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EFFECT OF SEED RATE AND SPACING ON YIELD, GROWTH AND ECONOMICS OF BAJRA (*PENNISETUM GLAUCUM*)

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ABSTRACT

The current field study titled "Effect of seed rate and spacing on yield, growth and economics of Bajra (*Pennisetum glaucum*)" was carried out in Agronomy research farm at Guru Kashi University, Talwandi Sabo. The experiment consisted of ten treatment combinations and was set up in Randomized Block Design (RBD) with three replicates. The whole experimental area was divided into three equal blocks. The treatment 1.5 kg + 40 cm shown the significantly minimum 3.14 DAS to seedling emergence, 13.13 DAS to attain five leaf stage, minimum 22.19 DAS to panicle initiation, minimum 36.24 DAS to emergence of flag leaf, minimum 67.27 DAS taken to physical maturity. At 20,40,60 DAS and at harvest plant height was maximum in the treatment 1.5 kg + 40 cm (34.36, 185.00, 221.26, 235.33 cm) respectively. Dry matter accumulation per plant at 20 DAS (5.45g), 40 DAS (28.73g), 60 DAS (127.33g) and at harvest 189.40g per plant was noticed in 1.5 kg +30 cm. The number of tillers per plant 5.85 at 30 DAS and 4.67 at harvest longer ear length (24.96 cm), the 1000 grain weight (10.70g) and maximum grain yield 30.82 q/ha in treatment 1.5 kg + 40 cm.
Keywords: Bajra, DAS, phenological stages, seed rate, spacing, yield attributes, economics.

Introduction

Bajra, often called pearl millet (*Pennisetum glaucum*), is staple grain consumed by over 10% of Indians. The fourth most resilient warm season cereal crop in the world (Reddy *et al*.2016). It is grown on more than 8.3 million hectares and serves as both food and feed. It has its origin in tropical western Africa, where the majority of both cultivated and wild species are found. Based on soils and rainfall patterns in India, the cultivated area for pearl millet is classified into three zones mainly (Rai *et al.,* 2015). It has chromosomal number 2n=14 and is a member of family Poaceae. The crop has high degree of cross - pollination since the flowers are protogynous. The edible section of the seed has an average composition of 12% moisture, 10-12% protein, 3-5% fat, 60-70% carbohydrates, 1.5-3% fiber, and 1-1.5% ash. Stalks are also used as fuel, to make thatch, and to make mats for winnowing (Venkatachalam and Sathe 2006). Annual production and yield of pearl millet in India is 9.22 million tonnes and 1374 kg per hectares (Anonymous, 2022). In Punjab it was grown on 1.83 lakh hectares (2022-23). Pearl mill*et al*so plays a significant role in the nutritional and food security of the country (Choudhary, 2005). This crop is one of the most drought resistant crop and can be grown in areas of lower rainfall such as Western Rajasthan but the crop cannot survive standing water in the field (Dass *et al*., 2020). According to Haile *et al*. (2013) plant height rose as the pace of seedling increased. Because of increased interspecific competition for better absorption of light and less penetration of light into the plant canopy bed, higher seedling rates resulted in changes in plant height and stem thickness. Additionally, plant spacing order around the amount of space each plant has, which in turn dictates the plant's access to nutrients and moisture. In a particular species, row spacing dictates the availability and use of resources by individual plants. Determining the ideal

row widths for the seed crop is necessary before planting.

Materials and Methods

A field experiment was conducted over the experimental area of the research farm of Guru Kashi University, Talwandi Sabo (Bathinda) during Kharif 2024. The farm is located at 29° 57` N latitude and 75° 7`E longitude and an altitude of 213 meters above the sea level as per google map. Climate and weather conditions: The mean maximum and mean minimum temperature ranged 38.7° and 20.0° respectively recorded from July 2024 to October 2024.Maximum average relative humidity ranged 72% recorded in July 2024. The mean monthly rainfall varied from 91mm (July 2024) to 13mm (October 2024). The experiment comprised of ten treatment combinations consisting three seed rate (S1, S2, S3) and three parameters of spacing (P1, P2, P3) and one check of broadcasting with each spacing variation. Experiment detail season: Kharif, 2024; Crop-Bajra; Total no. of treatments-10; Replications -3; Total plot-30; Plot size – 3*3meter square; Randomized Block Design; PCB165 variety; Analysis of all data as per materials and methods under thesis.

Results and Discussion

A field experiment–Effect of seed rate and spacing on yield, growth and economics of Bajra (*Pennisetum glaucum*) was conducted at research farm of Guru Kashi University, Talwandi Sabo (Bathinda) during Kharif season 2024. The experimental locating about growth parameters, yield attributes and economics influenced by different seed rates and spacing based on field experiments are presented in this chapter. The data recorded for important characters have also been depicted for elucidation of the important trends, wherever necessary.

Effect on plant height

It can be stated that data (Table 1) indicated that plant height at different growth stages of crop growth are determine by various combinations of treatments at 20,40,60 DAS and at harvest plant height was maximum in the treatment 1.5 kg + 40 cm (34.36 cm, 185.00 cm, 221.86 cm and 235.33 cm) which was statistically at par with treatment 1.5 kg + 30 cm with observation 33.34 cm, 183.00 cm, 219.00 cm and 232.33 cm respect to observation taken on 20,40,60 DAS and at harvest. Minimum plant height 29.21 cm, 155.00 cm, 204.65 cm and 215.57 cm at 20,40,60 DAS and at harvest was observed in broadcasting method with 3 kg seed rate treatment. Higher seeding rate caused to changing plant height and stem thickness because of the lower light penetrating in to the plants canopy bed and more inter specific competition to more absorption of light.

Table 1: Effect of seed rate and spacing on plant height of pearl millet at different stages.

		Plant Height (cm)			
Sr. No.	**Treatments**	**20 DAS**	**40 DAS**	**60 DAS**	**At Harvest**
1	T1: 1.5kg + 30 cm	33.34	183.00	219.00	232.33
2	T2 :1.5kg + 20 cm	31.40	178.33	215.80	219.40
3	T3 :1.5kg +40 cm	34.36	185.00	221.86	235.33
4	T4 :2kg +30 cm	32.33	174.00	219.60	223.33
5	T5: 2kg + 20 cm	32.67	171.67	210.00	226.67
6	T6:2kg +40 cm	32.67	170.00	209.00	222.87
7	T7:2.5kg +30cm	30.03	170.73	215.67	225.53
8	T8:2.5kg+20cm	30.22	172.33	210.87	226.53
9	T9:2.5kg +40cm	30.80	169.40	211.67	225.53
10	T10(3kg) broadcasting	29.21	155.00	204.65	215.57
CD at (0.05%)		1.40	2.67	3.04	3.153

Effect on Dry Matter accumulation (g plant^{-1})

Effect of various combinations of treatments in pearl millet on dry matter accumulation per plant at different growth stages of crop growth is presented in Table 2. Dry matter accumulation per plant was affected significantly at 20,40,60 DAS and at harvest due to spacing and seed rate. Dry matter accumulation per plant at 20 DAS (5.45g), 40 DAS (28.73g) and 60 DAS (127.33g) by 1.5 kg +40 cm treatment. At harvest 189.40g per plant was observe in 1.5 kg + 30 cm statistically at par with 1.5 kg + 30 cm treatment at 20 DAS, 40 DAS, 60 DAS and at harvest with observation 5.13g, 27.87g and 126.26g per plant dry matter accumulation respectively. At harvest dry matter per plant 188g was at par with treatment 1.5 kg +40 cm. The broadcasting method with 3 kg seed rate treatment produced significantly lower dry matter per plant at all stages of growth in pearl millet. These results are in superior agreement with Jimba and Adedeji (2003) who reported that wider spacing had higher dry matter yield than the close spacing crops.

Table 2: Effect of seed rate and spacing on dry matter accumulation of pearl millet at different stages.

Sr. No	Treatments	20 DAS	40 DAS	60 DAS	At Harvest
1	T1: 1.5kg + 30 cm	5.13	27.87	126.26	189.40
2	T2 :1.5kg + 20 cm	3.37	26.93	124.86	168.60
3	T3 :1.5kg +40 cm	5.45	28.73	127.33	188.60
4	T4 :2kg +30 cm	4.73	26.93	125.80	186.67
5	T5: 2kg + 20 cm	4.84	27.15	125.26	187.33
6	T6:2kg +40 cm	4.17	27.38	126.20	185.80
7	T7:2.5kg +30cm	4.86	26.77	126.20	185.53
8	T8:2.5kg+20cm	4.91	27.43	122.66	182.73
9	T9:2.5kg +40cm	4.39	27.54	127.66	185.00
10	T10(3kg) broadcasting	4.10	25.76	120.80	147.67
CD at (0.05%)		0.35	1.043	1.108	2.358

Yield Attributes and yield

Number of Tillers plant^{-1}

Number of tillers per plant of pearl millet as influenced by various combinations of treatments in pearl millet is presented in Table 3. In general, the number of tillers plant^{-1} of pearl millet decreased with the advancement of crop age i.e. from 30 DAS to harvest. However, numbers of tillers plant^{-1} 5.85 at 30 DAS and 4.67 at harvest was maximum in treatment 1.5kg + 40 and statically at par with treatment 1.5kg + 30 with observation 5.32 number of tillers plant^{-1}. At harvest 4.43 number of tillers plant^{-1} were influenced due to treatment 1.5kg + 30. Lowest numbers of tillers plant^{-1} 3.16 and 3.00 was recorded at 30 DAS and at harvest in broadcasting method with 3kg seed rate treatment.

Number of ears plant^{-1}

Number of car head plant^{-1} of pearl millet recorded under different treatments is presented in Table 3. The result revealed that higher 2.77 number of ears plant^{-1} was which is recorded with treatment 1.5kg + 40 cm which at par with 1.5kg + 30 cm i. e (2.65) number of ears plant^{-1} and lowest 1.40 number of ear plant^{-1} in broadcasting method with 3kg seed rate treatment. Gondal *et al.* (2017) study row density (30 cm) sowing and yielded the highest number of heads. This result was explained by better utilization of the given area

Ear length (cm)

A close perusal of the data in Table 3 on ear length reveals that various combinations of seed rate and spacing influenced the ear length of pearl millet significantly. The pearl millet in association with treatment 1.5kg + 40 cm resulted in significantly longer ear length (24.96 cm) as compared to rest of the treatments and it was at par with treatment 1.5kg + 30 (25.38 cm). The lowest 20.85cm number of ear length in broadcasting method with 3kg seed rate treatment.

1000 grain weight (g)

Test weight (1000 grain weight) of pearl millet was significantly influenced (Table 4). Perusal of data revealed that 1000 grain weight 10.70g of pearl millet was found to be statistically higher on which is in treatment 1.5kg + 40 cm which is at par with 1.5kg + 30 cm i.e 10.50g. Lowest 1000 grain weight 8.32 g m of pearl millet was obtained in broadcasting method with 3kg seed rate treatment. Also similar study by Worku (2008) showed that increasing the rate of seeding decreased the number of grains per spike. Moreover, Hussins and Pan (1993) reported that the number of kernels per spike decreased with an increase in seeding rate.

Grain yield (q ha^{-1})

The data pertaining to grain yield of pearl millet is presented in Table 4. Maximum grain yield 30.82 q ha^{-1} was recorded in treatment 1.5kg + 40 which was at par with treatment 1.5kg +30 (29.87 q ha^{-1}). Lowest grain yield was obtained in broadcasting method with 3kg seed rate treatment (19.51 q/ha). Similarly, with the present finding, Haile *et al.* (2013) reported that the lower seed rate resulted in lower grain yield while higher yield was due to higher seed rate. However, the interaction effect of seed rate and row spacing showed none significant ($p>0.05$) effect on grain yield.

Biological yield (q ha^{-1})

The data pertaining to grain yield of pearl millet is presented in Table 4. Maximum biological yield 110.91 q ha^{-1} was recorded in treatment 1.5kg + 40 which was at par with treatment 2kg +30 (106.78 q ha^{-1}). Lowest biological yield was obtained in broadcasting method with 3kg seed rate treatment (93.36 q/ha). Similarly, with the present finding, Haile *et al.* (2013) reported that the lower seed rate resulted in lower grain yield while higher yield was due to higher seed rate. However, the interaction effect of

seed rate and row spacing showed none significant ($p>0.05$) effect on grain yield.

Harvest index (%)

The data revels that the harvest index % of pearl millet is presented in Table 4. Maximum harvest index 27.78% was recorded in treatment 1.5kg + 40 which was at par with treatment 1.5kg +30 (27.67%). Lowest harvest index % was obtained in broadcasting method with 3kg seed rate treatment (20.89%). Similarly, with the present finding, Haile *et al*. (2013) reported that the lower seed rate resulted in lower grain yield while higher yield was due to higher seed rate.

Table 3: Effect of various treatments on yield attributes and yield of bajra.

Sr. No.	Treatments	No. of tillers/plant 30 DAS	No. of tillers/plant at Harvest	No. of ears per plant	Ear length (cm)
1	T1: 1.5kg+ 30 cm	5.32	4.43	2.65	25.38
2	T2 :1.5kg + 20 cm	4.77	3.70	2.03	22.21
3	T3 :1.5kg +40cm	5.85	4.67	2.77	24.96
4	T4 :2kg +30 cm	5.07	3.81	2.47	24.75
5	T5: 2kg + 20cm	5.03	4.10	2.36	24.60
6	T6:2kg +40 cm	5.18	3.80	2.64	25.14
7	T7:2.5kg+30cm	5.10	4.07	2.39	22.71
8	T8:2.5kg+20cm	4.63	3.57	2.24	23.70
9	T9:2.5kg+40cm	4.33	4.10	2.27	23.40
10	T10(3kg) broadcasting	3.16	3.00	1.40	20.85
CD at (0.05%)		0.38	0.35	0.14	0.21

Table 4: Effect of various treatments on yield attributes and yield of bajra.

Sr. No.	Treatments	1000 Grains weight (g)	Grain yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)
1	T1:1.5kg+30cm	10.50	29.87	107.95	27.67
2	T2 :1.5kg + 20 cm	09.38	26.14	104.63	24.98
3	T3 :1.5kg +40 cm	10.70	30.82	110.91	27.78
4	T4 :2kg +30 cm	10.12	27.60	106.78	25.84
5	T5: 2kg + 20 cm	09.88	25.51	102.91	24.78
6	T6:2kg +40 cm	09.29	26.76	105.50	25.36
7	T7:2.5kg +30cm	09.28	26.23	105.10	24.95
8	T8:2.5kg+20cm	08.49	26.84	105.79	25.37
9	T9:2.5kg +40cm	09.61	26.79	105.65	25.35
10	T10(3kg) broadcasting	08.32	19.51	93.36	20.89
	CD at (0.05%)	0.24	1.12	3.35	0.66

Phenological studies (DAS)

The data pertaining to days taken for the nine phenological stages i.e. emergence, five leaf stage, panicle initiation, flag leaf stage, boot stage, milk stage, dough stage and physiological maturity under different treatments are presented in Table 5. Perusals of data reveals that various combinations of treatments to influence any of the phenological stages of pearl millet.

Emergence (DAS)

The notable impact of different treatments on the emergence of seedlings of pearl millet. The treatment 1.5 kg + 40 cm shown the significantly minimum 3.14 DAS to seedling emergence at par with treatment 1.5 kg + 30 cm with 3.18 DAS to seedling emergence. The maximum 3.34 DAS to seedling emergence was taken by broadcasting (3kg) treatment

Five Leaf stage (DAS)

Data revels that the significantly minimum numbers of days taken to five leaf stage was recorded with the treatment 1.5 kg + 40 cm i.e. 13.13 DAS which is at par with treatment 1.5 kg + 30 cm and 2.5kg + 30 cm with 13.17 DAS and 13.20 DAS respectively. The maximum 14.24 days taken to five leaf with the treatment by 2.5 kg + 40 cm. Which is

due to enough space between the plant which helps in proper sunlight and aeration to grow more vigorously.

Panicle initiation (DAS)

Effect of panicle initiation of pearl millet was noticed that significantly minimum 22.19 DAS to panicle initiation was recorded with treatment 1.5 kg + 40 cm which is at par with treatment 1.5 kg + 30 cm with readings of 22.23 DAS to panicle initiation respectively. The maximum 23.15 DAS to attain panicle initiation in pearl millet plant was taken by broadcasting method with 3 kg seed rate treatment. Which is due to enough space between the plant which helps in proper sunlight and aeration to grow more vigorously.

Flag Leaf (DAS)

Data on emergence of flag leaf DAS were recorded and were summarized in Table 5 and remarkable improvement was observed due to different treatments. The significantly minimum 36.24 DAS was taken to emergence of flag leaf with treatment 1.5 kg + 40 cm which is at par with treatment 1.5 kg + 30 cm (36.26 DAS). The maximum 37.86 DAS was taken to emergence of flag leaf in pearl millet by the treatment broadcasting + 3 kg seed.

Boot Stage (DAS)

The significantly minimum 39.13 DAS was taken to initiation of boot stage with the treatment 1.5 kg + 40 cm which is at par with treatment 2 kg + 30 cm (39.18 DAS). The maximum 39.72 DAS was taken to initiation of boot stage in pearl millet with the treatment of broadcasting + 3 kg seed rate. This might be due to Lower seed rates and wider spacing which promote earlier and more uniform maturity by reducing stress and enhancing resource use efficiency.

Table 5: Effect of various treatments on phenological stages of bajra.

Sr. No.	Treatments	Emergence	Five leaf stage	Panicle initiation	Flag leaf	Boot stage	Milk stage	Dough stage	Physical maturity
1	T1: 1.5kg + 30 cm	3.18	13.17	22.23	36.26	39.44	52.50	60.20	67.32
2	T2 :1.5kg + 20 cm	3.28	13.92	22.36	36.34	39.24	52.43	60.81	68.32
3	T3 :1.5kg +40 cm	3.14	13.13	22.18	36.24	39.13	51.15	60.18	67.27
4	T4 :2kg +30 cm	3.28	13.80	22.50	36.56	39.18	51.17	60.32	68.12
5	T5: 2kg + 20 cm	3.26	13.67	22.45	36.66	39.63	52.83	60.33	68.40
6	T6:2kg +40 cm	3.23	13.66	22.46	36.76	39.67	52.40	60.47	67.73
7	T7:2.5kg +30cm	3.25	13.20	22.45	37.71	39.66	52.01	60.33	68.03
8	T8:2.5kg+20cm	3.26	14.17	22.41	37.73	39.60	52.43	60.97	67.97
9	T9:2.5kg +40cm	3.30	14.24	22.38	37.84	39.68	52.30	60.77	67.50
10	T10(3kg) broadcasting	3.34	14.14	23.15	37.86	39.72	55.61	63.73	70.53
CD at (0.05%)		0.03	0.19	0.22	0.03		0.05	0.042	0.040

Milk Stage (DAS)

The significantly minimum 51.15 DAS taken to milk stage was recorded with the treatment 1.5 kg + 40 cm which is at par with treatment 2 kg + 30 cm (51.17 DAS). The maximum 55.61 DAS was recorded to milk stage in pearl millet with the treatment broadcasting + 3 kg seed rate. This might be due to Lower seed rates and wider spacing which promote earlier and more uniform maturity by reducing stress and enhancing resource use efficiency.

Dough Stage (DAS)

The significantly minimum 60.18 DAS was taken to dough stage with treatment 1.5 kg + 40 cm which is at par with treatment 1.5 kg + 30 cm (i.e. 60.20 DAS). The maximum 63.73 DAS was observed for dough stage in pearl millet with the treatment broadcasting method with 3 kg seed rate. This might be due to Lower seed rates and wider spacing which promote earlier and more uniform maturity by reducing stress and enhancing resource use efficiency.

Physical Maturity (DAS)

Physiological maturity is marked by the formation of a small black layer in the hill region of the seed. The significantly minimum 67.27 DAS was taken to physical maturity with treatment 1.5 kg + 40 cm spacing which is at par with treatment 1.5 kg + 30 cm i.e. 67.32 DAS and followed by treatment 2.5 kg + 40 cm with 67.50 DAS. The maximum days was taken to physical maturity i.e. 70.53 DAS with the treatment broadcasting method with 3 kg seed rate. This might be due to Lower seed rates and wider spacing which promote earlier and more uniform maturity by reducing stress and enhancing resource use efficiency.

Economics:

Cost of cultivation:

Cost of cultivation was significantly influenced by the various seed rate and spacing, that the minimum cost of cultivation was recorded with the treatment of 1.5kg + 30 cm i.e. 18,700/- and maximum with the treatment 2.5kg+20cm.

Gross returns:

Significantly higher gross returns were recorded with the treatment 1.5kg +40 cm i.e. 72,215/- and minimum gross returns was recorded with the treatment broadcasting + 3kg seed rate. That the all other treatments show the results at par with each other.

Net returns effect of treatments

Economic analysis in Table 6 indicated that net returns of bajra influenced significantly due to seedrates and spacing. Crop sown using seed rate of 1.5kg ha^{-1} with 40 cm spacing recorded higher net return of 53,015 as compared to other seedrates and spacing.

B:C ratio effect of treatments

It can be stated that data in Table 6 indicated that B:C ratio of bajra influenced significantly due to various seed rates & spacing. Crop sown using 1.5kg seed rate ha^{-1} with 40 cm spacing recorded significantly higher B.C ratio 2.76 as Compared to seed rate 2.5 kg ha^{-1} and 3 kg ha^{-1}. But it was at par with 2 Kg ha^{-1} with same spacing.

Table 6: Effect of different treatments on cost of cultivation (Rs./ha.), gross returns (Rs./ha), net returns (Rs./ha) and benefit -cost ratio.

Sr. No	Treatments	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	Benefit cost ratio
1.	T1: 1.5kg + 30 cm	18,700	69680	50,989	2.72
2.	T2 :1.5kg + 20 cm	20,350	67040	46,690	2.29
3.	T3 :1.5kg +40 cm	19,200	72215	53,015	2.76
4.	T4 :2kg +30 cm	19,600	68870	49279	2.51
5.	T5 :2kg +20cm	20,210	66860	46,650	2.30
6.	T6:2kg +40 cm	19,100	67910	48,810	2.55
7.	T7:2.5kg +30cm	22,100	67,300	45,200	2.04
8.	T8:2.5kg+20cm	22,540	67970	45,430	2.01
9.	T9:2.5kg +40cm	21,970	67940	45,970	2.09
10.	T10 (3kg) broadcasting	20,000	56,700	36,700	1.83

Conclusion

It is concluded that the Crop sown with seed rate 1.5 kg ha^{-1} and spacing 40cm recorded significantly higher yield attribute, yield, Net return, B:C ratio on the findings of the present investigation. It is recommended that the crop sown using seed rate of 1.5 kg ha^{-1} with 40 cm spacing. However, these results are only indicatives and required further experimentation to arrive at some consistent and final conclusion.

Disclaimer (Artificial Intelligence)

Authors hereby declare that No generative AI technologies such as Large language models (Chat GPS, COPILOT, etc) and text to image generators have been used during writing, editing of manuscripts.

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Competing Interests

Authors have declared that no competing interests exist.

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