Asian Journal of Agricultural and Horticultural Research

4(4): 1-12, 2019; Article no.AJAHR.53101
ISSN: 2581-4478

Effect of Planting Method and Seeding Date on Leaf and Seed Production of Lettuce

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Authors' contributions

This work was carried out in collaboration among all authors. Author MS designed the study, collected data and wrote the first draft of the manuscript. Author MR managed the experiments of the study. Authors MMRS and BA performed the statistical analysis. Author MHR managed the literature and edited the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAHR/2019/v4i430037
Editor(s):
(1) Dr. Ahmed Medhat Mohamed Al-Naggar, Professor of Plant Breeding, Department of Agronomy, Faculty of Agriculture, Cairo University, Egypt.
Reviewers:
(1) Maria Lúcia Pereira da Silva, University of São Paulo, Brazil.
(2) Zdzisław Kaliniewicz, University of Warmia and Mazury in Olsztyn, Poland.
Complete Peer review History: http://www.sdiarticle4.com/review-history/53101

Original Research Article

Received 01 October 2019
Accepted 06 December 2019
Published 21 December 2019

ABSTRACT

Aim: The objective of this study is to identify the suitable planting method and seeding time for leaf and seed production of lettuce.
Place and Duration: A field study was carried out in Bangadandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur Bangladesh during 2012-13.
Materials and Design: A commercial lettuce variety BSMRAU lettuce-1 was used in this study. The experiment was laid out in a randomized complete block design with three replications and two factors, namely planting method (M1 – transplanted seedling produced on nursery bed, M2 - transplanted seedling produced in polybag and M3 - direct seeding) and seeding time (T1 - 16 October, T2 - 1 November, T3 - 16 November, T4 - 1 December and T5 - 16 December).
Results: Analyses of variance revealed with a statistically significant variation (p<0.01 or p<0.05) among the treatments. The treatment interaction revealed that the highest leaf yield 27.33 t/ha was

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harvested from M3T2, which was statistically similar with M2T2 (26.78 t/ha). On the other hand, the highest seed yield 412.00 kg/ha was harvested from the treatment combination of M3T2, which was statistically different from all other treatment combinations. Quality traits viz. dry matter content, fiber content and organoleptic test were also better in early seeding.

Conclusion: Considering leaf yield, seed yield and quality traits, direct seeding at 1 November was found to be the most suitable treatment combination for leaf and seed production of lettuce in Bangladesh conditions. But transplanting with polybag raised seedlings may be suitable if the land is occupied by the pervious crops.

Keywords: Dry matter; fiber content; lettuce; seeding; transplanting.

1. INTRODUCION

Lettuce (*Lactuca sativa* L.) is an annual leafy herb belongs to the family *Compositae* and is one of the most popular salad crops in the world [1]. It is rich in vitamin A and C and minerals such as calcium and iron [2]. The consumption of lettuce has become very popular as salad and soups in the most of the cities in Bangladesh. It occupies an important position for its cultivation in the country, but the production of leaf and seed is very low due to lack of appropriate agronomic practices. There are two principal techniques, namely direct seeding and transplanting of seedlings that are usually followed in the production of leaf and seeds of lettuce. In the United States, lettuce is grown mostly in direct seeding, whereas in Europe and other places, transplanting of lettuce is a prominent method of production [3]. Normally, the farmers of Bangladesh cultivate lettuce through transplanting, where requires a longer period of time for overcoming the transplanting shock as well as the establishment of seedlings. On the other hand, there is no need of extra time for establishing the seedlings in direct seeding method. As a result, producer can harvest lettuce early, which leads to early market and better price.

However, among the various factors, planting time and method are very important ones for leaf and seed production of lettuce. Therefore, it is time demanding to verify the effect of seeding time and planting methods on leaf and seed yield of lettuce. Influence of seeding time has been reported in previous studies [4,5,6,7]. It is also reported that lettuce performed better at the temperature of 18-25ºC/10-15ºC day/night [3]. In Bangladesh, temperature is comparatively lower (10-25ºC) in winter season and this low temperature remains for a longer period of time which is favorable for lettuce leaf and seed production. Unfortunately, research on the best seeding time and planting method under local conditions are meager. Therefore, the present study was conducted to recommend the suitable seeding time and planting method for lettuce leaf and seed production.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted at the research farm of the BSMRAU, Salna, Gazipur Bangladesh during October 2012 to May 2013. The field plot was previously under foreland and recently developed for the research work. The location of the site is 24.09ºN latitude and 90.26ºE longitudes with an elevation of 8.2 meter from the sea level [8].

2.2 Climate

The climate of the experimental site is subtropical, which is characterized by heavy rainfall during months from April to September and scantly rainfall for the rest of the year, which is reflected in weather data collected from October to May (Table 1). As we expected May (191.6 mm) and September (572.4 mm) had a huge rainfall whereas from November to April had no or scanty rainfall. The relative humidity of the experimental site was consistently higher in morning compared to afternoon throughout crop growing period along with an average maximum and minimum temperature of 30.11ºC (May) and 18.11ºC (January), respectively.

2.3 Plant Materials and Treatments

BSMRAU lettuce-1 was used throughout the study. Two factorial experiments were conducted: factor (A) 3 planting method viz. transplanted seedling produced on nursery bed (M1), transplanted seedling produced in polybags (M2) and direct seeding (M3); factor (B) 5 sowing time viz. 16 October (T1), 1 November (T2), 16 November (T3), 1 December (T4) and

16 December (T5). Treatment combination were M1T1 (transplanting seedlings form nursery bed on 16 October), M2T1 (transplanting seedlings form polybag on 16 October), M3T1 (direct seeding on 16 October), M1T2 (transplanting seedlings form nursery bed on 1 November), M2T2 (transplanting seedlings form polybag on 1 November), M3T2 (direct seeding on 1 November), M1T3 (transplanting seedlings form nursery bed on 16 November), M2T3 (transplanting seedlings form polybags on 16 November), M3T3 (direct seeding on 16 November), M1T4 (transplanting seedlings form nursery bed on 1 December), M2T4 (transplanting seedlings form polybag on 1 December), M3T4 (direct seeding 1 December), M1T5 (transplanting seedlings form nursery bed on 16 December), M2T5 (transplanting seedlings form polybag on 16 December) and M3T5 (direct seeding on 16 December).

2.4 Field Layout

The experiment was laid out in randomized complete block design with 3 replications. Fifteen treatment combinations were randomly assigned in each plot. The dimension of each plot was 1.6 m x 1.5 m accommodating 24 lettuce plants at final stage. Plant to plant distance was maintained at 25 cm and row to row distance was 40 cm in each plot. The plots to plot and block to block distance was 0.5 m and 1.0 m, respectively. Thirty days old seedlings (both seed bed and polybags) were transplanted in the experimental plots in afternoon and light irrigation was given around each seedling for their establishment.

2.5 Intercultural Operations

Necessary intercultural operations were done during the growing period for proper growth and development of the crops. Weeding and irrigation were done when necessary. Irrigation was given at an interval of 8-10 days depending on the soil moisture content. Top dressing of urea fertilizer was done at 12- and 24-days after transplanting of seedling and it was followed by irrigation at the same day. Two weeding were done at 10- and 20-days after transplanting. Plant protection measures were not required at vegetative stage. Other cultural operations including mulching of the pit soil were done as and when needed.

2.6 Seed Production Management

From each plot at 40 days after transplanting (DAT) 50% plants i.e. 12 plants were uprooted for leaf yield and rest of the 50% i.e. 12 plants were allowed for further growth. Forty DAT was followed for harvesting leaf as described by Rahman et al. [9]. Seed stocks were cut off when 80% of seed clusters display feathering followed by the sun dried for further processing. The seeds were threshed, dried and preserved in 4ºC until further use.

2.7 Data Collection and Analysis

Data were recorded for the following parameters; plant height (cm), number of leaves per plant, canopy diameter (cm), leaf size (cm^2), leaf yield per plant (g), leaf yield per hectare (t/ha), fiber content (%), dry matter content (%), organoleptic test, days to 50% flowering, days to seed maturity, seed yield per plant (g), and seed yield (t/ha). The recorded data for different characters were analyzed statistically using MSTAT-C programme to find out the variation among different treatments, treatment combinations and their interactions. Treatment means were also compared by the Duncan's Multiple Range Test (DMRT) as described by Gomez and Gomez [10].

Table 1. Weather data during the cropping period collected from meteorological station of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur Bangladesh

Month (2012-13)	Air temperature (°C)			Relative humidity (%)		Total rainfall (mm)
	Maximum	Minimum	Average	9 am	2 pm	
September	32.1	25.6	28.9	80.5	70.9	572.4
October	32.6	24.2	28.4	75.1	61.7	33.6
November	29.9	19.3	24.6	72.7	58.0	0
December	27.3	14.3	20.8	70.9	44.2	0
January	24.8	11.3	18.1	74.1	49.2	0
February	27.1	15.9	21.5	75.5	53.2	76.6
March	31.3	17.8	24.6	69.8	50.7	14.8
April	33.0	22.7	27.8	75.0	61.5	89.2
May	34.7	25.4	30.1	75.1	59.5	191.6

2.8 Procedure of Measuring Dry Matter Content (%)

After harvest, 100 g of fresh leaf sample was cut into thin pieces and kept in a paper bag. Paper bag was placed into an oven maintained at 70ºC for 72 hours. The sample was then transferred into a desecrator allowing them to cool down at the room temperature and converted to percentage as formula 1.

$$\text{Dry matter } (\%) = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100 \quad (1)$$

2.9 Procedure of Measuring Fiber Content (%)

After harvest, 100 g of fresh leaf was cut into thin pieces and boiled. The boiled sample was smashed for 25 minutes before sieving them. After sieving the fiber was dried out at room temperature and calculated fiber contents by a simple formula 2.

$$\text{Fiber content } (\%) = \frac{\text{Fiber weight}}{\text{Fresh weight of leaves}} * 100 \quad (2)$$

2.10 Overall Quality and Organoleptic Test

A panel of judges comprising of five members were assigned to evaluate harvested lettuce leaf according to firmness, visual quality, taste, crispiness, and other defects (if any). The judges scored the harvested lettuce from each plot using a scale of 1-5 as described by Schonemann et al. [11]; where 1 = unacceptable for human consumption, 2 = average quality, 3 = medium quality, 4 = good quality, and 5 = excellent quality.

3. RESULTS AND DISCUSSION

3.1 Analysis of Variance

Analysis of variance (ANOVA) for the genotypes showed highly significant difference (p<0.05 or p<0.01) for the maximum characters studied (Table 2). The coefficient of variance (CV) varied from 0.84 to 11.78, which indicated higher precision of data collection.

3.2 Effect of Planting Method on Leaf and Seed Production

Plant height: Significant effect was observed on plant height of lettuce by the planting methods (Table 3). The tallest plant (22.43 cm) was recorded from direct seeding followed by transplanting with polybags raised plant (22.23 cm) and the shortest plant (18.03 cm) was recorded from transplanting with nursery seedlings. The variation in the plant height might be due to the transplanting shock of the plants, which delayed the growth and development. Sharma et al. [12] reported higher plant height from direct seeding than the transplanting of seedlings on the production of lettuce, which is in an agreement with the present results.

Number of leaves: Three planting methods showed wide variation in leaf production (Table 3). Direct seeding produced the highest number of leaves 19.61 per plant and the transplanting with nursery seedlings produced the lowest number of leaves 13.16). Similar trend was observed by Sharma et al. [12].

Leaf size: There was a significant variation among the treatments in respect of leaf size (Table 3). It was evident that direct seeding produced the biggest leaf 346.30 cm^2 followed by transplanting with polybag raised plant (327.90 cm^2) and the smallest leaf 257.20 cm^2 produced by the transplanting with nursery seedlings. Leaf size involves in the efficiency of photosynthesis, which has an important role in leaf yield. Direct seeding produced larger leaf than the transplanting as reported by Sharma et al. [12].

Canopy diameter: There was significant variation found in the diameter of plant canopy due to different planting methods. The highest canopy diameter 25.62 cm was recorded from direct seeding, which was statistically identical with the transplanting with polybag seedlings (24.95 cm) and the lowest canopy 23.98 cm produced by the plants from transplanting with nursery seedlings (Table 3), which is in an agreement with the study of Sharma et al. [12].

Leaf yield: Leaf yield of lettuce showed statistically significant variation by planting methods (Table 3). Leaf yield varied from113.2 to 187.5 g per plant and 18.75 to 11.32 t/ha among the planting methods. The highest leaf yield 187.5 g per plant and 18.75 t/ha was obtained from the direct seeding method and the lowest seed yield 113.2 g per plant and 11.32 t/ha obtained from the transplanting with nursery seedlings. These findings were similar with Sharma et al. [12], where they reported leaf yield 17.16 t/ha in direct seeding and 9.08 t/ha in transplanting.

Table 2. ANOVA for various traits of BSMRAU lettuce-1 used in the study

Characters	Source of variation					
	Replications (2)	Planting methods (M=2)	Planting date (T=4)	Interaction (M×T=8)	Error (28)	CV (%)
Plant height (cm)	0.094	92.686**	81.949**	5.046**	0.156	1.89
Number of leaves/plant	0.116	170.888**	217.640**	3.328**	0.126	2.09
Leaf size (cm^2)	4.133	33221.459**	59235.230**	2469.406**	30.528	1.78
Canopy diameter (cm)	0.116	10.161**	55.857**	0.392 **	0.121	1.40
Leaf yield (g/plant)	5.684	24899.942**	54881.360**	257.162 **	6.157	1.55
Leaf yield (t/ha)	0.054	249.160**	548.750**	2.570**	0.061	1.54
Days to 50% flowering	0.821	24.583 **	1493.580 **	0.999 NS	1.131	0.95
Days to seed maturity	8.478	17.958 **	2401.410 **	0.965 NS	1.317	0.84
Seed yield (g/plant)	0.069	0.347 **	2.290 **	0.054 **	0.008	2.94
Dry matter (%)	0.005	2.802 **	10.182**	0.131 NS	0.192	6.08
Fiber content (%)	0.009	0.748 **	3.924 **	0.026 NS	0.044	11.78
Organoleptic test	0.006	1.880 **	5.950 **	0.155 **	0.013	3.17

***= significant at 1% level and *= significant at 5% level. NS = not significant*

Days to 50% flowering: Days to flowering of 50% plants from the plot was significantly varied by different methods of planting (Table 3). The earliest flowering was observed in direct seeding (111 days), which was statistically identical with the transplanting with polybag raised seedlings (111.7 days). Significantly late flowering was observed in transplanting with nursery seedlings (113.40 days). It might be due to the transplanting shock which delayed the development of the plants. Past study reported that transplanting of lettuce prolonged the development phase of plants [13].

Days to seed maturity: Significant difference was observed for the days to seed maturity among the methods (Table 3). The maximum period of 137.5 days required for seed maturity in transplanting with nursery seedlings and the minimum period of 134.4 days required in direct seeding. Sharma et al. [4] reported the maximum period of 148.71 days for seed maturity in transplanting method and minimum period of 146.15 days in direct seeding.

Seed yield per plant: In respect of seed yield per plant, significant variation was observed due to the effect of planting methods (Table 3). The highest amount of seed yield per plant 3.28 g was harvested from direct seeding, followed by transplanting with polybag raised seedlings (3.13 g) and the lowest seed yield 2.98 g per plant was recorded from the transplanting with nursery seedlings. Sharma et al. [4] reported that the direct seeding produced 2.94 g seed per plant whereas the transplanted plants produced 2.67 g seed per plant.

3.3 Effect of Seeding Time on Leaf and Seed Production

Plant height: Significant effect was observed in plant height by the seeding date. The tallest plant 25.31 cm was obtained from 1 November (T2) seeding, which was significantly different from other seeding time (Table 4). Seeding of 16 December (T5) showed the lowest plant height (17.27 cm). It might be due to very low temperature (12.62ºC) at the initial growth stage, which suppresses the normal growth of the seedlings. Sharma et al. [12] reported the effect of seven seeding date on the production of lettuce seed and found the highest plant height in 16 January seeding, which is statistically identical with 2 November seeding. Early November seeding also showed the tallest plant by a study in Bangladesh conditions [14], which is an agreement to this study.

Number of leaves: Variation in number of edible leaves was found due to difference of seeding time. The maximum number of edible leaves was obtained from 1 November (T2) seeding (22.13), which was statistically identical with 16 October (T1) seeding (21.86) (Table 4). The minimum of edible leaf (11.18) was found in 16 December (T5) seeding. This results in an agreement with Sharma et al. [12], where they reported the highest number of leaves (14.60) in 16 January seeding, which is statistically identical with 2 November seeding (14.50). The variation in number of leaves between studies might be due to the varietal difference of the study.

Leaf size: The maximum leaf size 390.50 cm^2 was recorded from 1 November seeding, which

was statistically identical with 16 October seeding (380.90 cm^2) (Table 4). The minimum leaf size was found in 16 December seeding (209.40 cm^2), which might be due to the unfavorable condition at initial growth stage. In later seeding, leaf size decreased due to low temperature and foggy environment which could reduce the photosynthesis. This study revealed that very low or high temperatures were not favorable for the normal growth and development of lettuce in Bangladesh conditions. On the other hand, larger leaf size 369.79 cm^2 was measured in 16 January seeding as reported by Sharma et al. [12], which is a disagreement with the present study. It might be due to the difference of variety or environment and/or both.

Canopy diameter: The highest canopy diameter 27.46 cm was found in 1 November seeding and the lowest diameter 21.42 cm was obtained from 16 December seeding (Table 4). Sharma et al. [12] reported canopy diameter 27.10 cm in 16 January seeding, which is a disagreement with the present study. It might be due to the difference of variety or environment and/or both.

Leaf yield: Significant variation in leaf yield was also recorded due to seeding time (Table 4). The maximum leaf yield 246.2 g/plant and 24.63 t/ha was obtained from 1 November seeding (T2), which was statistically different from all other seeding time and the lowest leaf yield 70.94 g/plant and 7.08 t/ha was found from 16 December (T5) seeding. It was noticed that leaf yield decreased in later seeding due to very low temperature and foggy weather. Firoz et al. [15] found the maximum leaf yield of lettuce at 10 November seeding out of six seeding time from 10 November to 20 December at 10 days interval in Bangladesh conditions. On the other hand, Sharma et al. [12] reported leaf yield 21.45 t/ha from 16 January seeding. This variation might be due to the difference of variety or environment and/or both.

Days to 50% flowering: Significant variation on days to flowering in 50% plants of lettuce was found by the seeding time (Table 4). Days to flowering in 50% plants decreased at the later seeding time. The maximum period of 125 days required for 50% flowering in early seeding (15 October) and the minimum period of 94 days required in late seeding (16 December), which is an agreement with the study of Firoz et al. [14]. They also reported that the early November seeding required the maximum days in 1st flowering.

Days to seed maturity: Days to seed maturity showed significant variation by seeding time (Table 4). It was observed that late seeding (16 December) took lesser number of days (111.70 days) than the earlier seeding (15 October) for seed maturity (152.4 days).

Seed yield: Results revealed that time of seeding had significant effect on seed yield per plant and per hectare (Table 4). The maximum amount of seed yield per plant (3.74 g) was obtained from 1 November seeding, which was statistically different from all other seeding time. This might be due to the fact that the plants from 1 November seeding experienced considerable low temperature during the vegetative growth at the initial stage, as the temperature was probably optimum to fulfill the vernalization requirement of the plants. These plants eventually produced maximum vegetative growth, flower stalks, capsules and seed per plant, which contributed to produce maximum seed yield 373.70 kg per hectare (Table 4). Later planting (16 December) produced lower seed yield per plant (2.48 g) and per hectare (248.00 kg). This might be due to the very high temperature (above 33ºC) during the flowering stage, which is harmful for the fertilization causing pollen sterility and affected the seed yield. Firoz et al. [14] reported that 10 November seeding produced significantly higher seed yield 28.4 g/plant and 770 kg/ha than the other seeding dates. Seed yield of spring-sown plants were approximately half the yields of autumn-sown plants reported by Kazim et al. [5]. It could be due to early bolting at the low temperature in autumn.

3.4 Interaction Effects of Planting Method and Seeding Time on Leaf Yield

The combined effect of planting method and seeding time had a significant effect on plant height, number of leaves per plant, leaf size, canopy diameter, leaf yield per plant and leaf yield per hectare (Table 5). The tallest plant was produced by the treatment M3T2 (26.73 cm), which was statistically identical with M2T2 (26.53 cm) and M3T3 (25.67 cm). The shortest plant (14.47 cm) was measured from M1T5, which was statistically different from all other treatment combinations. The highest number of leaves was counted from M3T2 (25.07), which were statistically identical with M3T1 (24.97). Treatment M1T5 produced the lowest number of leaves (8.53) per plant (Table 5). Data revealed that higher number of leaves was obtained from the direct seeding method along with all seeding

date. The highest leaf area was measured from M3T2 (412.1 cm^2), closely followed by M3T1 (408.4 cm^2) and M3T3 (405.7 cm^2) and the lowest leaf size was measured in M1T5 (152.8 cm^2) (Table 5). The smallest leaf was observed from the treatment M1T5, because of the suppression of the normal vegetative growth and leaf development. It might be due to late establishment of seedlings and they passed through very low temperature at the establishment period. Significant variation was observed in canopy diameter due to the interaction effect of planting method and seeding time (Table 5). The biggest canopy was obtained from M3T2 (28.47 cm), which was followed by M2T2 (27.81 cm) and the smallest canopy was found from M1T5 (20.73 cm). Sharma et al. [12] reported top performance in respect of plant height, number of leaves per plant, leaf size and canopy diameter from the direct seeding at 16 January. On the other hand, our results showed better performance on the direct seeding at 1 November. The variation in seeding time could be due to the difference of variety or environment and/or both.

Leaf yield showed significant variation due to the interaction effect of planting method and seeding time (Table 5). The highest leaf yield per plant (272.60 g) was harvested from M3T2, which was statically similar with M2T2 (267.70 g) and the lowest was harvested in M1T5 (36.43 g). It was found that the leaf yield per plant was highest from the direct seeding plot followed by the plot planted with polybag seedlings in 1 November seeding. Leaf yield per hectare was also significantly different due to the interaction effect of planting method and seeding time (Table 5). The highest leaf yield 27.33 t/ha was harvested from M3T2, which was statistically similar with M2T2 (26.78 t/ha) and statistically different from all other treatment combinations. Direct seeding and planting with polybag raised seedlings also performed better when planted at 1 November. Higher leaf production in 1 November seeding might be due to the optimum temperature along with clear sun light. It could also be due to undisturbed growth of the taproot and prevailing favorable environment conditions during growth and development stage. The lowest leaf yield 3.64 t/ha harvested from transplanting with nursery seedlings at 16 December seeding, which could be due to the presence of low temperature (20.84ºC) and continuous foggy weather during the establishment of lettuce seedlings. Sharma et al. [12] reported the highest yield 192.32 g/plant and 24.00 t/ha from the direct seeding at 16 January, whereas we found top yield performance from the direct seeding at 1 November. The yield variation in seeding time could be due to the difference of variety or environment and/or both.

3.5 Interaction Effects of Planting Method and Seeding Time on Seed Yield

The combination effect of planting method and seeding time on days to flowering in 50% plants and days to seed maturity of lettuce was not significant (Table 6). On the other hand, the interaction effect of planting method and seeding time had a significant effect on seed yield per plant and per hectare (Table 6). The highest seed yield (4.12 g/plant and 412.00 kg/ha) was harvested from M3T2, which was statistically different from all other treatment combinations. The second highest seed yield (3.74 g/plant and 374.00 kg/ha) was found from M2T2 and it was statistically identical with M3T1 (3.55 g/plant and 355.00 kg/ha), while M1T5 produced the lowest seed per plant (2.40 g) and per hectare (240.00 kg). Sharma, et al. [4] reported the highest seed production from direct seeding at 2 November, which is an agreement with the present study. Therefore, direct seeding in early November consider the best combination of planting method and seeding time for lettuce seed production in Bangladesh.

3.6 Effect of Planting Method and Seeding Time on Quality Characters

Dry matter content (%): Dry matter production was significantly varied by different planting methods of lettuce (Table 7). The highest dry matter content 6.82% was produced by plants from direct seeding, which was statistically similar with the transplanting with polybag raised seedlings (6.52%). The lowest dry matter content 5.97% was produced by transplanting with nursery seedlings. Maximum dry matter accumulation in direct seeding and transplanting with polybag raised seedlings was found in this study. It might be due to the uninterrupted growth and the maximum utilization of nutrients, light and water. Distinct variation was noted in the accumulation of dry matter by the effect of seeding time (Table 7). The significant highest dry matter content 7.74% was found from the plots seeded in 1 November and the lowest (5.34%) from the plots seeded in 16 December. Probably very low temperature and foggy weather at the initial growth

Table 3. Effect of planting method on leaf and seed production of lettuce

Treatments	Leaf yield contributing parameters						Seed yield contributing parameters			
	Plant height (cm)	Number of leaves / plant	Leaf size (cm²)	Canopy diameter (cm)	Leaf yield / plant (g)	Leaf yield (t/ha)	Days to 50% flowering	Days to seed maturity	Seed yield (g/plant)	Seed yield (kg/ha)
M1	18.03 b	13.16 c	257.20 c	23.98 b	113.20 c	11.32 c	113.40 a	137.5 a	2.98 b	298.42 c
M2	22.23 a	18.11 b	327.90 b	24.95 a	179.50 b	17.95 b	111.70 b	136.0 ab	3.13 ab	313.54 b
M3	22.43 a	19.61 a	346.30 a	25.62 a	187.50 a	18.75 a	111.00 b	135.4 b	3.28 a	328.47 a
F-test	**	**	**	**	**	**	*	*	**	**
CV (%)	1.89	2.09	1.78	1.40	1.55	2.12	0.95	0.84	2.94	2.87

*M1=Transplanting of seedlings raised on nursery seed bed, T2=Transplanting of seedlings produced in polybags and M3=Direct seeding; Means followed by same letter (s) in a column did not differ significantly from each other by DMRT. ** = Significant at 1% level, * = Significant at 5% level*

Table 4. Effect of planting time on leaf and seed production of lettuce

Treatments	Leaf yield contributing parameters						Seed yield contributing parameters			
	Plant height (cm)	Number of leaves / plant	Leaf size (cm²)	Canopy diameter (cm)	Leaf yield / plant (g)	Leaf yield (t/ha)	Days to 50% flowering	Days to seed maturity	Seed yield (g/plant)	Seed yield (kg/ha)
T1	20.80 c	21.86 a	380.90 a	26.66 b	231.80 b	23.18 b	125.0 a	152.4 a	3.40 b	341.30 b
T2	25.31 a	22.13 a	390.50 a	27.46 a	246.20 a	24.62 a	122.0 b	147.7 b	3.74 a	373.70 a
T3	21.87 b	16.09 b	327.80 b	25.45 c	153.40 c	15.34 c	115.5 c	140.6 c	3.27 b	327.30 c
T4	19.22 d	13.54 c	243.80 c	23.25 d	98.06 d	9.81 d	103.6 d	129.0 d	2.76 c	276.70 d
T5	17.27 e	11.18 d	209.40 d	21.42 e	70.94 e	7.09 e	94.31 e	111.7 c	2.48 d	148.00 e
F-test	**	**	**	**	**	**	**	**	**	**
C.V (%)	1.89	2.09	1.78	1.40	1.55	2.12	0.95	0.84	2.94	2.87

*T1=16 October, T2=1 November, T3=16 November, T4=1 December, T5=16 December; Means followed by same letter (s) in a column did not differ significantly from each other by DMRT. ** = Significant at 1% level, * = Significant at 5% level*

Table 5. Interaction effects of planting method and seeding time on the growth and leaf yield contributing characters of lettuce

Treat.	Plant height (cm)	Number of leaves/plant	Leaf size (cm^2)	Canopy diameter (cm)	Leaf yield /plant (g)	Leaf yield (t/ha)
M1T1	19.22 e	17.27 d	352.60 e	26.14 de	180.80 d	18.08 d
M1T2	22.67 c	17.60 d	365.50 d	26.11 de	198.30 c	19.83 c
M1T3	17.87 f	12.13 g	235.30 h	24.51 f	95.07 g	9.51 g
M1T4	15.90 g	10.27 h	179.80 i	22.41 gh	54.60 i	5.56 i
M1T5	14.47 h	8.53 i	152.80 j	20.73 i	36.43 j	3.64 j
M2T1	21.51 d	23.35 b	381.80 c	26.77 cd	256.10 b	25.63 b
M2T2	26.53 ab	23.73 b	393.80 bc	27.81 ab	267.70 a	26.77 a
M2T3	22.07 cd	16.07 e	342.30 e	25.33 e	169.50 e	16.95 e
M2T4	21.73 d	15.07 f	287.20 f	23.11 g	117.30 f	11.73 f
M2T5	19.30 e	12.33 g	234.20 h	21.71 h	86.80 h	8.68 h
M3T1	21.68 d	24.97 a	408.40 a	27.08 bc	258.30 b	25.83 b
M3T2	26.73 a	25.07 a	412.10 a	28.47 a	272.60 a	27.26 a
M3T3	25.67 b	20.07 c	405.70 ab	26.50 cd	195.50 c	19.55 c
M3T4	20.03 e	15.27 ef	264.40 g	24.23 f	121.30 f	12.14 f
M3T5	18.03 f	12.67 g	241.20 h	21.81 h	89.60 gh	8.96 h
F-test	**	**	**	**	**	**
CV (%)	1.89	2.09	1.78	1.40	1.55	2.12

*Means followed by same letter (s) in a column did not differ significantly from each other by DMRT at 1% level. ** = Significant at 1% level*

Table 6. Interaction effects of planting method and seeding time on seed yield contributing characters of lettuce

Treatments	Days to 50% flowering	Days to seed maturity	Seed yield / plant (g)	Seed yield (kg/ha)
M1T1	127.0	254.6	3.26 d	328 e
M1T2	124.1	148.7	3.35 cd	335 d
M1T3	116.4	141.7	3.18 d	318 f
M1T4	104.8	130.2	2.71efg	271 h
M1T5	95.13	112.3	2.40 h	240 k
M2T1	124.7	151.9	3.40 cd	341 d
M2T2	121.3	147.7	3.74 b	374 b
M2T3	115.2	140.2	3.27 d	327 e
M2T4	103.1	128.5	2.77 ef	277 gh
M2T5	94.07	111.7	2.48 gh	248 j
M3T1	123.3	150.7	3.55 bc	355 c
M3T2	120.5	146.7	4.12 a	412 a
M3T3	114.7	140.0	3.37 cd	337 d
M3T4	102.9	128.4	2.82 e	282 g
M3T5	93.73	111.0	2.56fgh	256 i
F-test	NS	NS	**	**
C.V (%)	0.95	0.84	2.94	3.10

*Means followed by same letter (s) in a column did not differ significantly from each other by DMRT. ** = Significant at 1% level NS = Not significant*

stage in December influenced the photosynthesis resulting decreased dry matter percentage to the later seeding. Interaction effect of planting method and seeding time on dry matter percentage was not significant (Table 7). This result was almost similar to Mousavi et al. [16], where they reported 5.10 - 7.81% of dry matter content. On the other hand, Koudela and Petrikova [17] reported 5.90 - 14.00% dry matter content of lettuce leaf, which was very high and different from the present findings. This variation could be due to the difference of genotypes or the environment and/or both.

Table 7. Effect of planting method, seeding time and their interaction on the quality characters

Treatments	Dry matter (%)	Fiber content (%)	Organoleptic test
Planting methods			
M1	5.97 b	2.03 a	3.13 b
M2	6.52 ab	1.64 b	3.74 a
M3	6.82 a	1.65 b	3.75 a
F-test	*	*	**
CV (%)	6.80	11.78	3.17
Seeding time			
T1	7.28 ab	1.31 c	4.18 b
T2	7.74 a	1.35 c	4.47 a
T3	6.31 bc	1.30 c	3.40 c
T4	5.50 c	2.13 b	3.22 c
T5	5.34 c	2.77 a	2.42 d
F-test	**	**	**
CV (%)	6.80	11.78	3.17
Interaction of planting methods and seeding time			
M1T1	6.67	1.63	3.67 cd
M1T2	7.17	1.52	4.23 b
M1T3	6.00	1.42	2.61 fg
M1T4	5.17	2.49	2.83 f
M1T5	4.83	3.09	2.31 h
M2T1	7.50	1.14	4.42 ab
M2T2	7.73	1.26	4.58 ab
M2T3	6.10	1.24	3.80 c
M2T4	5.67	1.92	3.42 de
M2T5	5.60	2.63	2.46 gh
M3T1	7.67	1.15	4.45 ab
M3T2	8.33	1.27	4.60 a
M3T3	6.83	1.25	3.80 c
M3T4	5.67	1.98	3.40 e
M3T5	5.60	2.60	2.50 gh
F-test	NS	NS	**
CV (%)	6.80	11.78	3.17

*Means followed by same letter (s) in a column did not differ significantly from each other by DMRT. ** = Significant at 1% level * = Significant at 5% level, NS=not significant*

Fiber content (%): Significant variations in percent fiber content were observed by planting methods (Table 7). Maximum fiber content (2.03%) was observed in plants from the transplanting with nursery seedlings. The minimum fiber content (1.64%) was found in plants from the transplanting with polybag raised seedlings, which was statistically similar with direct seeding (1.65%). Percent fiber content in lettuce leaf was also significantly varied by seeding times (Table 7). The highest fiber content 2.77% was recorded in plants from 16 December seeding and the lowest fiber content 1.30% was recorded in plants from 16 November seeding, which was closely followed by 16 October (1.31%) and 1 November (1.35%) seeding. Results revealed that fiber content was higher in late planting, which was undesirable for the salad crops. Hence the early planting is best compared to late planting for quality lettuce leaf. The interaction effect of planting methods and seeding time in fiber content of lettuce was not significantly varied (Table 7). Koudela and Petrikova [17] reported fiber content from 1.07 to 3.16% in a 2-year study. In the present study fiber content ranged from 1.31 to 2.77, which is partially confirmed by the above findings.

Organoleptic test: A significant variation was observed in respect of organoleptic test by the treatments (Table 7). The highest taste score 3.75 was found from the plants in direct seeding, which is identical with plants from transplanting with polybag raised method. On the other hand, organoleptic taste performed for the plants from transplanting with nursery seedlings got the lowest score of 3.13. It might be due to the lower dry matter and lower fiber content with high

crispness in direct seeding and transplanting with polybag seedlings. Sharma et al. [12] reported the highest organoleptic test score 3.27 produced by the plants from direct seeding. There was also significant variation in organoleptic taste by the time of seeding (Table 7). The highest score 4.47 obtained for the plants from 1 November seeding and the lowest (2.42) was found in plants from 16 December seeding. It was revealed that the quality of lettuce leaf was decreased gradually with the later seeding, which might be due to the increment of fiber content, toughness and bitterness of leaf in high temperature. Work [18] also reported that the bitterness of lettuce increased with the increment of temperature. The interaction effect of planting methods and seeding time also influenced taste of lettuce leaf significantly (Table 7). The highest score 4.60 for organoleptic test was obtained from M3T2, which was closely followed by M2T2 (4.58), M3T1 (4.45) and M2T1 (4.42). The lowest score 2.31 was found in M1T5, which was statistically similar with M2T5 (2.46) and M3T5 (2.50). Maynard [19] reported an average rating of 2.7 from a scale of 1-9 (1 = not at all bitter, and 9 = inedible bitter). Our test result was supported by the existing literature of Kumar et al. [20] and Maynard [19].

4. CONCLUSION

The highest leaf yield 187.5 g/plant as well as 18.75 t/ha was recorded from the direct seeding method (M3), whereas the maximum leaf yield 246.2 g/plant and 24.63 t/ha was obtained from 1 November seeding (T2). Thus, it was reflected in the interaction effect, where the highest leaf yields 272.60 g/plant and 27.33 t/ha was harvested from the treatment combination of M3T2. Similar treatment effect was also observed for the seed production of lettuce in the study. Transplanting of polybag raised seedlings (M2) may be considered if the land is pre-occupied by the pervious crops.

COMPETING INTERESTS

There is absolutely no conflict of interest between the authors and producers of the products. We do not intend to use these products as an avenue for any litigation but for the advancement of knowledge.

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