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RELATIVE PERFORMANCE OF VEGETABLE AMARANTHS WITH DIFFERENT SPACING UNDER HARYANA CONDITION

MAKHAN LAL, KULDEEP KUMAR AND VIKASH KUMAR

Department of Vegetable Science
CCS Haryana Agricultural University-Hisar (Haryana)
**(e-mail: makhanmajoka72@gmail.com)*

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SUMMARY

Amaranths or 'Chaulai' is used as a potherb and belongs to the family Amaranthaceae. It is the most common leafy vegetable grown during the summer and rainy seasons in India. This crop is suitable for crop rotations because of its short duration and more yield per unit area. Amaranth is believed to be originated in India. Amaranths (*Amaranthus spp.*) is an herbaceous plant or shrub that genus comprised of more than 50 species of annual or short-lived perennial plants. The present experiment was conducted at Research Farm, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar (Haryana) during 2023 and 2024, respectively. The experiment was laid out in Randomized Block Design with four replications to determine the most suitable variety with proper spacing to maximize per unit production. There were total two varieties *viz*. Pusa Kiran (Green) and Pusa Lal Chaulai (Red) and three spacing such as 20 x 10 cm, 25 x 10 cm and 30 x 10 cm, *respectively* were used for the present study. Among the varieties, higher average leaf yield per plant (56.39 g) and average leaf yield per hectare (228.28 q/ha) was recorded in Pusa Kiran (Green) variety. Among different spacing, maximum average leaf yield per plant (62.59 & 38.84 g), respectively were recorded in higher spacing 30x10 cm in both varieties. However, maximum average leaf yield per hectare (256.61 & 152.56 q/ha) was recorded in closer spacing 20x10 cm in both varieties Pusa Kiran (Green) and Pusa Lal Chaulai (Red), *respectively*.

Key words: Vegetable amaranths, spacing, variety and leaf yield

Amaranths or 'Chaulai' is used as a potherb and belongs to the family Amaranthaceae. The word 'Amaranth' is derived from the Greek word "Anthos" which means "everlasting" according to Sankaran (1943). It is the most common leafy vegetable grown during the summer and rainy seasons in India. The crop is suitable for crop rotations because of its short duration and more yield/unit area. Amaranth is believed to be originated in India. Amaranth (*Amaranthus spp.*) is an herbaceous plant or shrub of annual or short-lived perennial plants. Amaranths, a genus consisting of more than 50 species, is an important promising food crop for its resistance to heat, drought, disease & pest and high nutritional value (Rastogi and Shukla, 2013 & Svirskis, 2003). Four species of Amaranthus are documented as cultivated vegetables in eastern Asia are *Amaranthus cruentus, Amaranthus blitum, Amaranthus dubius, and Amaranthus tricolor.* Most of the cultivated species are monoecious, wind-pollinated but the grain species with colourful inflorescence are occasionally visited by bees (Khusboo and Pal, 1970). It is found globally, particularly prevalent in the tropics and subtropics. Amaranths are broad leaved plants that can reach a height of 0.5–3 meters, depending on the species. They have bushy forms with thick stalks and leaves that can be lanceolate, ovate or elliptic. Leaf color varies from green to red, purple or even mixed colors. The plants produce flowers on terminal spikes, usually red to purple. It is called leafy vegetable and the leaves of some species are widely consumed as vegetables, particularly in Asia and Africa. They are often eaten raw, stir-fried, steamed and used in curries and other dishes. Young leaves are a good substitute for spinach. Some species are cultivated for their seeds which are eaten as a cereal grain. These seeds can be ground into flour, popped like popcorn, cooked into porridge and used in confectionery. Amaranths also grow as an ornamental plant. Certain species are grown for their attractive appearance and used to decorate gardens. Amaranths have a long history of use in traditional medicine in various cultures. It is considered a super food due to its rich nutritional profile. Amaranth grain is notable for its high protein content (14-18%) and balanced amino acid profile, particularly rich in lysine. The leaves and stems are rich in both soluble

and insoluble dietary fibers, making it beneficial for managing cholesterol and weight. Amaranth leaves are packed with vitamins, especially vitamin-C and have high concentrations of vitamin-K. They also contain important antioxidant vitamins like vitamin-A. Amaranth is a good source of iron, potassium, phosphorus, manganese and calcium. Amaranth contains various phyto-nutrients and antioxidants. Amaranth holds cultural significance in some parts of the world. In India, it's known as 'Rajgira' (royal grain) or 'Ramdana' (God's own grain).

There is continues, needs for exploring its potential as a promising crop of the future due to its flexibility to harsh growing conditions and its high nutritional value. Land holding size is decreasing day by day and population is vice-versa across the country. Therefore, we have to capture maximum productivity with limited resources. Among the different limitations in production of amaranth, conventional methods such as suitable varieties and proper spacing are important issues to handle. Each and every crop needs a proper sowing date, optimum spacing depending upon climatic conditions, soil and variety so that its critical stage should correspond with favorable weather conditions. A good cultivar sown at an improper spacing will result in poor yield. Proper plant spacing and suitable cultivar is critical to increased production of amaranth. Inappropriate plant spacing leads to the yield penalty and ultimately the loss to the growers. If a good cultivar is sown at proper time, at a proper location with optimum spacing, it may give maximum yield (Bake *et al.*, 2017). Plant spacing less than optimum results in poor growth, less yield and poor quality fruits while high plant density may lead to vigorous growth, poor quality fruits and low yield (Moniruzzaman *et al.*, 2007). Optimum plant spacing is responsible for higher production by efficient utilization of underground resources and also solar radiation and in turn better photosynthetic (Thavaprakash *et al*., 2005). Therefore, emphasis must be given to increase the per hectare yield of amaranths by adopting proper spacing. Sowing of good quality seed at appropriate time with best spacing gives highest yield. (Yadav and Dhankhar 2001 & Moniruzzaman *et al.*, 2007).

Therefore, suitable variety and spacing are significant for seed production of the crop. Keeping the above facts in mind the present study was planned with the objective to find out the growth and leaf yield attributes of vegetable amaranths. Therefore, present study is planned to determine the most suitable varieties of vegetable amaranthus with proper spacing to maximize growth and leaf yield and its attributes.

MATERIALS AND METHODS

The present experiment was conducted at Research Farm, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar (Haryana) during two consecutive summer seasons 2023 and 2024, *respectively*. The experiment was laid out in Randomized Block Design with four replications to determine the most suitable variety with proper spacing to maximize per unit production under Haryana condition. There were total two varieties *viz.* Pusa Kiran (Green) and Pusa Lal Chaulai (Red) and three spacing such as 20x10 cm, 25x10 cm and 30x10 cm were used for the present study.

Mean monthly meteorological data for the amaranthus crop during the experimental period of the summer seasons of 2023 & 2024, *respectively*, which were recorded at the observatory in the Department of Agricultural Meteorology at Chaudhary Charan Singh Haryana Agricultural University, Hisar. Table 1 & Table 2 shows the mean monthly data for the same period is given below.

Amaranth crop was sown in the summer season in the first fortnight March of both years. The seed was sown in by drilling in lines keeping the spacing

TABLE 1
The mean monthly agro-meteorological data from month of March to June, 2023

Month	Temperature (°C)		Relative humidity (%)		Sun-shine hours	Total rainfall (mm)	Wind speed (km/h)	PAN Evap. (mm)
	Max.	Min.	Morn.	Even.				
MAR-23	28.9	13.9	89	57	5.8	12.8	4.0	3.2
APR-23	34.7	19.0	70	35	8.3	6.7	4.4	6.5
MAY-23	36.9	21.4	65	33	7.3	59.7	6.3	7.0
JUN-23	36.9	25.8	72	47	6.8	18.8	6.2	6.1

Source: Department of Agricultural Meteorology, CCS HAU, Hisar.

TABLE 2
The mean monthly agro-meteorological data from month of March to June, 2024

Month	Temperature (°C)		Relative humidity (%)		Sun-shine hours	Total rainfall (mm)	Wind speed (km/h)	PAN Evap. (mm)
	Max.	Min.	Morn.	Even.				
MAR-24	28.1	12.1	87	38	6.9	43.2	4.1	3.5
APR-24	35.6	17.8	66	22	7.8	6.8	4.5	6.1
MAY-24	41.8	24.2	51	17	9.4	0	5.4	9.4
JUN-24	41.3	27.5	58	31	7.5	38.4	7.3	9.2

Source: Department of Agricultural Meteorology, CCS HAU, Hisar.

as per the treatments. Seeds were sown 1.5-2.0 cm deep because of its small seed size and then covered with thin and fine layer of soil. Plant to plant spacing within the rows is maintained 10 cm at the time of thinning. First irrigation was given as a *plewa* (pre-irrigation) before sowing of amaranth crop and subsequent irrigations were given at 8-10 days intervals and whenever required to maintain optimum moisture content. To maintain the fertility of investigated field three major elements nitrogen, phosphorus and potassium were applied in the form of urea, di-ammonium phosphate and muriate of potash, *respectively* at the rate of 50:50:20 kg per hectare at the time of field preparation. Weeding was important in early stage of crop growth due to its small seed size and slow early growth. Pendimethalin 400-500 g/acre (stomp 30% @ 1.3-1.7 liters) just after sowing was applied for better weed control. There were total three hands weeding made to keep the weeds under check. In this experiment periodical cutting of leaves were taken of this crop. The first cutting was taken 3-4 week after sowing and subsequent cutting were made at 8-10 days interval as per variety character. To reduce the water loss from leaf surface, harvesting was made during the cooler part of the day as such early morning.

The data was analyzed statistically by using OPSTAT software developed by CCS Haryana Agricultural University, Hisar (Haryana) (Sheoran *et al*., 1998).

RESULTS AND DISCUSSION

Days to harvest and number of cuttings

Data regarding days to first harvest, days to last harvest and number of cuttings of both cultivated varieties were found non-significant on both years 2023 and 2024, respectively (Table 3). In Pusa Kiran (Green) variety of amaranths, average days to first harvest were recorded 24 days after sowing in both the consecutive year, on the other hand Pusa Lal Chaulai (Red) variety ready for harvest at 30 days after sowing. Regarding days to last harvest after sowing, average days for last harvest were recorded 101 days and 106, *respectively* in Pusa Kiran and Pusa Lal Chaulai variety of amaranths. Average 7.5 numbers of cuttings were taken in both varieties during both the year 2023 and 2024, respectively.

Average leaf length (cm) and average leaf width (cm)

Significant results were recorded regarding leaf yield parameters of amarnthus as average leaf length and average leaf width (Table-4). Among the varieties, higher average leaf length (8.21 cm) and leaf width (4.80 cm) were recorded in Pusa Kiran (Green) variety. Among different spacing, maximum average leaf length (8.31 & 6.50 cm) and leaf width (4.92 & 4.38 cm), respectively were recorded in higher spacing 30x10 cm in both varieties. However, minimum average leaf length (8.10 & 6.24 cm) and leaf width (4.67 & 4.17 cm), respectively were recorded in closer spacing 20x10 cm in both varieties. This might be due to the fact that closer plant spacing having higher plant density attributed the competition for light and other growth parameters. Similar results have also been reported by Singh *et al.* (1986) and Ram *et al.* (2013).

Average leaf yield per plant and Average leaf yield per hectare

The data presented in Table 3 shows that average leaf yield per plant and average leaf yield per hectare were found significant. Among the varieties, average higher leaf yield per plant (56.39 g) and leaf

TABLE 3
Varietal effect with different spacing on harvesting of vegetable amaranths (Pooled data 2023 and 2024)

Treat.	Days to first harvest			Days to last harvest			No. of cuttings		
	2023	2024	Mean	2023	2024	Mean	2023	2024	Mean
Pusa Kiran (Green)									
20x10	25	23	24	106	96	101	8	7	7.5
25x10	25	23	24	106	96	101	8	7	7.5
30x10	25	23	24	106	96	101	8	7	7.5
Mean	25	23	24	106	96	101	8	7	7.5
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	-	-	-	-	-	-	-	-	-
Pusa Lal Chaulai (Red)									
20x10	30	30	30	107	105	106	8	7	7.5
25x10	30	30	30	107	105	106	8	7	7.5
30x10	30	30	30	107	105	106	8	7	7.5
Mean	30	30	30	107	105	106	8	7	7.5
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	-	-	-	-	-	-	-	-	-

yield per hectare (228.28 q/ha) were recorded in Pusa Kiran (Green) variety as compare to Pusa Lal Chaulai. It may be due to varietal characters. Among different spacing, maximum leaf yield per plant 62.59 g in Pusa Kiran variety and 38.84 g in Pusa Lal Chaulai, *respectively* was found at higher spacing 30x10 cm in both varieties. This may be due to that widely spaced plants have more number of branches than close spaced plants and availability of more feeding area in terms of nutrients and light to plants in comparison to plants at closer spacing. A similar result has also been reported by Singh *et al*. (1986). However, maximum

TABLE 4
Varietal effect with different spacing on leaf length and width of vegetable amaranths (Pooled data 2023 & 2024)

Treatments	Av. leaf length (cm)			Av. leaf width (cm)		
	2023	2024	Mean	2023	2024	Mean
Pusa Kiran (Green)						
20x10	8.20	8.00	8.10	4.73	4.60	4.67
25x10	8.33	8.13	8.23	4.87	4.78	4.83
30x10	8.41	8.20	8.31	4.99	4.84	4.92
Mean	8.31	8.11	8.21	4.86	4.74	4.80
CD at 5%	0.08	0.07	0.08	0.08	0.06	0.07
CV (%)	1.57	1.51	1.54	0.73	0.62	0.68
Pusa Lal Chaulai (Red)						
20x10	6.28	6.20	6.24	4.19	4.15	4.17
25x10	6.40	6.32	6.36	4.29	4.21	4.25
30x10	6.55	6.44	6.50	4.45	4.30	4.38
Mean	6.41	6.32	6.37	4.31	4.22	4.27
CD at 5%	0.18	0.13	0.16	0.04	0.04	0.04
CV (%)	1.17	1.11	1.14	0.41	0.36	0.39

TABLE 5
Varietal effect with different spacing on yield of vegetable amaranths (Pooled data 2023 & 2024)

Treatments	Av. leaf yield/ plant(g)			Av. leaf yield/ha (q/ha)		
	2023	2024	Mean	2023	2024	Mean
Pusa Kiran (Green)						
20x10	54.46	48.66	51.56	271.97	241.25	256.61
25x10	59.67	50.33	55.00	238.67	201.36	220.02
30x10	67.67	57.50	62.59	225.55	190.83	208.19
Mean	60.60	52.17	56.39	245.40	211.15	228.28
CD at 5%	7.69	5.32	6.51	30.63	24.08	27.36
CV %	5.45	9.81	7.63	5.36	8.37	6.87
Pusa Lal Chaulai (Red)						
20x10	32.00	27.69	29.85	166.67	138.45	152.56
25x10	37.67	31.85	34.76	150.67	127.40	139.04
30x10	41.67	36.00	38.84	135.22	120.00	127.61
Mean	37.11	31.85	34.48	150.85	128.62	139.74
CD at 5%	4.91	4.48	4.70	15.56	12.38	13.97
CV %	5.68	8.17	6.93	5.57	6.88	6.23

average leaf yield per hectare (256.61 and 152.56 q/ha) was recorded in Pusa Kiran and Pusa Lal Chaulai varieties, respectively at closer spacing 20x10 cm. It is due more number of plants per unit area which increase the leaf yield of amaranthus.

CONCLUSION

On the basis of two years study, it may be concluded that among the varieties, higher average leaf yield per plant (56.39 g) and average leaf yield per hectare (228.28 q/ha) was recorded in Pusa Kiran

(Green) variety. Among different spacing, maximum average leaf yield per plant (62.59 and 38.84 g), respectively were recorded at higher spacing 30x10 cm in both varieties. However, maximum average leaf yield per hectare (256.61 and 152.56 q/ha), respectively was recorded at closer spacing 20x10 cm in both varieties.

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