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RESEARCH ARTICLE

Establishment Method, Spacing and Pinching Effect on Plant Growth and Seed Yield in Lamb's Quarters (*Chenopodium album* L.)

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ABSTRACT

Lamb's quarters (*Chenopodium album* L.) is a minor leafy vegetable has rich of minerals, vitamins, flavonoids etc. in which, the studies on establishment methods, spacing and pinching showed significant differences in plant growth, flowering habit and seed yield. In this regard, the direct sowing of seeds had greater effect on plant height (129.2 cm) and seed yield (2092 kg ha^{-1}) compared to transplanting of seedlings. Among different spacings, wider spacing (60 x 45 cm) recorded the highest plant height (127.9 cm), more number of primary (15) & secondary branches (111), maximum inflorescence length (23.2) and maximum seed yield $plant^{-1}$ (32.9 g) compared to other spacings. However, closer spacing (30 x 15 cm) has recorded maximum seed yield ha^{-1} (2337 kg) because of more population. Also, pinching on 30 days after sowing (DAS) has showed highest number of secondary branches (94.5) and seed yield $plant^{-1}$ (27.4 g) compared to pinching on 40 DAS and without pinching. Nevertheless, these results indicate that the direct sowing with closer placing (30 x 15 cm) and pinching on 30 DAS were found to be more suitable for earning higher seed yield in lamb's quarters.

Keywords: *Lamb's quarters; direct sowing; transplanting; spacing; pinching; seed yield.*

INTRODUCTION

Lamb's quarters (*Chenopodium album* L.) is a minor leafy vegetable, belongs to the family Amaranthaceae. It is the fast growing annual plant, grown well in tropical and sub-tropical region with soil rich in nitrogen. It is cultivated in wider range so its native is obscure. Hence, as described by Linnaeus, it is believed that lamb's quarters may be of European origin. This species has several subspecies, which cannot be differentiated easily. The crop is grown for various purposes like food, fodder and also for its medicinal purpose in Asian and African countries. In India, it is highly cultivated in Northern region, where winter season is most suitable. However in South India, it can grown throughout the year and the people consume it as leafy vegetable. In Tamil Nadu, it is commonly called as '*Paruppu keerai*' or '*Chakravarthi keerai'*.

The crop has recently gained worldwide attention due to its nutritional value. Economically, the leaves and stems are used as vegetable, either raw or cooked and the tender leaves are used in many Indian dishes. Seeds also used as food material and it can be grown as a pseudo-cereal. In the Himalayan region, it is considered as an important subsidiary grain crop, as a pot herb for secondary fodder and salad dressings (Bhargava and Ohri, 2007). The leaves are rich in vitamin A and C, essential oils, minerals particularly potash and considerable amount of albuminoids and nitrogen. The root contains saponin and two flavonoids *viz*., 'kampferol' and 'quercetin'. Therefore, it is widely used in folk medicine around the world. Particularly, it is used in the treatment of rheumatism, bug bites, sun stroke, urinary problems, skin problems *etc*. Also, the plant has medicinal values like laxative property and act as blood purifier and anti-ulcer agent (Sanwal, 2008). Therefore, considering its importance and economical value, Tamil Nadu Agricultural University (TNAU) has released a variety in Lamb's quarters (*Chakravarthi keerai*) named 'Ooty (Ck) 1'. This variety is rich in protein (22 %), zinc (23 ppm), calcium (0.84 %), magnesium (0.58%) and iron (474 ppm). Plant density and geometry are important factors that decides the seed yield and quality. The plant density get altered by the spacing followed during sowing or planting. The plant height and its geometry can also be altered by pinching of the apical meristem. Generally, plant height and number of branches are increased with decrease in plant population due to competition for photosynthetically active radiation (Maboko and Du Plooy, 2009). Therefore, the studies on altering

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the plant population and geometry are required to harvest the higher seed yield.

The lamb's quarters crop is mainly propagated through seeds. However, there are no studies on the seed production techniques to get higher seed yield. Therefore, studies were conducted to assess the effect of transplanting, spacing and pinching on plant growth and seed yield in lamb's quarters.

MATERIAL AND METHODS

The seeds of lamb's quarters (*Chakravarthi keerai*) var. Ooty (Ck) 1 were obtained from the Horticultural Research Station, TNAU, Ooty. The experiment was conducted in the Department of Seed Science and Technology, TNAU, Coimbatore during the year 2018 - 2019 by following split split plot design with the plot size of 3 m x 3 m.

The seedlings were raised in the protrays with pot mixture of cocopeat and vermicompost (3:1). Twenty days old seedlings were used for transplanting. The crop was established through direct sowing (M_1) and transplanting (M_2) in the field at different spacings *viz*., 30 x 15 cm (S_1), 45 x 30 cm (S_2), 60 x 45 cm (S_3). Also, it was ensured with the required plant population of 200 (30 x 15 cm), 66 (45 x 30 cm) and 33 (60 x 45 cm) plants plot^{-1}.

Pinching was done on 30 days after sowing (DAS) or 50 days after planting (DAP) (P_2) and pinching on 40 days after sowing (DAS) or 60 days after planting (DAP) (P_3). In which, the apical growing shoot tip of about 5 cm length were cut manually by sharp knife. Along with unpinched crop (P_1), the pinched crops were maintained by adopting recommended package of practices prescribed by TNAU, Coimbatore. Flowering, plant height, inflorescence length, number of branches and yield characters were recorded in all treatments by tagging ten plants in each plot. The mean data was calculated for each treatment and used for analysis. The data collected were statistically analysed (Panse and Sukhatme, 1967) and the critical difference values were calculated at 5 % probability level.

RESULTS AND DISCUSSION

The results on effect of transplanting, spacing and pinching in lamb's quarters have showed significant differences on plant growth, flowering and seed yield. In which, the direct sown plants have recorded maximum plant height (129.2 cm) compared to the transplanted plants (111.6 cm). Particularly, the direct sowing of seeds at 60 x 45 cm spacing without pinching have recorded the maximum plant height (142.1 cm) when compared to other treatments. While, the seedlings transplanted at 30 x 15 cm spacing and the apical shoots were pinched on 50 DAP had shortest plants (97.3 cm) (Table 1).

The increased plant height in wider spacing might be due to less competition between plants for the space and nutrients. Also, plant height was increased with decrease in plant population due to competition for photosynthetically active radiation (Maboko and Du Plooy, 2009). Also, the apical dominance of the plants might be the reason for the increased height in the un-pinched plants. Similarly, the seeds sown directly in the field and plants allowed without pinching have recorded the maximum inflorescence length (47.5 cm) followed by the transplanted plants with no pinching (43.3 cm). Consequently, the pinching has resulted the reduction in inflorescence length irrespective of the spacings (Table 1).

However, the number of primary branches (14) and secondary branches plant^{-1} (100) were more in the direct sown plants. In addition, the primary branches were more (20) in the plants raised by direct sowing under wider spacing (60 x 45 cm) and without pinching. Similarly, this wider spacing with pinching on 30 DAS has recorded the maximum number of secondary branches plant^{-1} (133) (Table 2). This might be due to the arrest of the apical dominance and induction of more lateral buds. However, the plants without pinching have resulted lesser secondary branches (54) invariable to the method of planting.

Thus, the highest plant height was observed in the plants without pinching due to apical dominance but number of secondary branches was more in pinched plants. The pinching was known to accumulate more photosynthates which are utilized for production of more number of flower bearing secondary branches which ultimately leads to higher seed yield (Pathania *et al.*, 2000). Decrease in plant height with increased number of leaves and branches due to pinching were studied earlier by Ahmad *et al.* (2007) and similar event of production of more number of secondary branches were recorded in the lamb's quarters also. The effect of pinching might be due to cell division in meristematic region which leads to production of large number of healthy branches and flowers results in increased seed yield (Irwin and Aarssen, 1996). Similar results were observed in broccoli (Ghimire *et al.*, 1993; El-Yazied *et al.*, 2007), spinach (Waseem *et al.*, 2000; Bharad *et al.*, 2013), okra (Sajjan *et al.*, 2002), chick pea (Baloch and Zubair, 2010), fenugreek (Vasudevan *et al.*, 2010; Krishnaveni *et al.*, 2016) and daincha (Nayak *et al.*, 2017). Any change in the proportion of shoot and root growth was affected the crop growth (Arkin and Taylor, 1981). Direct seeded plants have more balance root and stem than transplanting, which leads to more dry weight to fruit and seeds (Leskovar and Cantliffe, 1993).

Table 1. Effect of transplanting, spacing and pinching on plant growth in lamb's quarters (*Chakravarthi keerai*) var. Ooty (Ck) 1

Treatments	Sub-sub	Plant height (cm)			Inflorescence length (cm)		
		Main			Main		
		M_1	M_2	S X P (mean)	M_1	M_2	S X P (mean)
		M X S X P (mean)			M X S X P (mean)		
S_1	P_1	129.6	109.6	119.6	47.5	43.3	45.4
	P_2	118.3	97.3	107.8	34.1	32.4	33.3
	P_3	120.3	101.2	110.7	31.3	27.2	29.3
S_2	P_1	136.5	117.5	127.0	42.2	40.4	41.3
	P_2	123.8	107.9	115.8	25.5	24.5	25.0
	P_3	126.6	111.2	118.9	23.1	20.3	21.7
S_3	P_1	142.1	126.3	134.2	38.2	35.9	37.0
	P_2	131.2	115.4	123.3	18.4	17.2	17.8
	P_3	134.4	118.3	126.3	15.0	14.5	14.7
Sub	M X S (mean)			S (mean)		M X S (mean)	S (mean)
	S_1	122.8	102.7	112.7	37.7	34.3	36.0
	S_2	128.9	112.2	120.6	30.3	28.4	29.4
	S_3	135.9	120.0	127.9	23.9	22.6	23.2
Sub-sub	M X P (mean)			P (mean)		M X P (mean)	P (mean)
	P_1	136.1	117.8	126.9	42.7	39.9	41.2
	P_2	124.5	106.9	115.7	26.1	24.8	25.4
	P_3	127.1	110.3	118.7	23.2	20.7	21.9
Main	M (mean)	129.2	111.6	M (mean)	30.6	28.4	

For comparing means of	SEd	CD(P= 0.05)	SEd	CD (P=0.05)
Main (M	0.2	1.7	0.3	NS
Sub (S)	0.6	2.0	0.5	1.5
Sub-sub (P)	0.9	2.9	0.6	2.1
M X S	0.7	NS	0.3	NS
M X P	1.0	NS	0.4	NS
S X P	1.3	NS	0.5	1.6
M X S X P	1.8	NS	0.7	NS

M_1 - Direct sowing
M_2 - Transplanting

S_1 - 30 x 15 cm
S_2 - 45 x 30 cm
S_3 - 60 x 45 cm

P_1 - No pinching
P_2 - Pinching on 30 DAS / 50 DAP
P_3 - Pinching on 40 DAS / 60 DAP

Direct sown plants have strong root system, while transplants may developed distinctive root system by the early modification of root which ultimately affect the plant growth, seed development and subsequent seed yield (Thomas *et al.*, 1982; Stoffella *et al.*, 1988; Leskovar *et al.*, 1989).

Table 2. Effect of transplanting, spacing and pinching on branching habit in lamb's quarters (*Chakravarthi keerai*) var. Ooty (Ck) 1

Treatments	Sub-sub	No. of primary branches plant^{-1}			No. of secondary branches plant^{-1}		
		Main			Main		
		M_1	M_2	S X P (mean)	M_1	M_2	S X P (mean)
		M X S X P (mean)			M X S X P (mean)		
S_1	P_1	13	10	12	65	42	54
	P_2	9	5	7	83	57	70
	P_3	11	7	9	78	50	64
S_2	P_1	18	13	15	90	66	78
	P_2	12	8	10	105	82	94
	P_3	13	9	11	100	76	88
S_3	P_1	20	15	18	114	93	103
	P_2	15	11	13	133	107	120
	P_3	16	12	14	123	99	111
Sub	M X S (mean)			S (mean)		M X S (mean)	S (mean)
	S_1	11	7	9	75	50	63
	S_2	14	10	12	98	75	87
	S_3	17	13	15	123	100	111
Sub-sub	M X P (mean)			P (mean)		M X P (mean)	P (mean)
	P_1	17	13	15	90	67	78
	P_2	12	8	10	107	82	95
	P_3	13	9	11	100	75	88
Main	M (mean)	14	10		99	75	

For comparing means of	SEd	CD (P= 0.05)	SEd	CD (P=0.05)
Main (M	0.1	0.5	0.3	1.9
Sub (S)	0.1	0.2	0.5	1.6
Sub-sub (p)	0.1	0.4	0.7	2.3
M X S	0.1	0.2	0.5	NS
M X P	0.1	NS	0.7	NS
S X P	0.2	0.4	0.9	NS
M X S X P	0.2	0.7	1.3	NS

M_1 - Direct sowing
M_2 - Transplanting

S_1 - 30 x 15 cm
S_2 - 45 x 30 cm
S_3 - 60 x 45 cm

P_1 - No pinching
P_2 - Pinching on 30 DAS / 50 DAP
P_3 - Pinching on 40 DAS / 60 DAP

Maboko and Du Plooy (2008) reported that the increase in plant spacing was found to increase in canopy width, leaf number, leaf length and leaf fresh and dry mass. Generally, plant height and number of branches were increased with decrease in plant population due to competition for photosynthetically active radiation and similar findings were noticed in lamb's quarters also.

In addition, direct sown plants showed lesser number of days for 50 per cent flowering (42) when compared to transplanted plants (59). Similarly, the direct sown plants took lesser number of days to maturity (107) compared to transplanted crops (136) (Table 3). Specifically, the crops raised with wider spacing (60 x 45 cm) and no pinching have recorded minimum days (102) to maturity.

Table 3. Effect of transplanting, spacing and pinching on flowering and maturity of lamb's quarters (*Chakravarthi keerai*) var. Ooty (Ck) 1

Treatments	Sub-sub	Days to 50% flowering			Days to maturity		
		Main			Main		
		M_1	M_2	S X P (mean)	M_1	M_2	S X P (mean)
		M X S X P (mean)			M X S X P (mean)		
S_1	P_1	44	60	52	108	137	122
	P_2	43	58	50	109	137	123
	P_3	41	56	49	106	135	120
S_2	P_1	37	60	49	109	136	122
	P_2	42	58	50	109	139	124
	P_3	44	60	52	109	137	123
S_3	P_1	42	62	52	102	134	118
	P_2	44	58	51	106	138	122
	P_3	42	60	51	108	135	122
Sub	M X S (mean)			S (mean)		M X S (mean)	S (mean)
	S_1	43	58	50	107	136	122
	S_2	41	59	50	109	137	123
	S_3	43	60	51	105	136	121
Sub-sub	M X P(mean)			P (mean)		M X P(mean)	P (mean)
	P_1	41	61	51	106	136	121
	P_2	43	58	51	108	138	123
	P_3	42	58	50	107	136	122
Main	M (mean)	42	59		107	136	

For comparing means of	SEd	CD (P=0.05)	SEd	CD (P=0.05)
Main (M	0.1	1.0	0.4	2.8
Sub (S)	0.8	NS	0.6	1.9
Sub-sub (p)	1.1	NS	0.8	2.7
M X S	0.7	NS	0.6	1.7
M X P	1.0	NS	0.8	2.5
S X P	1.2	NS	1.1	3.1
M X S X P	1.7	NS	1.5	4.3

M_1 - Direct sowing
M_2 - Transplanting

S_1 - 30 x 15 cm
S_2 - 45 x 30 cm
S_3 - 60 x 45 cm

P_1 - No pinching
P_2 - Pinching on 30 DAS / 50 DAP
P_3 - Pinching on 40 DAS / 60 DAP

The highest seed yield plant^{-1} was recorded in direct sowing method (28.3 g) when compared with the transplanting method (18.9 g). Also, the plants grown under wider spacing (60 x 45 cm) and pinching on 30 DAS have resulted the maximum seed yield plant^{-1} (40.5 g) (Table 4). This might be due to the production of more number of secondary branches by pinching operation which was discussed earlier. The least seed yield plant^{-1} (6.3 g) was recorded in the transplanted plants grown under closer spacing (30 x 15 cm) and without pinching. Transplanting shock, lesser space and production of lesser number of branches might have caused reduction in yield in these closer spaced transplanted plants. Although, maximum yield was recorded in direct sown (2092 kg ha^{-1}) crop when compared to transplanted (1362 kg ha^{-1}) crop. In addition, the crop raised with closer spacing (30 x 15 cm) and pinching on 30 DAS have recorded maximum seed yield (3683 kg ha^{-1}) (Table 4).

Table 4. Effect of transplanting, spacing and pinching on seed yield in lamb's quarters (*Chakravarthi keerai*) var. Ooty (Ck) 1

Treatments	Sub-sub	Seed yield plant^{-1} (g)			Seed yield ha^{-1} (kg)		
		Main			Main		
		M_1	M_2	S X P (mean)	M_1	M_2	S X P (mean)
		M X S X P (mean)			M X S X P (mean)		
S_1	P_1	10.2	6.3	8.2	1708	1050	1379
	P_2	22.1	13.0	17.5	3683	2166	2925
	P_3	20.3	12.2	16.5	3388	2027	2708
S_2	P_1	23.2	12.1	17.6	1546	810	1178
	P_2	33.3	22.8	28.1	2237	1520	1878
	P_3	31.3	20.3	25.8	2086	1353	1720
S_3	P_1	35.0	21.2	28.5	1283	779	1031
	P_2	40.5	32.6	36.5	1487	1349	1418
	P_3	38.5	29.8	34.1	1411	1206	1309
Sub			M X S (mean)	S (mean)		M X S (mean)	S (mean)
	S_1	17.5	10.4	14.0	2926	1748	2337
	S_2	29.3	18.4	23.8	1957	1227	1592
	S_3	38.0	27.9	32.9	1394	1111	1252
Sub-sub			M X P(mean)	P (mean)		M X P(mean)	P (mean)
	P_1	22.8	13.2	18.0	1512	879	1196
	P_2	32.1	22.8	27.4	2469	1678	2074
	P_3	30.0	20.8	25.4	2295	1529	1912
Main	M (mean)	28.3	18.9		2092	1362	

For comparing means of	SEd	CD (P= 0.05)	SEd	CD P=0.05)
Main (M)	0.3	2.0	9.3	56.6
Sub (S)	0.4	1.2	26.4	86.3
Sub-sub (P)	0.5	1.6	37.4	122.1
M X S	0.2	0.8	32.0	93.6
M X P	0.4	NS	45.3	NS
S X P	0.5	NS	55.5	162.2
M X S X P	0.7	2.0	78.5	229.4

M_1 - Direct sowing
M_2 - Transplanting

S_1 - 30 x 15 cm
S_2 - 45 x 30 cm
S_3 - 60 x 45 cm

P_1 - No pinching
P_2 - Pinching on 30 DAS / 50 DAP
P_3 - Pinching on 40 DAS / 60 DAP

More plant population might be the cause for the increased yield per unit area. However, the crop raised under wider spacing (60 x 45 cm) and without pinching have recorded the least seed yield (779 kg ha^{-1}) due to the lesser plant population in an unit area. The rate of root production has a direct influence on nutrient acquirement and successive crop yield (Barber and Silberbush, 1984). This might be reason for direct sown crop which had highest plant growth and seed yield compared to transplanted in lamb's quarters. The similar results were found in bell pepper (Leskovar and Cantliffe, 1993) but controversy result was reported in amaranthus (Manikandan and Srimathi, 2015). Plant density is an important factor that decides the seed yield and quality. The plant population gets altered by the spacing followed during sowing or planting. Closer spacing has highest plant density

contributed to higher seed yield compared to wider spacing (Maboko and Du Plooy, 2009). Similar findings were noticed in lamb's quarters in which the higher plant population (200 plants in 9 m^2) tends to increase the seed yield compared with wider spacing.

An increasing plant density does not affect the performance of individual plant while, the plant density stays below the level at which competition occurs between plants (Foidl *et al.*, 2007) and occurrence of such event cannot be ruled out in the current study. Also, the plant growth parameters were found maximum in wider spacing (60 x 45 cm) but it couldn't able to compensate the yield received by the closer spacing (30 x 15 cm). The similar results of growth and yield differences were observed in moringa (Foidl *et al.*, 2001; Foidl *et al.*, 2007), lettuce (Moniruzzaman, 2006), onion (Umesh Thapa *et al.*, 2004) and amaranthus (Ananda and Dhanapal, 2006).

CONCLUSION

It is concluded that the direct sowing of lambs quarters seeds in the spacing of 30 x 15 cm and pinching on 30 DAS are suitable for getting higher seed yield.

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