potassium.The experiment was laid out in a randomized block design, replicated thrice, comprising eleven treatments *viz.* bispyribac sodium 2% (BS) + 2,4-D sodium salt 54.3% SP (DSS) (20.0 + 543.0 g ha^{-1}) (T_1), BS+ 2, 4- DSS (25.0 + 678.75 g ha^{-1}) (T_2), BS+ 2, 4- DSS (30.0 + 814.5 g ha^{-1})(T_3), BS+ 2, 4- DSS with adjuvant (WA) (20.0 + 543.0 g ha^{-1})(T_4), BS+ 2, 4- DSS (WA) (25.0 + 678.75 g ha^{-1})(T_5), BS+ 2, 4- DSS (WA) (30.0 + 814.5 g ha^{-1})(T_6), bispyribac sodium 10% SC @ 20 g *a.i.* ha^{-1}(T_7), 2, 4- D Ethyl ester 38 % EC (34% W/W) (EE) (850 g ha^{-1})(T_8), penoxsulam 21.7% SC (22.5 g ha^{-1})(T_9), weed free (20 & 40 DAS)(T_{10}) and weedy check (T_{11}) during both years. Rice variety 'Indira Rajeshwari (IGKV R 1)' was line sown on levelled field on 20th and 30th June of 2017 and 2018 respectively, with a seed rate of 80 kg ha^{-1}and applied with fertilizer level of 100:60:40 N:P_2O_5:K_2O kg ha^{-1}were during both years. Full dose of P and K were applied as basal, while N was applied half as basal and remaining half in two equal splits at tillering and panicle initiation stages of rice. The gross and net plot sizes were 5.0 m x 4.0 m and 4.2 m x 3.4 m, respectively. The herbicides were applied using spray volume of 500 L ha^{-1} knapsack

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sprayer having flood jet nozzle at 18 days after sowing (DAS). Total and species-wise weed dry weight were measured at 30 and 60 DAS by placinga quadrate of 0.50 m × 0.50 m randomly at 5 places in each plot. These were subjected to square-root transformation before analysis (Ramesha *et al.*, 2017). At harvest, the data on rice grain yield and straw yield were collected. In addition, the economics of weed management practices were also calculated based on the prevalent market prices of the inputs used. The data collected on different traits were statistically analysed using the standard procedure and the results were tested at 5% level of significance as given by Gomez and Gomez (1984).

The summed dominance ratio (SDR) was calculated by the given formula as suggested by Hia *et al.* (2017).

$$SDR = \frac{\text{Relative density}\left(RD\right) + \text{Relative dry weight}(RWD)}{2} \times 100$$

$$RD = \frac{\text{Density of a given weed species}}{\text{Density of all weed species}} \times 100$$

$$RWD = \frac{\text{Dry weight of a given weed species}}{\text{Dry weight of all weed species}} \times 100$$

The Weed Management index (WMI) was calculated by the given formula as suggested by Sarma (2016).

$$WMI = \frac{\frac{Y_t - Y_c}{Y_c}}{\frac{W_c - W_t}{W_c}}$$

Where, Yt = Yield of treated plot
Yc = Yield of control plot
Wt = Weed dry weight in treated plot
Wc = Weed dry weight in control plot

RESULTS AND DISCUSSION

Weed flora

Major weed flora observed in the experimental plots were *Echinochloa colona*, *Ischaemum rugosum*, *Digitaria sanguinalis* L. (Scop.), *Dactyloc-tenium aegyptium*, *Cynodon dactylon* (among grasses), *Cyperus iria*(sedge); whereas among broad-leaf weeds, *Alternanthera sessilis*, *Physalis minima*, *Phyllanthus-niruri*, *Cyanotis axillaris*, *Eclipta alba* and *Cassia tora* were present during both years (Table 1). The results revealed that twelve weed species belonging to eight families were observed in the experimental plots. Similar weed flora were also reported by Datta *et al.* (2017). Among the weed species, the infestation of *Echinochlo acolona*, *Ischaemumrugosum*, *Cyperusiria*, *Alternanther asessilis* and *Eclipta alba* were more than other weed species indicating their dominance and competitiveness with the direct-seeded rice during both years.

Based on the summed dominance ratio (SDR) values, grass weed species *Echinochloa colona* (SDR of 39 in 2017 and 55 in 2018) was the most dominant species in the weedy check plot (T_{11}) followed by the broadleaf weed *Alternanthera sessilis* (SDR of 15 and 7) (Fig. 1). On the other hand, the least dominant weed specie was broad leaf weed species *Physalis minima* (SDR of 2 and 3) during both years. The dominance of *Echinochloa* species in direct-seeded rice was also reported by Islam *et al.* (2018) and Yadav *et al.* (2018).

Weed dry weight

The data pertaining to the dry weight of weeds, species wise and total are presented in the Table 2 and 3, respectively. At 30 DAS the lowest dry weight of grassy weeds (*Cynodon dactylon, Echinochloa colona*) were recorded in weed free (20 & 40 DAS) (T_{10}) treatment and highest in weedy check (T_{11}) treatment, the same scenario was also observed in case of broad leaves and total weed dry weight. Among the herbicide treatments, the application of BS+ 2, 4- DSS (WA) (30.0 + 814.5 g ha^{-1}) (T_6) and BS+ 2, 4- DSS (WA) (25.0 + 678.75 g ha^{-1}) (T_5) were at par with weed free (20 & 40 DAS) (T_{10}) treatment in terms of dry weight of *Alternanthera sessilis*, *Ischaemum rugosum, Cyperu siria, Eclipta alba* and *Echinochloa colona* at 30 DAS. However among the herbicide treatments, 2, 4- D EE (850 g ha^{-1}) (T_8) recorded a significantly higher dry weight of grassy weeds. This was because 2,4-D is a selective herbicide and was recommended for controlling broadleaf weeds and sedges in rice (Anitha and Mathew, 2010; Sarkar *et al.,* 2017). The percentage reduction in total weed dry weight in BS+ 2, 4- DSS (WA) (30.0 + 814.5 g ha^{-1}) (T_6) as compared to weedy check (T_{11}) treatment was 97.44%, however as compared to the sole application of bispyribac sodium 10% SC @ 20 g *a.i.* ha^{-1} (T_7) was 89.65% and 2, 4- D EE @ 850 g *a.i.* ha^{-1} (T_8) was 93.54% at 30 DAS. Similar pattern

Table 1: Weeds flora observed in the experiment field during the crop period

No.	Scientific name	Common name	Local name	Family	Growth habit *
A. Grasses					
1	*Echinochloa colona* (L.) Link	Jungle rice	Sawa	Poaceae	A M Rs
2	*Ischaemum rugosumSalisb.*	Wrinkle duck-beak	Badauri	Poaceae	A M Rs
3	*Digitaria sanguinalis* L.*(*Scop.*)*	Large crabgrass	GhudDoob	Poaceae	A M RsRv
4	*Dactyloctenium aegyptium* (L.) Willd	Crowfoot grass	Makadaghass	Poaceae	A M Rs
5	*Cynodon dactylon* (L.) Pers.	Bermuda grass	Dhoobi	Poaceae	P M RsRv
B. Sedges					
1	*Cyperusiria L.*	Rice field flat sedge	Motha	Cyperaceae	A M Rs
C. Broad-leave weed (BLW)					
1	*Alternanthera sessilis*(L.) DC.	Sessile joyweed	Resham kata	Amaranthaceae	P D Rs
2	*Eclipta alba*	Country mallow	Bhrangraj	Malvaceae	A D Rs
3	*Phyllanthus niruri* L.	Stonebreaker/ Gripeweed	Hajardana	Euphorbiaceae	A D Rs
4	*Physallis minima* L.	Sunberry/ Hogweed	Chirpoti	Solanaceae	A D Rs
5	*Cassia tora* (L.) Roxb.	Sickle pod	Charota	Fabaceae	A D Rs
6	*Cyanotis axillaris* Roem. &Schult. F.	Spreading dayflower	Badhanula/ Pondi	Commelinaceae	A D RsRv

Asterisk (*) details as:

A: Annual	M: Monocot	Rs: Reproducing by seeds
P: Perennial	D: Dicot	Rv: Reproducing by vegetative means

was also observed at 60 DAS where the weed free (20 & 40 DAS) (T_{10}) and weedy check (T_{11}) treatment recorded a lowest and highest weed dry weight, respectively.

It was noticed that there is significant variation in the dry weight of grassy and broad leaf weeds during both years (Fig. 2). The grassy weeds were more prominent in 2018 as compared to 2017, whereas the broad leaf weeds recorded higher dry weight in 2017 as compared to 2018.The total weed dry weight of grassy weeds were 80% and 79% higher in 2018 as compare to 2017 at 30 and 60 DAS, respectively, in weedy check (T_{11}) treatment. On the other hand in 2017, we witnessed higher infestation of broad leaf weeds, to an amount of 44% and 77% as compared to 2018 at 30 and 60 DAS, respectively.

Weed index (WI) and weed management index (WMI)

Among the weed management treatments, higher weed index of 50.09% was recorded in weedy check (T_{11}) treatment, which might be due to greater competition stress with prolific weed growth (Table 4). Among the herbicide treatments, the lowest WI of 1.73% was observed in the application of BS+ 2, 4-DSS (WA) @ (30.0 + 814.5) g *a.i.* ha^{-1}(T_6), which was at par with the BS+ 2, 4- DSS (WA) @ (25.0 + 678.75) g *a.i.* ha^{-1}(T_5), BS+ 2,4- DSS @ (30.0 + 814.5) g *a.i.* ha^{-1}(T_3) and BS+ 2,4-DSS (WA) @ (20.0 + 543.0) g *a.i.* ha^{-1}(T_4) treatment. Fischer *et al.* (2004) and Damalas *et al.* (2005) observed that the use of single herbicide seldom furnishes satisfactory and season long weed control due to narrow spectrum of activity, while the herbicide mixture containing different herbicides with different target site action broadens the spectrum of weed control in single application. This might be the reason of obtaining lower weed index in case of mixture herbicide than their alone application. Among the herbicide treatments, highest weed management index (1.04% in 2017 and 1.06% in 2018) was observed in the BS+ 2, 4-DSS (WA) @ (30.0 + 814.5) g *a.i.* ha^{-1} (T_6) and the application of penoxsulam 21.7% SC @ 22.5 g *a.i.* ha^{-1} (T_9) witnessed the lowest value (Fig. 3). In 2018 higher value of weed management index was observed as compared to 2017 except in treatments BS+ 2, 4-DSS (25.0 + 678.75 g ha^{-1}) (T_2), bispyribac sodium 10% SC @ 20 g *a.i.* ha^{-1} (T_7) and weed free (20 & 40 DAS) (T_{10}) treatment.

Yield and economics

The data pertaining to grain and straw yield (t ha^{-1}) and percentage increase in grain yield over control of rice were presented in Table 4. The weed free (20 & 40 DAS)(T_{10}) treatment recorded significantly higher grain (5.83 t ha^{-1}) and straw yield (7.15 t ha^{-1}). It was found at par with the application of BS+ 2, 4- DSS (WA) (30.0 + 814.5 g ha^{-1}) (T_6), BS+ 2, 4- DSS (WA) (25.0 + 678.75 g ha^{-1}) (T_5), BS+ 2, 4- DSS (30.0 + 814.5 g ha^{-1}) (T_3) and BS+ 2, 4- DSS (WA) (20.0 + 543.0 g ha^{-1}) (T_4). The lowest grain (2.87 t ha^{-1}) and straw yield (3.83 t ha^{-1}) was observed in weedy check (T_{11}) treatment. The

Table 2: Weed dry weight (g m^{-2}) as influenced by different herbicide treatment in direct seeded rice at 30 DAS (pooled data of two years)

Treatment		Dosage	Dry weight (g m^{-2})						
		(*a.i.* g ha^{-1})	AS	IR	CI	EA	EC	Others	Total
T_1	BS+ 2,4- DSS	20.0 + 543.0	**1.52** (1.30)	**1.13** (0.28)	**1.10** (0.22)	**1.35** (0.82)	**1.91** (2.66)	**1.35** (0.81)	**2.66** (6.10)
T_2	BS+ 2,4- DSS	25.0 + 678.75	**1.49** (1.22)	**1.03** (0.05)	**1.07** (0.14)	**1.29** (0.67)	**1.80** (2.25)	**1.27** (0.60)	**2.43** (4.93)
T_3	BS+ 2,4- DSS	30.0 + 814.5	**1.30** (0.69)	**1.01** (0.01)	**1.00** (0.00)	**1.26** (0.58)	**1.59** (1.53)	**1.22** (0.48)	**2.07** (3.30)
T_4	BS+ 2,4- DSS (WA)	20.0 + 543.0	**1.35** (0.83)	**1.00** (0.01)	**1.00** (0.00)	**1.29** (0.67)	**1.60** (1.57)	**1.24** (0.53)	**2.15** (3.61)
T_5	BS+ 2,4- DSS (WA)	25.0 + 678.75	**1.10** (0.21)	**1.00** (0.00)	**1.00** (0.00)	**1.07** (0.14)	**1.26** (0.58)	**1.16** (0.35)	**1.51** (1.27)
T_6	BS+ 2,4- DSS (WA)	30.0 + 814.5	**1.07** (0.14)	**1.00** (0.00)	**1.00** (0.00)	**1.03** (0.07)	**1.16** (0.35)	**1.07** (0.15)	**1.31** (0.71)
T_7	Bispyribac sodium 10% SC	20	**1.57** (1.48)	**1.09** (0.19)	**1.13** (0.27)	**1.41** (1.00)	**1.99** (2.98)	**1.39** (0.94)	**2.80** (6.86)
T_8	2,4- D Ethyl ester 38 % EC (34% W/W)	850	**1.82** (2.30)	**1.36** (0.85)	**1.15** (0.33)	**1.54** (1.38)	**2.38** (4.66)	**1.57** (1.47)	**3.46** (11.00)
T_9	Penoxsulam 21.7% SC	22.5	**1.65** (1.72)	**1.07** (0.14)	**1.15** (0.31)	**1.48** (1.18)	**2.02** (3.09)	**1.48** (1.18)	**2.94** (7.63)
T_{10}	Weed free (20 & 40 DAS)	-	**1.00** (0.00)	**1.00** (0.00)	**1.00** (0.00)	**1.00** (0.00)	**1.00** (0.00)	**1.00** (0.00)	**1.00** (0.00)
T_{11}	Weedy check	-	**2.84** (7.06)	**1.82** (2.32)	**1.84** (2.38)	**2.28** (4.20)	**3.00** (7.98)	**2.20** (3.83)	**5.36** (27.76)
SEm±	**0.09**	**0.10**	**0.09**	**0.05**	**0.13**	**0.03**	**0.11**		
LSD (P=0.05)		**0.26**	**0.29**	**0.27**	**0.15**	**0.37**	**0.08**	**0.33**	

DAS: Days after sowing; Figures in parentheses are original values, data were transformed to values "x+1
AS=*Alternantherasessilis*,**IR**= *Ischaemumrugosum*, **CI**= *Cyperusiria*, **EA**= *Ecliptaalba*, **EC**= *Echinochloacolona*
BS+ 2,4- DSS= bispyribac sodium 2% + 2,4- D sodium salt 54.3% SP; WA=with adjuvant

Table 3: Weed dry weight (g m^{-2}) as influenced by different herbicide treatment in direct seeded rice at 60 DAS (pooled data of two years)

Treatment		Dosage	Dry weight (g m-2)						
		(*a.i.* g ha^{-1})	AS	IR	CI	EA	EC	Others	Total
T_1	BS+ 2,4- DSS	20.0 + 543.0	**1.66** (1.76)	**1.44** (1.07)	**1.28** (0.64)	**1.59** (1.51)	**2.29** (4.26)	**1.47** (1.15)	**3.36** (10.32)
T_2	BS+ 2,4- DSS	25.0 + 678.75	**1.63** (1.65)	**1.39** (0.94)	**1.26** (0.60)	**1.52** (1.32)	**2.29** (4.25)	**1.39** (0.93)	**3.28** (9.75)
T_3	BS+ 2,4- DSS	30.0 + 814.5	**1.44** (1.07)	**1.15** (0.31)	**1.15** (0.33)	**1.35** (0.82)	**2.10** (3.40)	**1.33** (0.76)	**2.81** (6.91)
T_4	BS+ 2,4- DSS (WA)	20.0 + 543.0	**1.46** (1.14)	**1.14** (0.29)	**1.20** (0.43)	**1.39** (0.93)	**2.16** (3.69)	**1.37** (0.87)	**2.91** (7.49)
T_5	BS+ 2,4- DSS (WA)	25.0 + 678.75	**1.30** (0.69)	**1.12** (0.27)	**1.10** (0.22)	**1.26** (0.58)	**1.72** (1.95)	**1.30** (0.69)	**2.32** (4.39)
T_6	BS+ 2,4- DSS (WA)	30.0 + 814.5	**1.24** (0.54)	**1.11** (0.22)	**1.09** (0.19)	**1.22** (0.48)	**1.61** (1.58)	**1.19** (0.41)	**2.11** (3.47)
T_7	Bispyribac sodium 10% SC	20	**1.70** (1.88)	**1.47** (1.15)	**1.33** (0.78)	**1.62** (1.61)	**2.33** (4.45)	**1.65** (1.73)	**3.53** (11.46)
T_8	2,4- D Ethyl ester 38 % EC (34% W/W)	850	**1.97** (2.88)	**1.71** (1.91)	**1.49** (1.23)	**1.73** (2.00)	**2.69** (6.23)	**1.82** (2.30)	**4.19** (16.55)
T_9	Penoxsulam 21.7% SC	22.5	**1.84** (2.37)	**1.52** (1.32)	**1.38** (0.90)	**1.60** (1.56)	**2.37** (4.61)	**1.70** (1.88)	**3.66** (12.37)
T_{10}	Weed free (20 & 40 DAS)	-	**1.03** (0.06)	**1.00** (0.00)	**1.00** (0.00)	**1.02** (0.03)	**1.12** (0.25)	**1.07** (0.15)	**1.22** (0.49)
T_{11}	Weedy check	-	**3.11** (8.66)	**2.59** (5.73)	**2.24** (4.04)	**2.76** (6.61)	**3.75** (13.06)	**2.94** (7.62)	**6.84** (45.73)
SEm±		**0.09**	**0.09**	**0.11**	**0.13**	**0.20**	**0.06**	**0.17**	
LSD (P=0.05)		**0.26**	**0.27**	**0.31**	**0.38**	**0.60**	**0.18**	**0.49**	

DAS: Days after sowing; Figures in parentheses are original values, data were transformed to values "x+1

AS=*Alternantherasessilis*,**IR**= *Ischaemumrugosumn*, **CI** = *Cyperusiria*, **EA**= *Ecliptaalba*, **EC**= *Echinochloacolona*

BS+ 2,4- DSS= bispyribac sodium 2% + 2,4- D sodium salt 54.3% SP; WA=with adjuvant

Table 4: Grain yield, weed index and economics of direct seeded rice as influenced by different herbicide treatment (pooled data of two years)

Treatment		Dosage (*a.i.* g ha^{-1})	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	NMR (x 10^{3}Rs ha^{-1})	B:C ratio	Weed Index (%)	Percentage increase in grain yield over control
T_1	BS+ 2,4- DSS	20.0 + 543.0	4.34	5.41	48.24	1.73	25.06	51.32
T_2	BS+ 2,4- DSS	25.0 + 678.75	4.71	5.85	53.92	1.91	19.10	64.15
T_3	BS+ 2,4- DSS	30.0 + 814.5	5.16	6.36	62.00	2.17	11.47	79.79
T_4	BS+ 2,4- DSS (WA)	20.0 + 543.0	5.05	6.25	59.70	2.09	13.21	76.23
T_5	BS+ 2,4- DSS (WA)	25.0 + 678.75	5.35	6.60	64.73	2.24	8.12	86.63
T_6	BS+ 2,4- DSS (WA)	30.0 + 814.5	5.73	7.05	71.10	2.43	1.73	99.82
T_7	Bispyribac sodium 10% SC	20	3.90	4.94	40.20	1.47	32.49	36.11
T_8	2,4- D Ethyl ester 38 % EC (34% W/W)	850	3.55	4.68	35.88	1.33	38.35	23.80
T_9	Penoxsulam 21.7% SC	22.5	3.62	4.70	35.51	1.24	37.24	26.12
T_{10}	Weed free (20 & 40 DAS)	-	5.83	7.15	64.90	1.76	-	103.30
T_{11}	Weedy check	-	2.87	3.83	37.17	0.93	50.09	-
SEm±			**0.28**	**0.31**			**4.20**	
LSD (P=0.05)			**0.82**	**0.91**			**12.42**	

*NMR= Net Monetary Return; MSP of rice in 2017=[1] 1550.00 and in 2018=[1] 1750.00

BS+ 2,4- DSS= bispyribac sodium 2% + 2,4- D sodium salt 54.3% SP; WA=with adjuvant

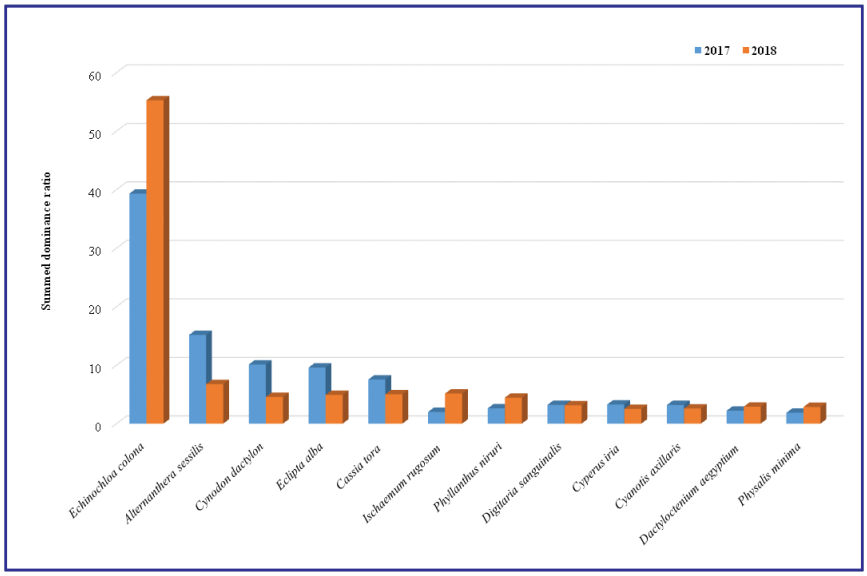

Fig. 1: Summed dominance ratio (SDR) of weeds found in weedy check plot

weedy check (T_{11}) treatment registered 50.77% reduction in grain yield compared to weed free (20 & 40 DAS) (T_{10}) treatment owing to sever competition offered by uncontrolled weeds for nutrients, soil moisture, space and light. The higher percentage increase in grain yield over control was found under the weed free (20 & 40 DAS) (T_{10}) treatment. Among the herbicide treatment, the highest percentage increase in grain yield over control was computed under the application of BS + 2, 4- DSS (WA) (30.0 + 814.5 g ha^{-1}) (T_6) followed by BS+ 2, 4- DSS (WA) (25.0 + 678.75 g ha^{-1}) (T_5), BS+ 2, 4- DSS (30.0 + 814.5 g ha^{-1})

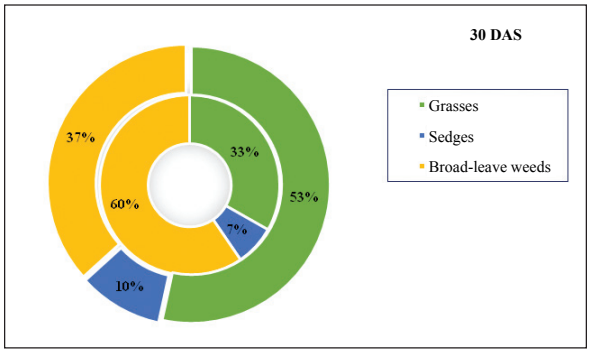

Fig. 2(a): Weed composition in the weedy check treatment at 30 DAS

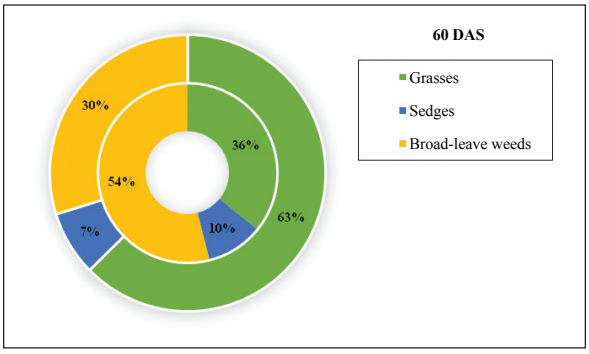

Fig. 2(b): Weed composition in the weedy check treatment at 60 DAS

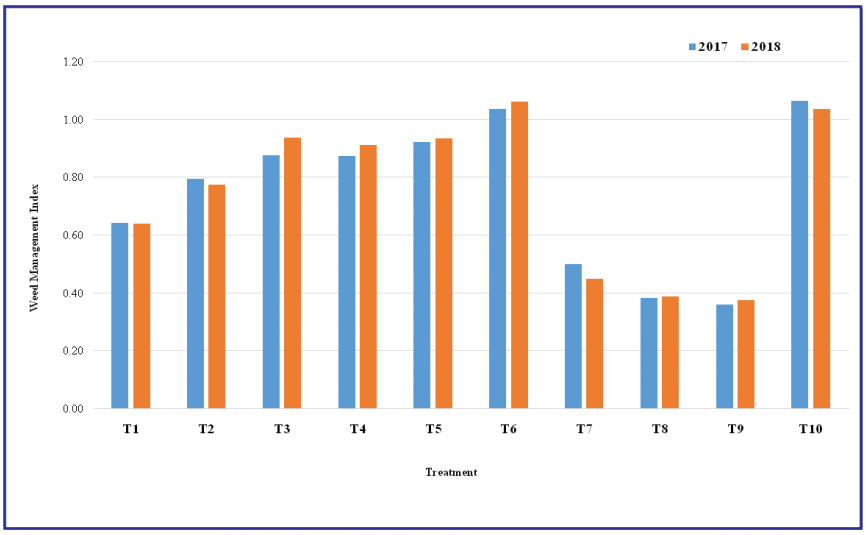

Fig. 3: Weed management index (WMI) as influenced by different herbicides in direct-seeded rice

(T_3) and BS+ 2, 4- DSS (WA) (20.0 + 543.0 g ha^{-1}) (T_4) treatment.

Higher crop grain production with lesser cost of cultivation could result in better economic parameters like higher net returns and benefit cost ratio.The highest net monetary returns (` 71103.38) and B:C ratio (2.43) were recorded in the BS+ 2, 4- DSS (WA) @ (30.0 + 814.5) g *a.i.* $ha^{-1}$($T_6$) treatment (Table 4). This gives a profit margin of 190% over the weedy check ($T_{11}$) treatment, which noticed the lowest net monetary returns (` 24457.48) and B : C ratio (0.93). The highest B:C ratio under the application of BS+ 2, 4- DSS (WA) (30.0 + 814.5 g ha^{-1}) (T_6) was due to the fact that there was relatively higher netmonetary return associated with lower cost of cultivation.

From this investigation, it may be inferred that the application of BS+ 2,4-DSS (WA) (30.0 + 814.5 g/ha) may be suggested for managing weeds in DSR as it controlled the weeds significantly throughout the crop growth period and recorded higher gain yield, net monetary returns and B : C ratio.

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