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Effect of time of sowing and spacing on grain Amaranthus (*Amaranthus hypochondriacus* L.)

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Abstract
A field experiment was conducted at Agronomy Instructional Farm, C.P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar, Gujarat to find out the Effect of time of sowing and spacing on grain amaranthus during *rabi* season of the year 2021-22. The experiment consists of twelve treatment combinations comprised of four time of sowing (3rd week of October, 1st week of November, 3rd week of November and 1st week of December) and three row spacing (22.5 cm, 30.0 cm and 45.0 cm). Among four time of sowing 3rd week of November to 1st week of December was found markedly superior than 3rd week of October and 1st week of November in respect to growth and yield attributes *viz.*, Plant height, Inflorescence length, Grain yield per plant, Test weight, Grain yield and Stover yield, Harvest index along with Benefit Cost ratio Whereas, 22.5 cm row spacing recorded significantly highest Grain yield and Benefit Cost ratio followed by 30.0 cm row spacing and lowest was associated with 45.0 cm row spacing, but reverse trend was observed regarding length of Inflorescence and grain yield per plant both. The highest net realization of ₹ 100443 ha^{-1} and higher BCR value of 3.34 were recorded in time of sowing 3rd week of November. Among spacing S_1 (22.5 cm) resulted in highest net realization ₹ 104671 ha^{-1} with BCR value of 3.36.

Keywords: Grain amaranthus, *Amaranthus hypochondriacus* L., sowing times

Introduction
Grain amaranthus/Rajgira (*Amaranthus hypochondriacus* L.) is a potential upcoming subsidiary food crop of the future. It belongs to the family Amaranthaceae. Its called a pseudo cereal is an under exploited tropical novel crop with a high nutritive value. Amaranthus are broad-leafed plants, one of the few nongrasses that produces significant amount of edible "cereal" grain. Amaranthus, as already noted are among the group of plants that carry on photosynthesis by the spealized C_4 path-way they are one of the few C_4 crop species that are not grasses. The C_4 path-way is modification of normal photosynthesis process that makes efficient use of CO_2 avaialable in air by concentrating it in the chloroplast of specialized cell surrounding the leaves vascular bunduls. C_4 plant such as amaranthus, perform better than C_3 plant under adverse conditions such as drought and salinity. It is the richest source of protein (16%) and amino acids like lysine (5%), cystine (2.9%), methionine (4.4%) and tryptophan (1.4%) in comparison to the cereal crops *viz.*, barley, maize, rice and wheat. Lysine in grain amaranthus is said to be herbal cure for herpes. The high lysine content of amaranthus improve the protein quality of foods that is particularly beneficial for infants, children, pregnant and lactating women. Among the crop management factor, time of sowing and spacing play a vital role in boosting the yield. Environmental factors could be governed possibly by sowing time which have great bearing on the realization of the yield potential of the crop. Besides, weather parameter, management practices also influence the overall performance of the crop. Grain amaranthus show considerable variation in regards to its growth habit, yield potential and respond differentially to plant population. Optimum plant population is necessary to fully utilize higher level of nutrient in the soil to realize higher yield. So, optimum row spacing play an important role in increasing yield. Therefore, this experiment was framed out.

Materials and Methods
A field experiment was conducted at Agronomy Instructional farm, Sardarkrushinagar Dantiwada Agriculture University, Sardarkrushinagar to find out the "Effect of time of sowing and spacing on grain amaranthus (*Amaranthus hypochondriacus* L.)" during *rabi* season of 2021-22. The experiment consists of twelve treatment combinations comprised of four time of sowing (3rd week of October, 1st week of November, 3rd week of November and 1st week of

December) and three row spacing (22.5 cm, 30.0 cm and 45.0 cm). The experiment was laid out in Strip Plot Design with four replications. The soil of experimental plot was loamy sand in texture. The soil was low in organic carbon (0.29%) and available nitrogen (137.56 kg ha^{-1}), medium in available phosphorus (43.42 kg ha^{-1}) and high in available potash (281 kg ha^{-1}). During the investigation, grain amaranthus 'GA 6' variety was used. This variety was improved variety of grain amaranthus released by Centre for Crop Improvement, Sardarkrushinagar Dantiwada Agricultural University, SDAU. Amaranthus were sown with seed rate as per spacing requirements. The economics was workout on current market price basis. Nitrogen was given as per recommended in the form of Urea. The full dose of Phosphorus from DAP and half dose of Nitrogen applied as basal dose at the time of sowing and remaining half dose was applied 30 DAS after sowing. Based on the plant apparent status, irrigation water was applied. The protein content (%) in seed was estimated from the nitrogen as per Kjeldahl's method and protein was calculated by multiplying nitrogen with a factor of 6.25. The value of "F" was worked out and compared with the values of table F at 5 percent level of significance. The value of S.Em±, C.D. and C.V. percent were also calculated.

Results and Discussion

The finding of present study as well as relevant discussion have been presented under following heads.

Table 1: Growth, Yield attributes, Yield, quality and economics of grain amaranthus as influenced by different time of sowing and spacing

Treatment	Plant height at Harvest (cm)	Inflorescence length (cm)	Grain yield per plant (g)	Protein content (%)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Net return (₹ ha^{-1})	BCR
Time of sowing (D)								
D_1: 3rd week of Oct.	114.3	64.5	8.4	12.50	1377	3237	68938	2.61
D_2: 1st week of Nov.	114.7	67.0	8.6	12.62	1602	3487	87062	3.03
D_3: 3rd week of Nov.	126.0	72.7	9.7	12.75	1767	3847	1004443	3.34
D_4: 1st week of Dec.	122.0	71.1	9.2	12.92	1712	3658	95948	3.24
S.Em±.	2.49	1.74	0.24	0.15	54.57	126.12	-	-
C.D. at 5%	7.95	5.56	0.77	NS	175	403	-	-
C.V. %	7.22	8.75	9.30	4.16	11.71	12.28	-	-
Spacing (S)								
S_1: 22.5 cm	124.8	66.4	7.8	12.68	1838	3833	104671	3.36
S_2: 30.0 cm	117.4	69.5	9.2	12.71	1609	3656	87828	3.06
S_3: 45.0 cm	115.6	70.6	9.9	12.69	1397	3183	71834	2.73
S.Em±.	2.13	0.88	0.20	0.13	35.81	87.07	-	-
C.D. at 5%	7.38	3.05	0.69	NS	124	301	-	-
C.V. %	7.16	7.75	8.95	4.02	8.87	9.79	-	-
Interaction (D×S)								
S.Em±.	4.23	2.41	0.38	0.25	62.66	162.00	-	-
C.D. at 5%	NS	NS	NS	NS	186	NS	-	-
C.V. %	7.09	7.12	8.55	3.86	7.76	9.11	-	-

Effect of time of sowing (D)

The data presented in (Table -1) showed that, among different time of sowing, 3rd week of November (D_3) produced significantly higher grain yield of 1767 kg ha^{-1} which was remained at par with 1st week of December (D_4). The increase in grain yield of grain amaranthus under the treatment D_3, D_4 and D_2 were at the extent of 28.32, 24.33 and 16.34 percent, respectively as compared to D_1. The increase in stover yield of sowing time D_3 (3rd week of November) recorded significantly the higher value 3847 kg ha^{-1} which was remained at par with 1st week of December (D_4). The increase in stover yield of grain amaranthus under the treatment D_3, D_4 and D_2 were at the extent of 18.84, 13.00 and 7.72 percent, respectively as compared to D_1.The higher grain yield and stover yield of 3rd week of November sowing time, might be due to under favourable temperature and weather conditions throughout the growing period might have resulted in higher rate of photosynthesis as well as higher translocation of photosynthates from various plant organs to the development and ultimately higher values of growth and yield attributes *viz.*, plant height and inflorescence length which resulted in higher grain yield and stover yield. The results agreed with the finding of Trioni *et al.* (2004) [11] and Bhargava *et al.* (2007) [1]. The result showed that the time of sowing 3rd week of November recorded significantly the higher plant height at 60 DAS (82.3 cm) and at harvest (126.0 cm), inflorescence length (72.7 cm) and grain yield per plant (9.7 g) which was remained at par with D_4 (1st week of December). This might be due to vigorous growth of plants, as favourably influenced by weather conditions for better growth and development as well as reproductive growth phase. The results collaborate with the findings of Trioni *et al.* (2004) [11], Chaudhary *et al.* (2009) [2] and Vaghela *et al.* (2018) [12].

Effect of spacing (S)

The data presented in (Table 1) showed that, the effect on grain yield was observed in spacing S_1 (22.5 cm) recorded significantly the highest grain yield 1838 kg ha^{-1}. In case of stover yield S_1 (22.5 cm) recorded also significantly the higher stover yield 3833 kg ha^{-1} which was remained at par with spacing S_2. It might be due to these yield contributing characters were significantly affected by different plant population. Even though, per plant grain yield was higher in wider spacing, the total grain yield of grain amaranthus was low as compared to the closer spacing (higher plant population) as it could not compensate the loss in number of plants per hectare. Higher grain yield of grain amaranthus at closer spacing might be due to more number of inflorescence per hectare as compared to wider spacing. Higher stover yield obtained under closer spacing in present investigation might

be due to higher number of plant density per hectare as well as plant height and higher vegetative growth. Similar observations of higher grain and stover yield of grain amaranthus under closer spacing (higher plant density) as compared to wider spacing (lower plant density) was also reported by Patel (2003) [8], Chaudhary *et al.* (2009) [2], Mulandana *et al.* (2009) [6], Olofintoye *et al.* (2011) [7], Pravin *et al.* (2013) [9], Maseko *et al.* (2015) [3], Ramesh *et al.* (2017) [10] and Mohammad *et al.* (2020) [5]. In case of spacing S_1 recorded significantly the higher inflorescence length which was remained at par with S_2. Grain yield per plant were recorded significantly the highest at spacing S_1. The highest grain yield per plant and higher inflorescence length under the spacing 45.0 cm might be due to low plant density, less plant competition, availability of sufficient light and moisture to an individual plant in wider spacing might be enhanced better plant growth, development and reproductive phase, which ultimately resulted in increased inflorescence length and grain yield per plant. Similar results were also reported by Chaudhary *et al* (2009) [2].

Interaction effect

Interaction effect between time of sowing and spacing was found nonsignificant with respect to growth attributes and yield attributes but it was found significant in case of grain yield. The higher grain yield was recorded in treatment combination of D_3S_1 (3rd week of November along with 22.5 cm) (2100 kg ha^{-1}), but it was at par with D_4S_1.

Economics of different treatment

Economics play important role in deciding the adoption of particular treatment by the farmers. Therefore, the gross realization, net realization and benefit cost ratio (BCR) were calculated for time of sowing and spacing.

Effect of time of sowing (D)

The data on economics revealed that maximum gross realization (143284 ₹ ha^{-1}) and net realization (100443 ₹ ha^{-1}) with maximum BCR value of 3.34 were obtained under sowing time D_1 (3rd week of November).

Effect of spacing (S)

Maximum gross realization (148957 ₹ ha^{-1}) and net realization (104671 ₹ ha^{-1}) with maximum BCR value of 3.36 were obtained under spacing S_1 (22.5 cm).

Conclusion

Based on result of the field experiment, it is concluded that grain amaranthus crop should be sown on 3rd week of November to 1st week of December along with row spacing 22.5 cm for obtaining higher grain yield and net return.

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