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Effect of crop geometry and weed management on growth, yield attributes and yield of rice (*Oryza sativa* L.)

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Abstract
A field experiment was carried out at the Instructional farm, BTC CARS, Bilaspur (C.G.) during *kharif* season 2022. The experiment was carried out in split plot design with the goal of "Effect of crop geometry and weed management on growth, yield attributes and yield of rice (*Oryza sativa* L.)". The study included eighteen treatment combinations with three replications. The two factors were crop geometry and weed management. Results revealed that for crop geometry treatment S_2 (20 cm x 15 cm) was recorded higher grain yield (46.26 q ha^{-1}) and straw yield (65.51 q ha^{-1}) and for weed management practices W_2 (2 Hand weeding 20 and 40 DAT) are recorded higher grain yield (50.04 q ha^{-1}) and straw yield (67.03 q ha^{-1}) ideal for rice crop.

Keywords: Split plot design, rice (*Oryza sativa* L.), crop geometry, weed management

Introduction

Rice (*Oryza sativa* L.) is one of the major crops grown as a primary source of food in the world. It is a member of the Graminae Family. It is a calorie-dense diet with a high starch content (75%) along with protein levels of 6-7%, fat levels of 22.5%, cellulose levels of 0.8%, and ash levels of 5-9%, respectively. More than two billion Asians consume 60–70% of the daily energy from rice products (Tomar *et al*., 2018) [4].

Around the world rice production was 518.1 million tonnes in 2020–21 and 525.1 million tonnes in 2021–22 (FAO, 2022). In India, rice production is expected to reach an all-time high at 127.93 million tonnes in 2021–22. It produces more than the average of 116.44 million tonnes during the preceding five years from 11.49 million tonnes (Anonymous, 2022 a) [1]. Rice production in Chhattisgarh state is 3889.34 (000 hectares). With productivity of 3212 kg ha^{-1} (Anonymous, 2022b) [2].

Weeds are a significant factor among many others that influence crop productivity. Weed competition is inversely related to crop geometry. The most crucial factor in maximizing rice output is optimal plant population in a suitable planting geometry (Siddiqui *et al*., 1999) [6]. Rice production, development and growth are significantly influenced by plant spacing in field. Optimal plant spacing ensures that the plant grows successfully in both its aerial and subterranean portions by utilizing light and nutrients. The highest yield benefit can be reached when planting is done with the proper spacing. With proper planting geometry, rice exhibits higher growth- attributing features such as dry matter accumulation and crop growth rate. With closer planting geometry compared with wider planting geometry, there were considerably more effective tillers and better grain. The planting geometry had a considerable impact on panicle-emergence and tillering (Mahato and Adhikari., 2017) [5].

Weed growth is more favourable to an aerobic environment than to the growth of crops Additionally, they have a wide range of weed plants, that could have an impact on the development phases of crops and ultimately on agricultural yields. (Schreiber *et al*. 2018) [8].

Low rice productivity can be attributed to a number of factors. The infestation of weeds is the main factor. As compared to other cereal crops, rice crops are more susceptible to weed competition. Weeds and agricultural plants compete for moisture, nutrients, light, space, and other growth elements, which results in a large yield loss.

Herbicide, manual labour, or mechanical methods are typically used to control weeds. Only until the weeds have grown to a height that they can be plucked out by hand with at ease, can manual weeding be done.

Herbicides exceed other techniques of weed control because they provide selective control, easier to use, and are more efficient, time-saving, and reasonably priced.

However, the application of herbicides to manage weeds requires a high level of technical skill, and improper use can have a severe impact on the environment, the diversity of species and the appearance of new diseases.

Materials and Methods

The current demonstration was conducted during the *kharif* season of 2022 at BTC CARS Instructional Farm in Bilaspur (Chhattisgarh). There were eighteen treatment combinations with three replications in the experiment. The Split Plot Design (SPD) was used to analyse the data. The crop variety was “Zinco Rice” which was transplanted on 27th July 2022. The gross plot size of 5.0 m x 4.2 m (21 m^2) was laid out.

Eighteen treatment combinations were included in the evaluation. Which were three spacing levels: S_1 (20 cm x 10 cm), S_2 (20 cm x 15 cm) and S_3 (20 cm x 20 cm) and for weed management W_0: Control, W_1: 1 Hand weeding 20 DAT, W_2: 2 Hand weeding 20 and 40 DAT, W_3: Pyrazosulfuron - ethyl 20 g a.i. ha^{-1} as pre - emergence, W_4: Bispyribac - sodium 25 g a.i. ha^{-1} as post – emergence, W_5: Pyrazosulfuron- ethyl 20 g a.i. ha^{-1} as pre- emergence + Bispyribac – sodium 25 g a.i. ha^{-1} as post -emergence.

Results and Discussions

Pre harvest observations

1. Number of hills m^{-2}

The plant population was observed at 30 DAT and at harvest. It was observed that maximum plant population was under treatment S_1 (20 cm x 10 cm) (48.73 hill m^{-2}) it was followed by S_2 (20 cm x 15 cm) (33.04 hill m^{-2}). However, the lowest plant population was observed under treatment S_3 (20 cm x 20 cm) and for weed management plant population was recorded non- significant at all the growth stage of the crop.

Interaction effect between crop geometry and weed management shows non- significant.

2. Plant height (cm)

Results revealed that the highest plant height was recorded under treatment S_1 (20 cm x 10 cm) at 30 DAT (50.24 cm), 60 DAT (84.25 cm), 90 DAT (108.11 cm) and at harvest (104.16 cm) which was at par with S_2 treatment (20 cm x 15 cm) and lowest plant height was recorded under treatment S_3 (20 cm x 20 cm).

Regarding weeds control the highest plant height was observed under treatment W_2 (2 Hand weeding - 20 and 40 DAT) at 30 DAT (50.52 cm), 60 DAT (90.52 cm), 90 DAT (114.29 cm) and at harvest (110.10 cm) which was at par with treatment W_5 (Pyrazosulfuron- ethyl 20 g a.i. ha^{-1} as pre - emergence + Bispyribac- sodium 25 g a.i. ha^{-1} as post-emergence), plant height in the plot W_4 (Bispyribac- sodium 25 g a.i. ha^{-1} as post- emergence) was statistically at par with W_3 (Pyrazosulfuron- ethyl 20 g a.i. ha^{-1} as pre -emergence) and significantly lowest plant height was recorded under treatment W_0 (Control). Due to reduced crop-weed competition maximum plant height was observed. Similar results were also observed by (Walia *et al.* 2008a) [9].

Interaction effect between crop geometry and weed management was recorded non-significant.

2. Number of tillers m^{-2}

A critical analysis of data at 30th DAT after transplanting clearly indicates that there was significant difference in number of tillers due to different crop geometry. The highest number of tillers were recorded under treatment S1 (20 cm x 10 cm) (342.52) m^{-2} which at par with S2 (20 cm x 15 cm) while the lowest was recorded under S3 (20 cm x 20 cm). Similar trends were recorded at 60th, 90th DAT after transplanting.

Data revealed that W2 (2 Hand weeding - 20 and 40 DAT) (359.39) observed the highest number of tillers which was at par with W5 (Pyrazosulfuron- ethyl 20 g a.i. ha^{-1} as pre - emergence + Bispyribac-sodium 25 g a.i. ha^{-1} as post-emergence) and W_4 (Bispyribac- sodium 25 g a.i. ha^{-1} as post-emergence) was statistically at par with W_3 (Pyrazosulfuron-ethyl 20 g a.i. ha^{-1} as pre -emergence), while the treatment W0 (control) (303.05) recorded the lowest number of tillers.

Interaction effect between crop geometry and weed management was recorded non-significant.

3. Dry matter accumulation (g m^{-2})

Different crop geometry significantly influenced the total dry matter accumulation (m^{-2}) at all stages of growth. At 30 DAT after transplanting, maximum total dry matter accumulation (m^{-2}) was recorded under treatment S_2 (20 cm x 15 cm) (179.77 g m^{-2}) which at par with treatment S_1 (20 cm x 10 cm) (176.64 g m^{-2}) while the lowest dry matter accumulation was found under treatment S_3 (20 cm x 20 cm). Similar trends were observed at the 60, 90 DAT and at harvest.

It is observed from data that among weed management the highest dry matter production (m^{-2}) was recorded in treatment W_2 (2 Hand weeding - 20 and 40 DAT) (187.08 g m^{-2}) which was at par with W_5 (Pyrazosulfuron- ethyl 20 g a.i. ha^{-1} as pre - emergence + Bispyribac- sodium 25 g a.i. ha^{-1} as post-emergence) (183.09 g m^{-2}). While the minimum was recorded under the weed management (106.07 g m^{-2}). Similar trends were noticed at the 60th, 90th DAT after transplanting and at harvest.

Interaction effect between crop geometry and weed management was recorded non-significant.

Table 1: Number of hills m^{-2} of rice as influenced by crop geometry and weed management

Treatments	Plant population hill m^{-2}	
	30 DAT	At Harvest
(A) Spacing		
S_1 - 20 cm X 10 cm	48.73	45.71
S_2 - 20 cm X 15 cm	33.04	31.10
S_3 - 20 cm X 20 cm	24.82	24.07
S.Em±	0.28	0.43
CD (0.05)	1.09	1.23
(B) Weed management		
W_0 – Control	35.17	33.28
W_1- 1 Hand weeding 20 DAT	35.46	33.61
W_2 -2 Hand weeding 20 and 40 DAT	35.97	33.85
W_3 - Pyrazosulfuron- ethyl 20 g a.i. ha^{-1} as pr- emergence	35.31	33.50
W_4 -Bispyribac- sodium 25 g a.i. ha^{-1} as post- emergence	35.39	35.57
W_5 -Pyrazosulfuron- ethyl 20 g a.i. ha^{-1} as pre-emergence+Bispyribac- sodium 25 g a.i. ha^{-1} as post -emergence	35.90	33.84
S.Em±	0.74	0.79
CD (0.05)	NS	NS
Interaction	NS	NS

Table 2: Plant height (cm) of rice as influenced by crop geometry and weed management

Treatments	Plant height (cm)			
	30 DAT	60 DAT	90 DAT	At Harvest
(A) Spacing				
S_1 - 20 cm X 10 cm	50.24	84.25	108.11	104.16
S_2 - 20 cm X 15 cm	48.08	82.83	105.91	101.94
S_3 - 20 cm X 20 cm	46.37	78.47	101.45	98.56
S.Em±	0.70	1.12	1.29	1.23
CD (0.05)	2.74	4.40	5.05	4.85
(B) Weed management				
W_0 – Control	40.42	68.21	90.75	89.37
W_1 -1 Hand weeding 20 DAT	47.80	82.49	106.06	102.96
W_2 -2 Hand weeding 20 and 40 DAT	54.02	90.52	114.29	110.10
W_3 -Pyrazosulfuron- ethyl 20 ga.i. ha^{-1} as pre-Emergence	47.27	80.59	103.72	101.14
W_4 -Bispyribac- sodium 25 g a.i. ha^{-1} as post – emergence	47.86	81.31	104.68	100.94
W_5 -Pyrazosulfuron - ethyl 20 ga.i. ha^{-1} as pre - emergence + Bispyribac-sodium 25 ga.i. ha^{-1} as post – emergence	51.98	87.99	111.44	106.83
S.Em±	1.29	2.41	2.94	1.84
CD (0.05)	3.72	6.95	8.48	5.31
Interaction	NS	NS	NS	NS

Table 3: Number of tillers m^{-2} of rice as influenced by crop geometry and weed management

Treatments	Number of tillers m^{-2}			
	30 DAT	60 DAT	90 DAT	Effective tillers at harvest
(A) Spacing				
S_1 - 20 cm X 10 cm	342.52	547.68	570.54	480.28
S_2 - 20 cm X 15 cm	333.89	524.31	544.47	472.20
S_3 - 20 cm X 20 cm	308.27	472.30	499.21	453.21
S.Em±	4.60	7.25	9.22	2.68
CD (0.05)	18.06	28.46	36.20	10.53
(B) Weed management				
W_0 – Control	303.05	477.58	507.41	431.13
W_1- 1 Hand weeding 20 DAT	324.06	489.09	519.23	473.63
W_2 -2 Hand weeding 20 and 40 DAT	359.39	529.07	549.45	486.42
W_3- Pyrazosulfuron- ethyl 20 ga.i. ha^{-1} as pre-Emergence	336.58	495.82	519.27	464.83
W_4 -Bispyribac- sodium 25 g a.i. ha^{-1} as post – emergence	318.99	493.80	522.90	469.53
W_5 -Pyrazosulfuron – ethyl 20 ga.i. ha^{-1} as pre - emergence + Bispyribac-sodium 25 ga.i. ha^{-1} as post – emergence	347.28	498.69	530.28	484.83
S.Em±	6.05	9.38	8.85	7.10
CD (0.05)	17.48	27.08	25.57	20.49
Interaction	NS	NS	NS	NS

Table 4: Crop dry matter accumulation (g m^{-2}) of rice as influenced by crop geometry and weed management

Treatments	Crop dry matter accumulation (g m-2)			
	30 DAT	60 DAT	90 DAT	At harvest
(A) Spacing				
S1 - 20 cm X 10 cm	176.64	1049.59	1646.41	1760.28
S2 - 20 cm X 15 cm	179.77	1071.96	1710.07	1839.64
S3 - 20 cm X 20 cm	173.06	1006.68	1597.72	1735.00
S.Em±	1.03	12.58	20.44	20.72
CD (0.05)	4.06	49.40	80.25	81.34
(B)Weed management				
W0 – Control	160.07	934.99	1491.98	1543.19
W1- 1 Hand weeding 20 DAT	176.29	1052.31	1677.85	1812.38
W2 -2 Hand weeding 20 and 40 DAT	187.08	1101.22	1734.59	1880.71
W3 – Pyrazosulfuron- ethyl 20 g a.i. ha^{-1} as pre – emergence	173.34	1069.12	1655.47	1792.61
W4 -Bispyribac -sodium 25 g a.i. ha^{-1} as post - emergence	177.06	1018.67	1668.72	1806.15
W5 -Pyrazosulfuron - ethyl 20 g a.i. ha^{-1}as pre -emergence + Bispyribac- sodium 25 g a.i. ha^{-1} as post-Emergence	183.09	1080.16	1679.76	1834.81
S.Em±	5.16	29.81	47.50	66.61
CD (0.05)	14.90	86.09	137.18	192.39
Interaction	NS	NS	NS	NS

Post harvest observation

1. Number of effective tillers (m^{-2})

The highest effective tillers (m^{-2}) were recorded under treatment S_1 (20 cm x 10 cm) (480.28), which found to be at par with treatment S_2 (20 cm x 15 cm) and the minimum effective tillers was found in treatment S_3 (20 cm x 20 cm). similar results were observed by (Walia *et al.*, 2008)) [9] and (Yadav *et al.*, 2009) [10].

Among different weed management treatment W_2 (2 Hand weeding 20 and 40 DAT) (486.42) produced maximum effective tillers followed by W_5 (Pyrazosulfuron- ethyl 20 g a.i. ha^{-1} as pre- emergence + Bispyribac- sodium 25 g a.i. ha^{-1} as post-emergence) and the lowest was recorded in W_0 (control).

Interaction effect between crop geometry and weed management shows non- significant.

2. Panicle length (cm)

The length (cm) of crop panicle at harvest had a big impact through treatment S_3 (20 cm x 20 cm) had the longest panicle length (18.68 cm) with which at par with S_2 (20 cm x 15 cm) (18.23 cm) and the shortest panicle length were found in S1 (20 cm x 10 cm) (17.11 cm).

Among different weed management practices treatment W_2 (2 Hand weeding - 20 and 40 DAT) produced maximum panicle length (21.97 cm) and the lowest was recorded in treatment W_0 (control) (13.45 cm). Interaction effect between crop geometry and weed management in the of panicle length (cm) was recorded non- significant at harvest.

3. Number of grain panicle^{-1}

Among the treatment S_3 (20 cm x 20 cm) had the highest number of grains panicle^{-1} (141.84), which was at par with treatment S_2 (20 cm x 15 cm) (137.66), while the lowest number of grain panicle^{-1} was observed under treatment S_1 (20 cm x 10 cm) (129.26). Similar results were observed by (Patra and Nayak 2001) [11].

Different weed management practices also indicated significant difference in number of grain panicle^{-1}. Among different weed management maximum number of grains panicle^{-1} was recorded under treatment W_2 (2 Hand weeding - 20 and 40 DAT (146.02), which was at par with W_5 (Pyrazosulfuron- ethyl 20 g a.i. ha^{-1} as pre -emergence + Bispyribac-sodium 25 g a.i. ha^{-1} as post-emergence) however, treatment W_1 (1 Hand weeding 20 DAT) and treatment W_4 (Bispyribac-sodium 25 g a.i. ha^{-1} as post-emergence) were intern also at par. The minimum number of grain panicle^{-1} was found in W_0 (control) (121.69). Similar results were observed by (Yadav and Singh, 2009) [10].

Interaction effect between crop geometry and weed management for the panicle length was recorded non-significant.

4. Test weight (g)

The crop planted with treatment S_3 (20 cm x 20 cm) had the higher test weight (21.40 g) while the lowest test weight was recorded under treatment S_1 (20 cm x 10 cm) (21.12 g).

Different weed management also had significant difference in seed weight. Among different weed management the highest test weight was recorded under treatment W_2 (2 Hand weeding - 20 and 40 DAT) (22.53 g) which was at par with treatment W_5 (Pyrazosulfuron- ethyl 20 g a.i. ha^{-1} as pre - emergence + Bispyribac- sodium 25 g a.i. ha^{-1} as post-emergence) (22.09 g), while the minimum test weight was recorded under treatment W_0 (control).

Interaction effect between crop geometry and weed management for the test weight (g) was recorded as non-significant.

Table 5: Panicle length, number of grain panicle^{-1} and test weight (g) of rice as influenced by crop geometry and weed management

Treatments	Panicle length (cm)	No. of grain panicle^{-1}	Test weight (g)
(A) Spacing			
S1 - 20 cm X 10 cm	17.11	129.26	21.12
S2 - 20 cm X 15 cm	18.23	137.66	21.32
S3 - 20 cm X 20 cm	18.68	141.84	21.40
S.Em±	0.30	2.39	0.23
CD (0.05)	1.18	9.39	NS
(B) Weed management			
W0 - Control	13.45	121.69	20.04
W1 - 1 Hand weeding 20 DAT	18.61	139.70	21.22
W2 -2 Hand weeding 20 and 40 DAT	21.97	146.02	22.53
W3 - Pyrazosulfuron-ethyl 20 g a.i. ha^{-1} as pre-emergence	16.10	130.86	20.55
W4 -Bispyribac- sodium 25 g a.i. ha^{-1} as post-emergence	16.37	136.50	20.86
W5 -Pyrazosulfuron- ethyl 20 g a.i. ha^{-1} as pre-emergence + Bispyribac- sodium 25 g a.i. ha^{-1} as post-emergence	21.53	142.76	22.09
S.Em±	0.40	5.03	0.35
CD (0.05)	1.15	14.53	1.02
Interaction	NS	NS	NS

Grain yield (q ha^{-1})

The crop's grain yield was significantly influenced by the crop geometry and weed management practices. Higher grain yield was found in treatment S_2 (20 cm x 15 cm) (46.26q h^{-1}) which was at par with S_1 (20 cm x 10 cm) (44.66 q h^{-1}), whereas S_3 (20 cm x 20 cm) (42.67 q h^{-1}) showed lower output of grains. Similar results were also observed by (Ronaki *et al.*, 2014) [13]

Data from various weed management methods also showed that the amount of produced grain, differed significantly depending on the weed control technique. The weed management treatment with the highest grain yield was observed the treatment W_2 (2 Hand weeding - 20 and 40 DAT) (50.04 q h^{-1}), which was at par with W_5 (Pyrazosulfuron - ethyl 20 g a.i. ha^{-1} as pre- emergence + Bispyribac- sodium 25 g a.i. ha^{-1} as post - emergence) (49.46 q h^{-1}), whereas the lowest grain yield was observed with treatmnt W_0 (control) (33.07q h^{-1}). Similar results were also observed by (Yadav and Singh 2009) [10].

At harvest, there was non- significant interaction between crop geometry and weed management.

Straw yield (q ha^{-1})

The higher straw production was observed with treatment S_2 (20 cm x 15 cm) (65.51q h^{-1}) which was at par with treatment S_1 (20 cm x 10 cm) (61.58q ha^{-1}), while S_3 (20 cm x 20 cm) (58.71q ha^{-1}) was recorded the lower straw yield.

Data on various weed management practices also showed that the yield of straw was significantly affected by the weed management method. The highest straw yield among the various weed managements was observed under treatment W_2 (2 Hand weeding 20 and 40 DAT) (67.03q ha^{-1}) which was at par with treatment W_5 (Pyrazosulfuron- ethyl 20 g a.i. ha^{-1} as pre - emergence + Bispyribac-sodium 25 g a.i. ha^{-1} as post-emergence) followed by treatment W_4 - Bispyribac- sodium 25 g a.i. ha^{-1} as post - emergence), while the lowest straw yield was recorded under treatment W_0 (control) (54.55q ha^{-1}). Similar results were observed by (Nivetha *et al.*, 2017) [12].

Interaction effect between crop geometry and weed management was observed non- significant.

Harvest index (%)

Higher harvest index was observed for the crop that planted with S_2 (20 cm x15 cm) (42.38%), followed by treatment S_1 (20 cm x 10 cm) (42.08%), while the lowest harvest index was observed under the treatment S_3 (20 cm x 20 cm) (41.03%).

Various weed management methods affected the harvest index. The highest harvest index among various weed management methods was found in treatment W_2 (2 Hand weeding 20 and 40 DAT) (42.74%), followed by treatment W_5 (Pyrazosulfuron- ethyl 20 g a.i. ha^{-1} as pre - emergence + Bispyribac-sodium 25 g a.i. ha^{-1} as post- emergence) (42.41%). The lowest harvest index was observed from the treatment W_0 (control) (37.74%).

Table 6: Grain yield, straw yield and harvest index of rice as influenced by crop geometry and weed management

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
(A) Spacing			
S1 - 20 cm X 10 cm	44.66	61.58	42.08
S2 - 20 cm X 15 cm	46.26	65.51	42.38
S3 - 20 cm X 20 cm	42.67	58.71	41.03
S.Em±	0.83	1.26	_
CD (0.05)	3.27	4.93	_
(B) Weed management			
W0 - Control	33.07	54.55	37.74
W1- 1 Hand weeding 20 DAT	46.46	63.33	42.31
W2 -2 Hand weeding 20 and 40 DAT	50.04	67.03	42.74
W3 - Pyrazosulfuron- ethyl 20 g a.i. ha^{-1} as pre- emergence	43.76	60.90	41.81
W4 -Bispyribac- sodium 25 g a.i. ha^{-1} as post-emergence	44.40	61.23	42.03
W5 -Pyrazosulfuron- ethyl 20 g a.i. ha^{-1}as pre-emergence + Bispyribac- sodium 25 g a.i. ha^{-1} as post-emergence	49.46	64.56	42.41
S.Em±	1.01	1.24	_
CD (0.05)	2.92	3.59	_
Interaction (S x W)	NS	NS	_

Conclusion

The study's conclusion indicate that the crop geometry S_2 (20 cm X15 cm) recorded higher grain yield (46.26 q ha^{-1}) and straw yield (65.51 q ha^{-1}) and for weed management practices W_2 (Hand weeding 20 and 40 DAT) are recorded higher grain yield (50.04 q ha^{-1}) and straw yield (67.03 q ha^{-1}) ideal for rice crop.

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