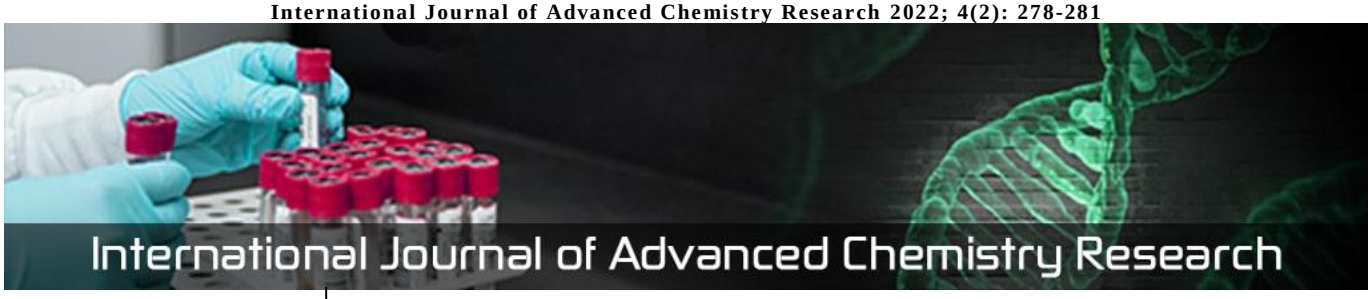

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Performance of power weeders and herbicides on growth, weed dynamics and profitability of direct seeded rice (*Oryza sativa* L.) under various planting geometry

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Abstract
A field experiment was conducted on Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *Kharif* 2021 to evaluate the "Performance of power weeders and herbicides on growth, weed dynamics and profitability of direct seeded rice under various planting geometry". Among all the treatments highest values of yield and yield attribute characters (*viz.* no. of effective tillers m^{-2}, number of grains $panicle^{-1}$, panicle length, panicle weight, test weight, grain yield and straw yield), lowest weed dry weight and highest weed control efficiency were found under weed free (T_{10}) treatment followed by of 20 cm row spacing+ single row motorized weeder at 20 and 40 DAS + bispyribac-sodium @ 25g *a.i.* ha^{-1} at 2-4 leaf stage (30 DAS).

Keywords: Single row motorized weeder, bispyribac-sodium, direct seeded rice, yield attribute and yield

Introduction
Rice (*Oryza sativa* L.) is one of the world's most significant cereal crops which play vital role in food security. The world's total rice area is 162.06 M ha and production is about 769.66 MT with the productivity of 4.6 t ha-1. India has the largest area among rice growing countries, where it is grown in an area of 43.79 M ha annually with a production of 168.50 MT. Chhattisgarh accounts for 3.76 M ha area with the production of 4.73 MT (Anonymous ,2018). In recent year, there have been issues with the timing of rice transplanting due to deficiency of irrigation water as well as monsoon rains that are unpredictable and expensive field labour costs. In many Asian nation, including India farmers have been shifted from transplanting to direct seeded rice (DSR).
Weeds are unwanted and undesirable plants which interfere and compete with main crop for utilization of land, nutrient, sunlight and water resources. Weeds are being controlled by various methods such as biasi operation, manual weeding, chemical weeding and mechanical weeding (Din *et al*., 2014) [2]. Early in the growing season, when the weeds are too little to pluck out, manual weeding is challenging to follow. Herbicides are replacing manual weeding as they are easy to use, however, there are concerns about the sole use of herbicides, such as development of resistance in weeds, shifts in weed populations, and concerns about the environment due to overuse of herbicides. Mechanical control is among the most important classical weed management methods. The development of advanced motorized rotary tillers/weeders with single and double row operating system with adjustment of row spacing has provided it an effective and economically viable weed control technique. Also, motorized rotary tillers/weeders will reduce the time and energy needed to execute the process. Development of power weeder is beneficial to reduce the time involved in weeding operation, reducing drudgery occurred due to continuous changing in posture. Hence, the present investigation was to study the performance of power weeders and herbicides on growth, weed dynamics and profitability of direct seeded rice under various planting geometry.

Material and method
The field experiment was conducted in the Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during Kharif 2021.

The meteorological data, recorded during experimental period showed that crop received 813 mm rainfall during the crop period. The maximum temperature during crop period varied from 28.9 °C in the last week of July to 33.6 °C in the third week of July, while minimum temperature varied from 13.3 °C in the first week of November to 26.3 °C in the second week of July. The soil of the experimental field was clayey in texture and neutral (pH 6.8) in reaction with medium fertility having 0.51% soil organic carbon, low nitrogen (211.5 kg ha^{-1}), medium phosphorous (11.3 kg ha^{-1}) and high potassium (331.7 kg ha^{-1}) content. The experiment was arranged in randomized block design with three replications. Twelve treatment were include to evaluate different weed management practices in DSR. Weed management treatments were 20 cm row spacing + single row motorized weeder at 20 and 40 DAS (T_1), 20 cm row spacing + double row motorized weeder at 20 and 40 DAS (T_2), 20 cm row spacing + single row motorized weeder + intra row hand weeding at 20 and 40 DAS (T_3), 20 cm row spacing + single row motorized weeder at 20 and 40 DAS + bispyribac-sodium @ 25g *a.i.* ha^{-1} at 2-4 leaf stage (30 DAS) (T_4), 22.5 cm row spacing + single row motorized weeder at 20 and 40 DAS (T_5), 22.5 cm row spacing + double row motorized weeder at 20 and 40 DAS (T_6), 25 cm row spacing + single row motorized weeder at 20 and 40 DAS (T_7), 25 cm row spacing + double row motorized weeder at 20 and 40 DAS (T_8), Pretilachlor 50 EC @ 750 g *a.i.* ha^{-1} as PE *fb* bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_9), weed free (20, 40, and 60 DAS) (T_{10}), Farmer practice (Broadcast seeding with *biasi*) (T_{11}) and weedy check (T_{12}). Rice Variety IGKV R 1 (Indira Rajeshwari) was seeded with different row spacing (20, 22.5 and 25 cm) on 6th July and harvested on 8th November 2021. Seed was directly sown in line.

Result and Discussions

Effective tillers (no. m^{-2})

The Data on number of effective tillers m^{-2} are presented in Table 1. Among all the treatments, the maximum number of (420) effective tillers recorded under weed free treatment (T_{10}). It was found at par with the application of 20 cm row spacing + single row motorized weeder at 20 and 40 DAS+ bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_4) (419) followed by pretilachlor 50 EC @ 750 g *a.i.* ha^{-1} as PE *fb* bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_9) (414), 20 cm row spacing + single row motorized weeder + intra row hand weeding at 20 and 40 DAS (T_3) (411) and 20 cm row spacing + double row motorized weeder at 20 and 40 DAS (T_2) (410). The minimum number (227) of effective tiller was recorded under weedy check treatment (T_{12}). Khaliq *et al*. (2008) [4] and Jaysuria *et al.*, (2011) [3] also supported that hand weeding and chemical treatment with bispyribac sodium as post emergence resulted the more number of effective tiller.

Number of grains $panicle^{-1}$

Data regarding number of grains $panicle^{-1}$ as influenced by different treatments are presented in Table 1. Among all the treatments the highest number of grains $panicle^{-1}$ was noticed under the weed free treatment (T_{10}) (140). It was found at par with the application of 20 cm row spacing + single row motorized weeder at 20 and 40 DAS+ bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_4) (138), followed by pretilachlor 50 EC @ 750 g *a.i.* ha^{-1} as PE *fb* bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_9) (137), 20 cm row spacing + single row motorized weeder + intra row hand weeding at 20 and 40 DAS (T_3) (136) and 20 cm row spacing + double row motorized weeder at 20 and 40 DAS (T_2) (134). The higher number of grain $panicle^{-1}$ observed in these treatments may be attributable to the lower weed competition in terms of dry matter of weeds, which created an overall congenial environment for rice growth and development and increased the availability of light, moisture, nutrients and space for the rice plant resulting in a higher number of healthy grain $panicle^{-1}$, the result of investigation confirm the findings of Saini *et al.*, (2001) [1] and Kiran *et al*., (2010) [5]. The lowest number of grain $panicle^{-1}$ was recorded under weedy check plot (T_{12}) (103) where no weed control treatments were adopted.

Panicle length (cm)

Data pertaining to panicle length of rice plant as influenced due to different treatments are presented in Table 1. Among all the treatments, the maximum length of panicle (24.61cm) was recorded under weed free treatment (T_{10}). It was found at par with the application of 20 cm row spacing + single row motorized weeder at 20 and 40 DAS+ bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_4) (24.36cm), followed by pretilachlor 50 EC @ 750 g *a.i.* ha^{-1} as PE *fb* bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_9) (23.71cm), 20 cm row spacing + single row motorized weeder + intra row hand weeding at 20 and 40 DAS (T_3) (23.68cm) and 20 cm row spacing + double row motorized weeder at 20 and 40 DAS (T_2) (23.36cm). The minimum length of panicle (21.42cm) was recorded under weedy check (T_{12}) treatment.

Panicle weight (g)

Data pertaining to panicle weight of rice plant as influenced due to different treatments are presented in Table 1. Among all the treatments, the maximum weight of panicle (5.02 g) was recorded under weed free treatment (T_{10}). It was found at par with the application of 20 cm row spacing + single row motorized weeder at 20 and 40 DAS+ bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_4) (4.90 g), followed by pretilachlor 50 EC @ 750 g *a.i.* ha^{-1} as PE *fb* bispyribac–sodium@ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_9) (4.87g), 20 cm row spacing + single row motorized weeder + intra row hand weeding at 20 and 40 DAS (T_3) (4.72 g) and 20 cm row spacing + double row motorized weeder at 20 and 40 DAS (T_2) (4.53g). The minimum weight of panicle (2.93 g) was recorded under weedy check (T_{12}) treatment.

Test weight (g)

The Data related to test weight are presented in Table 1. The data revealed that the different weed management practices did not influence the test weight significantly due to different weed control treatments. The highest test weight was recorded under the weed free treatment (T_{10}) (25.86 g) and lowest was recorded under weedy check treatment (T_{12}) (23.9 g). Among all other treatments highest test weight found under 20 cm row spacing + single row motorized weeder at 20 and 40 DAS+ bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_4) (25.67 g), followed by pretilachlor 50 EC @ 750 g *a.i.* ha^{-1} as PE *fb* bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed

(30 DAS) (T_9) (25.35 g).

Grain yield (t ha^{-1})

Grain yield of rice as influenced by different weed management treatments are presented in Table 1. The result show that the grain yield of direct seeded rice significantly varied as a result of different weed management treatments. The grain yield was lowest (3.3 t ha^{-1}) under weedy check (T_{12}) treatment where weeds were allowed to grow throughout the crop season. The grain yield was recorded highest in weed free (T_{10}) treatment. It was found at par with the application of 20 cm row spacing + single row motorized weeder at 20 and 40 DAS+ bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_4) (5.78 t ha^{-1}), followed by pretilachlor 50 EC @ 750 g *a.i.* ha^{-1} as PE *fb* bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_9) (5.67 t ha^{-1}), 20 cm row spacing + single row motorized weeder + intra row hand weeding at 20 and 40 DAS (T_3) (5.61 t ha^{-1}) and 20 cm row spacing + double row motorized weeder at 20 and 40 DAS (T_2) (5.52 t ha^{-1}).The removal of weeds improve the availability of nutrients, space, sunlight and water, resulting in better growth and development of agricultural plants which contributed to the increased yields under these treatments. Better yield attribution characteristics and a buildup of more dry matter finally led to the best yields as a result of this.

Table 1: Yield and Yield attribute characters as influenced by different treatment in direct seeded rice

Treatments		No. of effective tiller m^{-2}	No. of grain panicle^{-1}	Panicle length (cm)	Panicle weight (g)	Test weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)	Weed index (%)
T_1	20 cm + SRW at 20 and 40 DAS	375	126	22.88	3.87	34.93	5.37	6.60	44.86	9.89
T_2	20 cm + DRW at 20 and 40 DAS	410	134	23.36	4.53	35.03	5.52	6.95	44.26	7.38
T_3	20 cm + SRW + IR at 20 and 40 DAS	411	136	23.68	4.72	35.08	5.61	7.01	44.45	5.87
T_4	20 cm + SRW at 20 and 40 DAS + BS @ 25 g *a.i.* ha^{-1} at 30 DAS	419	138	24.36	4.90	35.67	5.78	7.28	44.25	3.02
T_5	22.5 cm + SRW at 20 and 40 DAS	355	119	21.61	3.20	34.72	5.19	6.27	45.28	12.91
T_6	22.5 cm + DRW at 20 and 40 DAS	371	123	22.78	3.72	34.55	5.31	6.58	44.65	10.90
T_7	25 cm + SRW at 20 and 40 DAS	370	120	21.78	3.47	34.41	5.27	6.48	44.85	11.57
T_8	25cm + DRW at 20 and 40 DAS	357	119	21.73	3.24	34.17	5.21	6.35	45.06	12.58
T_9	PC 50 EC @ 750 g *a.i* ha^{-1} (PE) *fb* BS 25 g *a.i.* ha^{-1} at 30 DAS	414	137	23.71	4.87	35.35	5.67	7.20	44.05	4.86
T_{10}	weed free (20,40 and 60 DAS)	420	140	24.61	5.02	35.86	5.96	7.56	44.08	-
T_{11}	Farmer practice (Broadcast seeding with *biasi*)	324	116	21.45	3.13	34.05	4.84	5.95	44.85	18.79
T_{12}	Weedy check	227	103	21.42	2.93	33.9	3.13	3.91	44.46	47.48
SEm±		12.11	4.42	0.47	0.21	0.01	0.19	0.23	0.35	0.39
CD (P = 0.05)		35.53	12.98	1.40	0.63	NS	0.57	0.69	NS	1.14

*DAS= Days after sowing, SRW= Single row weeder, DRW= Double row weeder, IR = Intra row

Straw yield (t ha^{-1})

Straw yield of rice as influenced by different weed management treatments are presented in Table 1. The result show that the straw yield of direct seeded rice significantly varied as a result of different weed management treatments. The straw yield was lowest (3.91 t ha^{-1}) under weedy check treatment (T_{12}) where weeds were allowed to grow throughout the crop season. The straw yield was recorded highest (7.20 t ha^{-1}) in weed free treatment (T_{10}). It was found at par with the application of 20 cm row spacing + single row motorized weeder at 20 and 40 DAS+ bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_4) (7.28 t ha^{-1}) followed by pretilachlor 50 EC @ 750 g *a.i.* ha^{-1} as PE *fb* bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_9) (7.20 t ha^{-1}), 20 cm row spacing + single row motorized weeder + intra row hand weeding at 20 and 40 DAS (T_3) (7.01 t ha^{-1}) and 20 cm row spacing + double row motorized weeder at 20 and 40 DAS (T_2) (6.95 t ha^{-1}).

Harvest index (%)

Data with regard to harvest index (HI) is presented in Table 1. The data clarified that all the treatments did not influence the harvest index significantly. The maximum harvest index recorded under weed free (T_{10}) treatment and the lowest under weedy check (T_{12}) treatment.

Weed index (%)

Data with regard to weed index (WI) is presented in Table 1. Weed index is the percent reduction in crop yield under a particular treatment due to the presence of weeds in comparison to weed free treatment. Among all the treatments, the weedy check treatment (T_{12}) recorded the highest (47.48%) weed index, representing the highest reduction in yield due to weed competition. Among all remaining treatments lowest weed index recorded under 20 cm row spacing + single row motorized weeder at 20 and 40 DAS+ bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_4) (3.02%),

Table 2: Total weed dry weight (gm^{-2}) and Weed control efficiency (WCE) at different periods of plant growth as influenced by different treatment in direct seeded rice

Treatments		Total weed dry weight (gm^{-2})		Weed control efficiency (%)	
		60 DAS	90 DAS	60 DAS	90 DAS
T_1	20 cm +SRW at 20 and 40 DAS	3.11 (8.73)	4.04 (15.37)	78.94	69.43
T_2	20 cm + DRW at 20 and 40 DAS	2.82 (6.96)	3.59(11.89)	83.21	76.35
T_3	20 cm + SRW +IR at 20 and 40 DAS	2.76 (6.64)	3.42 (10.72)	83.98	78.67
T_4	20 cm + SRW at 20 and 40 DAS + BS @ 25 g *a.i.* ha^{-1} at 30 DAS	2.48 (5.17)	2.83 (7.03)	87.53	86.01
T_5	22.5cm + SRW at 20 and 40 DAS	3.62 (12.16)	4.93 (23.37)	70.67	53.52

T_6	22.5cm + DRW at 20 and 40 DAS	3.16 (9.00)	4.38 (18.26)	78.29	63.68
T_7	25 cm + SRW at 20 and 40 DAS	3.24 (9.56)	4.57 (19.95)	76.95	60.32
T_8	25cm + DRW at 20 and 40 DAS	3.48 (11.15)	4.69 (21.06)	73.10	58.11
T_9	PC 50 EC @ 750 g *a.i* ha^{-1} (PE) *fb* BS 25 g *a.i.* ha^{-1} at 30 DAS	2.65 (6.03)	3.09 (8.56)	85.45	82.97
T_{10}	weed free (20,40 and 60 DAS)	1.76 (2.1)	2.35 (4.53)	94.93	90.99
T_{11}	Farmer practice (Broadcast seeding with *biasi*)	3.89 (14.16)	5.17 (25.76)	65.84	48.76
T_{12}	Weedy check	6.51 (41.46)	7.16 (50.28)	-	-
SEm±		0.59	0.22	1.83	1.83
CD (P=0.05)		1.28	1.30	5.38	5.38

*DAS= Days after sowing, SRW = Single row weeder, DRW = Double row weeder, IR = Intra row, Figures in parentheses are original values, data were transformed to values √(x+1) are in bold letters

followed by pretilachlor 50 EC @ 750 g *a.i.* ha^{-1} as PE *fb* bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_9) (4.86%), 20 cm row spacing + single row motorized weeder + intra row hand weeding at 20 and 40 DAS (T_3) (5.87%) and 20 cm row spacing + double row motorized weeder at 20 and 40 DAS (T_2) (7.38%).

Weed flora

The weed species found in the experimental plot were *Cynodon dactylon* L., *Dactyloctenium aegyptium*, *Echinochloa colona* L. among grassy weeds; *Fimbristylis miliacea* L., *Cyperus difformis* L. and *Cyperus iria* L. among sedges; *Alternanthera sessilis* L., *Abutilon indicum* L., *Commelina diffusa*, *Cyanotis axillaris* L., *Eclipta alba* L., *Ludwigia parviflora* L., *Phyllanthus niruri* L. and *Physalis minima* L. among broad-leaved weeds.

Weed dry weight (g m^{-2})

The data on weed dry biomass at 60 and 90 DAS presented in Table 2. At both the stages lowest weed dry matter was recorded under weed free (T_{10}) treatment and highest was under weedy check (T_{12}) treatment. Among other treatments lowest dry matter was recorded under 20 cm row spacing + single row motorized weeder at 20 and 40 DAS+ bispyribac–sodium@ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_4) followed by pretilachlor 50 EC @ 750 g *a.i.* ha^{-1} as PE *fb* bispyribac–sodium @ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_9) and 20 cm row spacing + single row motorized weeder + intra row hand weeding at 20 and 40 DAS (T_3) and 20 cm row spacing + double row motorized weeder at 20 and 40 DAS (T_2) which were at par with the weed free (T_{10}) treatment.

Weed control efficiency (%)

Data related to weed control efficiency (WCE) at 60 and 90 DAS were presented in Table 2. It was evident from the data that at both the growth stages the highest weed control efficiency was recorded under the weed free treatment (T_{10}), due to season long weed free condition. Among different chemical, mechanical and integrated treatments highest weed control efficiency recorded under 20 cm row spacing + single row motorized weeder at 20 and 40 DAS+ bispyribac–sodium@ 25 g *a.i.* ha^{-1} at 2-4 leaf stage of weed (30 DAS) (T_4) followed by pretilachlor 50 EC @ 750 g *a.i.* ha^{-1} as PE *fb* bispyribac–sodium@ 25 g *a.i.* ha^{-1}at 2-4 leaf stage of weed (30 DAS) (T_9), 20 cm row spacing + single row motorized weeder + intra row hand weeding at 20 and 40 DAS (T_3) and 20 cm row spacing + double row motorized weeder at 20 and 40 DAS (T_2).

Conclusion

Based on study it can be concluded that the highest yield attributes and yield, lowest weed dry weight and highest weed control efficiency were noted under the integrated management with mechanical + chemical in the 20 cm row spacing + single row motorized weeder at 20 and 40 DAS + bispyribac-sodium @ 25g *a.i.* ha^{-1} at 2-4 leaf stage (30 DAS) (T_4) treatment next to the weed free (20, 40 and 60 DAS) (T_{10}) treatment.

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