EFFECT OF SEED SOWING TIME AND NUTRIENTS ON THE GROWTH AND YIELD OF FENNEL (*Foeniculum vulgare*)

Abstract

In order to investigate the influence of seed sowing time and nutrients on the growth and yield of fennel, an experiment based on Randomized Complete Block Design with twelve treatments and three replications at the Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during October, 2019 to July, 2020 season was carried out. Fennel variety 'BARI Mouri-1' was used as planting material in this study. The experiment consisted of two factors: Factors-A: Sowing time (4 levels): S_1 = First week of November, S_2 = Last week of November, S_3 = First week of December and S_4 = Last week of December; Factors-B: Nutrients (4 levels): T_0 = Control, T_1 = Vermicompost (2.50 t ha^{-1}), T_2 = NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}) and T_3 = Vermicompost (2.50 t ha^{-1}) + NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}). The result revealed that in case of seed sowing time S_2 (Last week of November) and in case of different level of nutrients T_3 [Vermicompost (2.50 t ha^{-1}) + NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1})] treatment exhibited its superiority to other treatments in terms of plant height, number of leaves , number of primary branches, number of secondary branches, number of umbel per plant, number of umbellet per umbel, no. of days to first flowering, seed weight per umbel, weight of 1000-seeds and seed weight per ha. Significantly the highest seed yield (2.34t ha^{-1}) was found in S_2T_3 [(Last week of November with Vermicompost (2.50 t ha^{-1}) + NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1})] interaction due to the tallest plant at harvest (117.59 cm), number of leaves (15.07), number of primary branches (7.62), number of secondary branches (20.18), minimum days to first flower (82.60), maximum number of umbellet $umbel^{-1}$ (27.72), number of umbel $plant^{-1}$ (26.75), maximum weight of 1000-seeds (6.38 g), maximum seed weight $umbel^{-1}$ (2.09 g).

Keywords: Seed sowing time; nutrients; vermicompost; growth; yield; fennel.

1.Introduction

Foeniculum vulgare Mill., universally known as fennel, is a medicinal and aromatic plant belonging to the Apiaceae (Umbelliferae) family. All parts of the plant such as root, stem, leaves and especially seeds are aromatic and can be used in many ways [1]. Phenols, phenolic glycosides and volatile aroma compounds such as trans-anethole, estragole and fenchone have been reported as the major phytoconstituents of this species. The phenolic compounds isolated from fennel are considered to be responsible for its antioxidant activity while the volatile aroma compounds make it an excellent flavouring agent. Mean essential oil content is 1.0-1.5% in leaves, 0.6-0.7% in roots and 2.0-6.0% in fruits [2]. Fennel is widely cultivated in Europe, Asia, the USA and many African countries as well as Brazil and Argentina for medicinal and feeding purposes [3]. Fennel is a minor spices crop in Bangladesh and is cultivated throughout the country in winter season. In Bangladesh and neighbouring country seeds are used for flavouring soaps, meat dishes and sauces, bread rolls, pastries and confectionery, liquors and in the manufacture of pickles.

Sowing date are very important parameters in crop production. Adjustment in sowing time creates favourable environmental condition for better performance of all physiological processes in plant and for escaping from pest and diseases which provides great opportunity to maximize the production. In very early seeding, the low temperatures of soil and frost damages cause a weak growth for plants in spring. On the other hand, very delaying seeding leads to a reduction in the growth period of plants and the chance of coincidence in the blossoming time since high temperatures which will have an opposite impact on the plant growth. One of the most important factors of agricultural production management is choosing the suitable time for cultivation to obtain optimum use of natural resources during the growth season [4].

Plant nutrient one of the most important factors that increase plant production. Adequate supply of nutrients incrcase the yield. Chemical fertilizers are key components for providing crop nutrients needs in recent years. In many cases, using chemical fertilizers have different negative environmental effects such as soil, water and air pollution, which increase environmental production cost [5]. To avoid the risk of these negative effects of chemical fertilizers, it is necessary to use organic or biological fertilizers which

provide plant nutrients and also increase long term sustainability of agroecosystems. There is a strong relation between soil organic matter content and soil fertility, widely and universally accepted. At present, using organic manures and biofertilizers, such as vermicompost has led to a decrease in the application of chemical fertilizers and provide high quality products free of harmful agro chemicals for human safety [6]. Vermicompost is produced as an alternative to fertilizer to improve plant growth while not at the outlay of the environment. Vermicompost increased the bioavailability of nutrients from mineralization, which encourages high germination and dry matter production of plants [7]. Application of nutrient such as NPK and vermicompost induce the fennel production. [8] reported that vermicompost contains most nutrients in plant available forms, such as nitrates, phosphates and exchange ablecalcium and soluble potassium. Soil treated with vermicompost, total porosities were 24% higher than in the unfertilized soil [9]. Some studies have reported that vermicompost can increase the quantity and quality of essential oil in a few medicinal plants such as basil [10] coriander [11], fennel [12]. The aim of this study was to determine growth and yield of fennel (*Foeniculum vulgare*) essential oil as affected by the sowing time and application of vermicompost and NPK fertilizer.

2. MATERIALS AND METHODS

2.1 Experimental Site and Experimental Framework The research work was conducted at "Horticulture Farm" of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from November 2019 to March 2020. The location of the site was 23°74′ N Latitude and 90°35′ E Longitude with an elevation of 8.2 meters from the sea level (Anon, 1987). There are two factors named as factor-A (sowing time): S_1 = First week of November, S_2 = Last week of November, S_3 = First week of December, S_4 = Last week of December and Factor-B (nutrients): T_0 = Control, T_1 = Vermicompost (2.50 t ha^{-1}), T_2 = NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}), T_3 = Vermicompost (2.50 t ha^{-1}) + NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}). The two-factorial experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were distributed randomly. There were 36 unit plots altogether in the experiment.
Planting materials The seeds of fennel cv. BARI Mouri-1 variety were collected from Bangladesh Agricultural Research Institute (BARI), Gazipur.

2.3 Application of manures and fertilizers Farmyard manure (FYM), Urea, TPS and MoP and were applied @ 2.5-ton ha^{-1}, 80, 50 and 60 kg ha^{-1}, respectively as per treatment. The FYM was applied after opening the land. The total amount of TSP and MoP were applied at the final land preparation. Total urea was applied in two installments. The 1st installments were applied at final land preparation and 2nd installments were applied 45 days after planting as top dressing as per treatment. The fertilizer was thoroughly mixed with the soil.

2.4 Statistical Analysis The collected data were compiled and tabulated. Statistical analysis was done on various plant characters to find out the significance of variance resulting from the experimental treatments. Data were analyzed using analysis of variance (ANOVA) technique with the help of computer package program MSTAT-C (software) and the mean differences were adjudged by least significant difference test (LSD) as laid out by [13].

3. RESULTS AND DISCUSSION

3.1 Plant height (cm)

Plant height is an important parameter which reflects the vegetative growth of plant. The plant height was significantly influenced by different sowing time on fennel (Figure 1). At 45 DAS, first week of November (S_1)showed the longest plant (9.25 cm) which was statistically identical to S_2 (9.11 cm) whereas, the shortest plant (7.83 cm) was found from last week of December (S_4) treatment. The last week of November (S_2) showed the longest plant (49.04 cm and 107.44 cm at 90 and 135 DAS, respectively) and the shortest plant (38.72 and 97.15 cm at 90 and 135 DAS, respectively) was found from last week of December (S_4) treatment. This might be due to the fact that last week of November possibly received favorable condition for quickest growth than those of other sowing time. This result agrees with the result

obtained by [14] they reported that the sowing of fennel in the first date (20th November) resulted in increase of all studied vegetative.

The plant height was observed significantly influenced by different nutrients application (Figure 2). The tallest plant (10.84, 56.25 and 114.83 cm, respectively) was recorded from T_3 (Vermicompost (2.50 t ha^{-1}) + NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1})) application at 45, 90 and 135 DAS, while the shortest plant (6.63, 32.06 and 86.33 cm, respectively) was observed from control (T_0) treatment at the same growth stage. The tallest plant at all dates of observations were found when vermicompost with NPK application. The variation in plant height as influenced by different nutrients was perhaps due to proper utilization nutrients, moisture and light. This result is agreed with the findings [16]. [18] also conducted that the application of vermicompost increased the growth measurements.

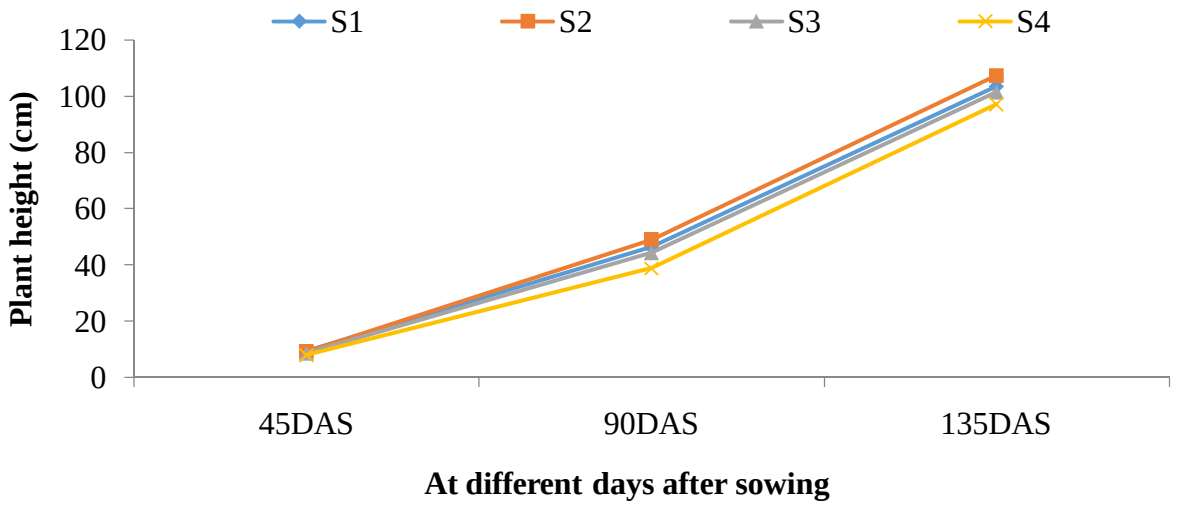

Figure 1. Effect of different sowing time on plant height (cm) at different days after sowing of fennel (*Foeniculum vulgare*) Here, Sowing time: S_1 – First week of November, S_2 – Last week of November, S_3 – First week of December and S_4 – Last week of December.

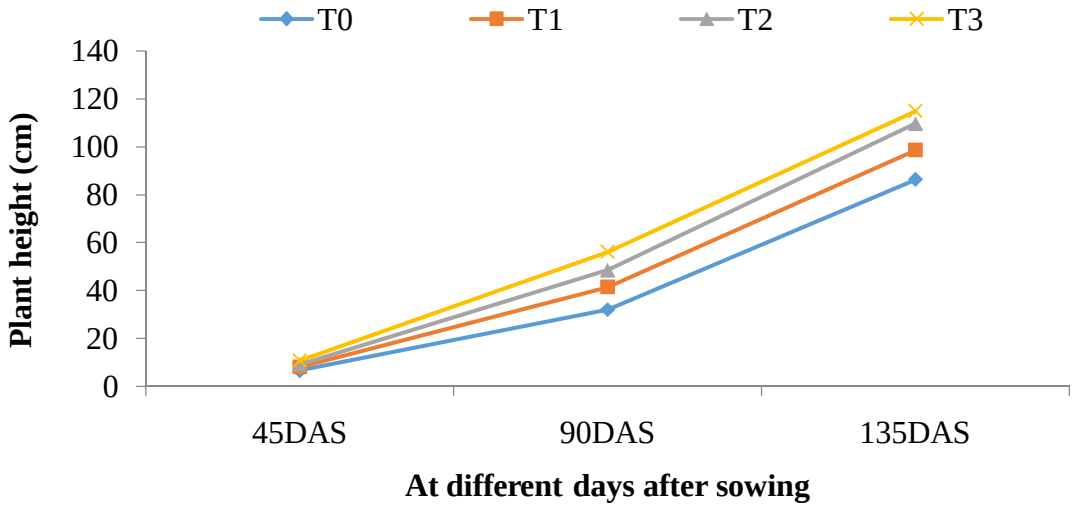

Figure 2. Effect of different nutrients on plant height (cm) at different days after sowing of fennel (*Foeniculum vulgare*) Here, Nutrient: T_0 - Control, T_1 - Vermicompost (2.50 t ha^{-1}), T_2 - NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}), T_3 - Vermicompost (2.50 t ha^{-1}) + NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}).

The combined effect of different sowing time and nutrients was found statistically significant on all dates of observation (Table 1). At 45 DAS, the tallest plant (11.83 cm) was measured from S_2T_3 (last week of November with Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment, which was statistically similar to S_1T_3 (11.33 cm) and the shortest plant (6.00 cm) was recorded from S_3T_0 (first week of December with control) treatment, which was statistically similar to S_4T_0 (6.33 cm) and S_2T_0 (7.04 cm). At 90 DAS, the tallest plant (60.73 cm) was measured from S_2T_3 (last week of November with Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment which was statistically similar to S_1T_3 (59.20 cm) whereas, the shortest plant (29.27 cm) was recorded from S_4T_0 (last week of December with control) treatment which was statistically similar to S_3T_0 (30.00 cm). At 135 DAS, the longest plant (117.59 cm) was measured from S_2T_3 (last week of November with Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment while, the shortest plant (82.00 cm) was recorded from S_4T_0 (last week of December with control) treatment. This might be due to the fact that environmental conditions for vegetative growth were favorable for older seedlings for completing vegetative growth.

3.2 Number of leaves $plant^{-1}$

Good foliage indicates higher growth, development and productivity of plant. In the present study, the number of leaves per plant was found to be significantly influenced by the different sowing time (Table 2). The maximum number of leaves (12.68) $plant^{-1}$ of fennel was observed from S_2 (last week of November) treatment. Similar trend was obtained by [14] who reported that the planting of fennel plant in the first date (20^{th} November) resulted in increase of number of leaves $plant^{-1}$.

The results showed highly significant effect of different nutrients application on the number of leaves $plant^{-1}$ (Table 3). The maximum number of leaves (14.02) was recorded from T_3 (Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment. It was observed that number of leaves per plant was higher in plants with all nutrient's application. This result agrees with the findings of [16].

The maximum number of leaves (15.07) was recorded from S_2T_3 (last week of November with Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment which was statistically similar (14.00) by S_3T_3 (first week of December with Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment. On the other hand, the minimum number of leaves (8.20) was observed from S_4T_0 (last week of December with control) treatment of fennel which was statistically similar to S_3T_0 (9.33) and S_4T_1 (9.40) treatment.

Table 1. Combined effect of different sowing time and nutrients on plant height at different days after sowing of fennel (*Foeniculum vulgare*)

Treatments	Plant height (cm)		
	45 DAS	90 DAS	135 DAS
S_1T_0	7.17 gh	33.13 j	87.07 i
S_1T_1	8.50 de	42.47 g	98.00 f
S_1T_2	10.00 c	50.47 d	113.53 b
S_1T_3	11.33 ab	59.20 ab	115.27 b
S_2T_0	7.04 hi	35.83 i	92.00 h
S_2T_1	8.41 d-f	46.27 f	105.40 d
S_2T_2	9.13 d	53.33 c	114.77 b
S_2T_3	11.86 a	60.73 a	117.59 a
S_3T_0	6.00 j	30.00 k	84.27 j
S_3T_1	7.77 fg	40.13 h	96.00 fg
S_3T_2	9.13 d	48.27 e	110.47 c
S_3T_3	11.07 b	58.53 b	115.07 b

S_4T_0	6.33 ij	29.27 k	82.00 k
S_4T_1	7.73 f-h	37.20 i	95.00 g
S_4T_2	8.13 ef	41.87 gh	100.20 e
S_4T_3	9.10 d	46.53 ef	111.40 c
$LSD_{(0.05)}$	0.7238	1.9092	2.0084
CV%	4.91	2.49	3.08

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability. Here, Sowing time: S_1 – First week of November, S_2 – Last week of November, S_3 – First week of December, S_4 – Last week of December and Nutrient: T_0 - Control, T_1 - Vermicompost (2.50 t ha^{-1}), T_2 - NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}), T_3 - Vermicompost (2.50 t ha^{-1}) + NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}).

3.3 Number of primary branches

Effect of different sowing time significantly influenced number of primary branches $plant^{-1}$ (Table 2). The highest number of primary branches $plant^{-1}$ (6.99) was recorded from the S_1 (first week of November) treatment. The lowest number (6.00) of primary branches $plant^{-1}$ was recorded from the S_4 (last week of December) treatment. This study revealed that first week of November produced maximum number of primary branches $plant^{-1}$. These findings are in accordance with the results of [19], [20].

Effect of different nutrients application significantly influenced number of primary branches $plant^{-1}$ (Table 3). The highest number (7.42) of primary branches $plant^{-1}$ was recorded from the Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1} (T_3) treatment. On the other hand, the lowest number (5.56) of primary branches $plant^{-1}$ was recorded from the control (T_0) treatment. This study revealed that all nutrients application produced maximum number of primary branches $plant^{-1}$. [[21] showed that the integrated nutrient management significantly affected different growth and yield attributes of fennel viz., plant height (cm), number of branches per plant.

The combined effect of different sowing time and nutrients application was also found to be statistically significant in this respect (Table 4) The highest number (7.99) of primary branches $plant^{-1}$was recorded from S_1T_3 (first week of November with Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment which was statistically similar to S_1T_3 (7.62) treatment. On the other hand, the lowest number (4.81) of primary branches $plant^{-1}$ was observed from S_4T_0 (last week of December with control) treatment of fennel which was statistically identical to S_3T_0 (5.08) treatment.

3.4 Number of secondary branches

Effect of different sowing time significantly influenced number of secondary branches $plant^{-1}$ (Table 2). The maximum number of secondary branches $plant^{-1}$ (17.64) was recorded from the S_2 (last week of November) treatment whereas, the minimum (15.45) was recorded from the S_4 (last week of December) treatment. This study revealed that last week of November produced highest number of secondary branches $plant^{-1}$.

Effect of different nutrients application significantly influenced number of secondary branches $plant^{-1}$ (Table 3). The maximum number (18.61) of secondary branches $plant^{-1}$ was recorded from the T_3 (Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment whereas, the minimum (13.87) was recorded from the control (T_0) treatment. This study revealed that all nutrients application produced maximum number of secondary branches $plant^{-1}$.

Table 2. Effect of different sowing time on number of leaves, number of primary branches, number of secondary branches and number of umbellet $umbel^{-1}$ of fennel (*Foeniculum vulgare*)

Treatments	Number of leaves	Number of primary branches	Number of secondary branches	Number of umbellet $umbel^{-1}$
S_1	11.67 b	6.99 a	16.40 b	23.51 b
S_2	12.68 a	6.73 b	17.64 a	24.53 a
S_3	11.33 b	6.26 c	15.82 c	22.63 c
S_4	10.42 c	6.00 d	15.45 d	21.65 d

$LSD_{(0.05)}$	0.6283	0.2444	0.3389	0.5526
CV %	6.32	4.51	2.49	2.96

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability. Here, Sowing time: S_1 – First week of November, S_2 – Last week of November, S_3 – First week of December and S_4 – Last week of December.

Table 3. Effect of different nutrients on number of leaves, number of primary branches, number of secondary branches and number of umbellet umbel^{-1} of fennel (*Foeniculum vulgare*)

Treatments	Number of leaves	Number of primary branches	Number of secondary branches	Number of umbellet umbel^{-1}
T_0	9.30 d	5.56 c	13.87 d	20.34 d
T_1	10.77 c	6.38 b	16.03 c	21.85 c
T_2	12.02 b	6.62 b	16.81 b	24.55 b
T_3	14.02 a	7.42 a	18.61 a	25.58 a
$LSD_{(0.05)}$	0.6283	0.2444	0.3389	0.5526
CV %	6.32	4.51	2.49	2.96

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability. Here, Nutrient: T_0 - Control, T_1 - Vermicompost (2.50 t ha^{-1}), T_2 - NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}), T_3 - Vermicompost (2.50 t ha^{-1}) + NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}).

The combined effect of different sowing time and nutrients application was also found to be statistically significant in this respect (Table 4). The maximum number of secondary branches plant^{-1} (20.18) was recorded from S_2T_3 (last week of November with Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment combination which was statistically similar to S_1T_3 (19.61) treatment whereas, the minimum number (12.73) of secondary branches plant^{-1} was observed from S_4T_0 (last week of December with control) treatment.

3.5 Number of umbel plant^{-1}

Different sowing time had significant effect on number of umbel plant^{-1} of fennel (Figure 3). The highest number of umbel plant^{-1} (22.94) was recorded from S_2 (last week of November) treatment. In comparison, the lowest number of umbel plant^{-1} (17.53) was recorded from S_4 (last week of December) treatment of sowing time. Ayub *et al.* (2008) found that the number of umbels per plant were affected significantly by different sowing date.

Different nutrients application had significant effect on number of umbel plant^{-1} of fennel (Figure 4). The highest number of umbel plant^{-1} (24.39) was recorded from T_3 (vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment. In comparison, the lowest number of umbel plant^{-1} (16.79) was recorded from T_0 (control) treatment of nutrients application.

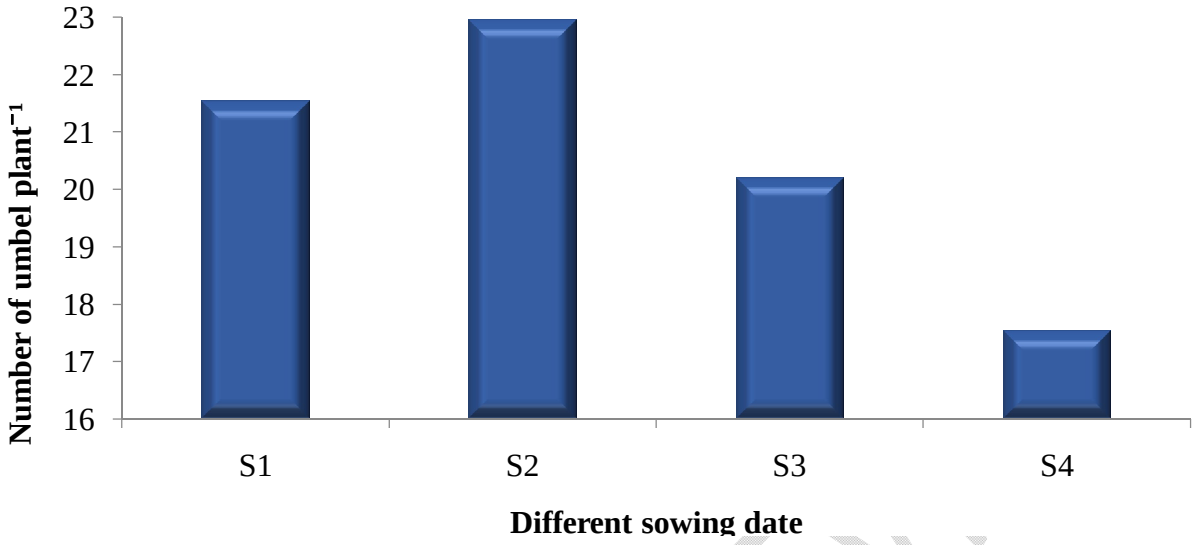

Figure 3. Effect of different sowing time on number of umbel plant^{-1} of fennel (*Foeniculum vulgare*)(LSD value = 0.6279). Here, Sowing time: S_1 – First week of November, S_2 – Last week of November, S_3 – First week of December and S_4 – Last week of December.

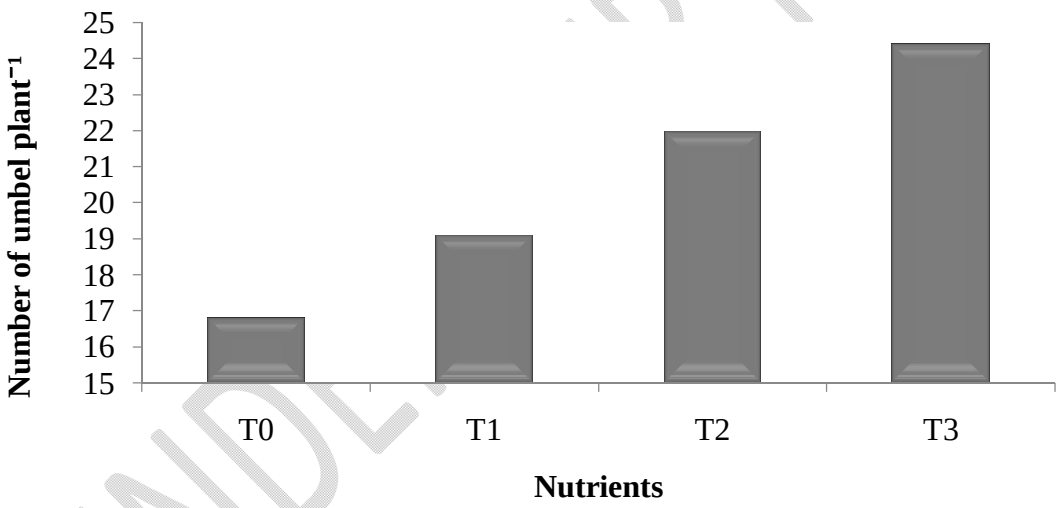

Figure 4. Effect of different nutrients on number of umbel plant^{-1} of fennel (*Foeniculum vulgare*) (LSD value = 0.6279). Here, Nutrient: T_0 - Control, T_1 - Vermicompost (2.50 t ha^{-1}), T_2 - NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}), T_3 - Vermicompost (2.50 t ha^{-1}) + NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}).

Combined effect of different sowing time and nutrients application showed significant effect on number of umbel plant^{-1} of fennel (Table 4). The highest number of umbel plant^{-1} (26.75) was recorded from treatment combination of last week of November with Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1} (S_2T_3) which was statistically similar to S_1T_3 (25.80) treatment. In comparison, the lowest number of umbel plant^{-1} (14.53) was recorded from last week of December with control treatment combination (S_4T_0).

3.6 Number of umbellet umbel^{-1}

Different sowing time had significant effect on number of umbellet umbel^{-1} of fennel (Table 2). The maximum number of umbellet umbel^{-1} (24.53) was recorded from S_2 (last week of November) treatment and the minimum (21.65) was recorded from S_4 (last week of December) treatment of sowing time.

Different nutrients application had significant effect on number of umbellet umbel^{-1} of fennel (Table 3). The maximum number of umbellet umbel^{-1} (25.58) was recorded from T_3 (vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment whereas, the minimum number of umbellet umbel^{-1} (20.34) was recorded from T_0 (control) treatment of nutrients application.

Combination effect of different sowing time and nutrients application showed significant effect on number of umbellet umbel^{-1} of fennel (Table 4). The maximum number of umbellet umbel^{-1} (27.72) was recorded from treatment combination of S_2T_3 (last week of November with Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}). On the other hand, the minimum number of umbellet umbel^{-1} (19.07) was recorded from S_4T_0 (last week of December with control) treatment combination.

Table 4. Combined effect of different sowing time and nutrients on number of leaves, number of primary branches, number of secondary branches, number of umbel plant^{-1} and number of umbellets umbel^{-1} of fennel (*Foeniculum vulgare*)

Treatments	Number of leaves	Number of primary branches	Number of secondary branches	Number of umbel plant^{-1}	Number of umbellet umbel^{-1}
S_1T_0	9.67 d	6.33 de	14.00 i	17.40 i	20.67 ij
S_1T_1	11.67 c	6.80 cd	15.00 gh	20.20 fg	22.13 gh
S_1T_2	12.00 c	6.88 c	17.00 d	22.73 d	24.67 cd
S_1T_3	13.33 b	7.99 a	19.61 ab	25.80 ab	26.58 b
S_2T_0	10.00 d	6.03 e	15.20 f-h	19.00 gh	21.40 hi
S_2T_1	12.00 c	6.47 c-e	17.00 d	21.13 ef	23.75 d-f
S_2T_2	13.67 b	6.80 cd	18.17 c	24.85 bc	25.25 c
S_2T_3	15.07 a	7.62 ab	20.18 a	26.75 a	27.72 a
S_3T_0	9.33 de	5.08 f	13.53 i	16.23 i	20.20 j
S_3T_1	10.00 d	6.13 e	14.83 h	18.73 h	21.27 h-j
S_3T_2	12.00 c	6.40 c-e	15.80 ef	21.53 de	25.52 bc
S_3T_3	14.00 ab	7.41 b	19.12 b	24.27 c	23.53 ef
S_4T_0	8.20 e	4.81 f	12.73 j	14.53 j	19.07 k
S_4T_1	9.40 de	6.13 e	17.27 d	16.20 i	20.27 j
S_4T_2	10.40 d	6.40 c-e	16.27 e	18.67 h	22.75 fg
S_4T_3	13.67 b	6.68 cd	15.53 fg	20.73 ef	24.50 c-e
$LSD_{(0.05)}$	1.2566	0.4888	0.6777	1.2558	1.1051
CV%	6.32	4.51	2.49	3.48	2.96

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability. Here, Sowing time: S_1 – First week of November, S_2 – Last week of November, S_3 – First week of December, S_4 – Last week of December and Nutrient: T_0 - Control, T_1 - Vermicompost (2.50 t ha^{-1}), T_2 - NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}), T_3 - Vermicompost (2.50 t ha^{-1}) + NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}).

3.7 DAS to first flower

Significant variation was observed for DAS (days after sowing) to first flower among the different sowing time (Table 5). The maximum DAS to first flower (88.43 day) was observed in S_4 (last week of December) treatment, while the minimum (82.76 day) was observed in S_1 (first week of November) treatment. The minimum number of days after sowing to first flower was observed with the crops sown on first week of November.

Significant variation was observed for DAS to first flower among the different nutrient's application of fennel (Table 6). The maximum DAS to first flower (88.45 day) was observed in T_0 (control) treatment

whereas, the minimum (83.30 day) was observed in T_3 (Vermicompost 2.5 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment.
Combined effect of different sowing time with different nutrients applicationshowed significant variation in DAS to first flower on fennel (Table 7). The maximum DAS to first flower (90.83 day) was recorded from S_4T_0 treatment. On the other hand, the minimum DAS to first flower (80.20 day) was observed from S_1T_3 treatment, which was statistically identical to that of S_1T_2 (80.57 day) treatment. The lowest number of DAS to first flower was observed in crops sown on first week of November with Vermicompost 2.5 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1} application.

3.8 Seed weight umbel^{-1}(g)
Different sowing time had significant effect on seed weight umbel^{-1} of fennel (Table 5). The maximum seed weight umbel^{-1} (1.48 g) was recorded from S_4 (Last week of December) treatment whereas, the minimum seed weight umbel^{-1} (1.27 g) was recorded from S_3 (first week of December) treatment of sowing time which was statistically identical (1.33 g) to S_2 (last week of November). Rassam *et al.* (2006) reported that delay in planting date caused significant reduction in seed weight per umbel.

Different nutrients application had significant effect on seed weight umbel^{-1} of fennel (Table 6). The maximum seed weight umbel^{-1} (1.92 g) was recorded from T_3 (vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment whereas, the minimum seed weight umbel^{-1} (0.88 g) was recorded from T_0 (control) treatment of nutrients application.

Combination effect of different sowing time and nutrients application showed significant effect on seed weight umbel^{-1} of fennel (Table 7). The maximum seed weight umbel^{-1} (2.09 g) was recorded from treatment combination of S_2T_3 (last week of November with Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment which was statistically identical (2.08 g) to S_4T_3 (Last week of december with Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment. On the other hand, the minimum seed weight umbel^{-1} (0.78 g) was recorded from last week of November with control treatment combination (S_2T_0) which was statistically similar to S_1T_0 (0.89 g) treatment combination.

3.9. 1000-seeds weight (g)
1000-seeds weight showed significant difference of fennel due to different sowing time (Table 5). The highest weight of 1000 seeds (5.96 g) was recorded from S_2 (last week of November) treatment, which was statistically similarto S_1 (5.83 g), whereas the lowest weight of 1000 seeds (5.39 g) was observed in S_4 (last week of December) treatment. [19] found that the effect of different sowing time on 1000-seed weight of main, primary and secondary umbels was found to be non-significant.

1000-seed weight of fennel differed significantly due to different nutrients application (Table 6). The highest weight of 1000 seeds (5.97 g) was recorded from T_3 (Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment, which statistically similar to T_2 (5.81 g) treatment. On the other hand, the lowest weight of 1000 seeds (5.49 g) was found T_0 (control) treatment, which statistically similar to T_1 (5.65 g) treatment. Further increase in 1000-seed weight in treatments receiveing NPK dcompared to control might be due to better availability of nutrients that might have helped in producing bolder and heavier seeds.

Combined effect between different sowing time and nutrients applicationshowed significant variation in weight of 1000 seeds (Table 7). The highest 1000-seed weight (6.38 g) was recorded from S_2T_3 (last week of November with Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) which was statistically similar to S_1T_3 (6.12 g) treatment combination. On the other hand, the lowest 1000-seed weight (5.13 g) wasobserved in S_4T_0 (last week of December with control), which was statistically similar to S_4T_1 (5.35 g) and S_4T_3 (5.40 g) treatment combination.

3.10 Seed yield plant^{-1}(g)
In the present study, the seed yield plant^{-1} was found to be significantly influenced by the different sowing time (Figure 6). The highest seed yield plant^{-1} (32.36 g) of fennel was observed from S_2 (last week of November) treatment, while the lowest seed yield plant^{-1} (27.23 g) was observed from S_4 (last week of December) treatment.

The results showed highly significant effect of different nutrients application on the seed yield plant^{-1} (Figure 7). The highest seed yield plant^{-1} (47.76 g) was recorded from T_3 (Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment, while the lowest seed yield plant^{-1} (15.05 g) of fennel was found from T_0 (control) treatment.

The combined effect of different sowing time and nutrients application was also found to be statistically significant in this respect (Table 7). The highest seed yield plant^{-1} (56.04 g) was recorded from S_2T_3 (last week of November with Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment combination. On the other hand, the lowest seed yield plant^{-1} (13.80 g) was observed from S_4T_0 (last week of December with control) treatment combination of fennel.

Figure 5. Effect of different sowing time on seed yield plant^{-1} (g) of fennel (*Foeniculum vulgare*) (LSD value = 0.4858).**Here, Sowing time:** S_1 – First week of November, S_2 – Last week of November, S_3 – First week of December and S_4 – Last weekof December.

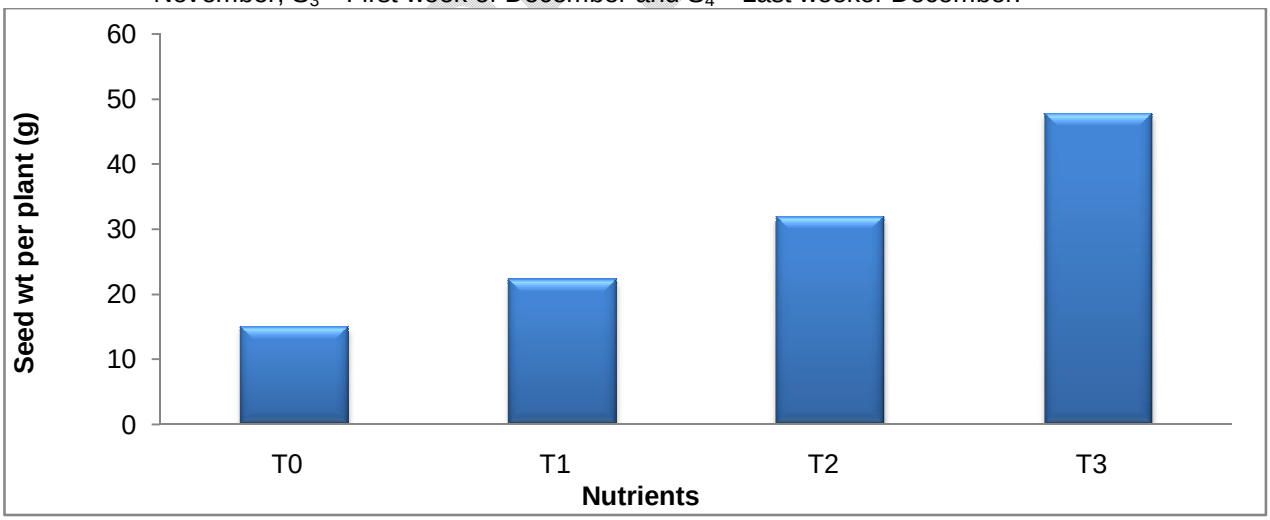

Figure 6. Effect of different nutrients on seed yield plant^{-1} (g) of fennel (*Foeniculum vulgare*) (LSD value = 0.4858)**Here, Nutrient:** T_0 - Control, T_1 - Vermicompost (2.50 t ha^{-1}), T_2 - NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}), T_3 - Vermicompost (2.50 t ha^{-1}) + NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}).

3.11 Seed yield ha^{-1} (ton)

In the present study, the seed yieldha^{-1} was found to be significantly influenced by the different sowing time (Table 5). The maximum seed yieldha^{-1} (1.35 ton) of fennel was observed from S_2 (last week of November) treatment, while the minimum seed yieldha^{-1} (1.13 ton) was observed from S_4 (last week of December) treatment. The obtained results correlated with those given by authors like [11] they noticed that the earliest sown plants produced the highest seed yields compared with control plants.

The results showed highly significant effect of different nutrients application on the seed yieldha^{-1} (Table 6). The maximum seed yield ha^{-1} (1.99 ton) was recorded from T_3 (Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment, while the minimum seed yield ha^{-1} (0.63 ton) of fennel was found from T_0 (control) treatment. It was observed that seed yield ha^{-1} was higher in plants with all nutrient's application. It was probably due to reduced inter plant competition for access to nutrient, moisture and other resources. Increase in yield attributes due to increasing levels of N and P had direct and positive effect on seed, straw and biological yields of fennel. [24] recorded maximum yield and yield attributes of cluster bean with vermicompost @ 2.5 t ha^{-1} + 75% NPK.

Table 5. Effect of different sowing time on seed weight $umbel^{-1}$, seed yield $plot^{-1}$, seed yield ha^{-1} and 1000-seed weight of fennel (*Foeniculum vulgare*)

Treatments	DAS to first flower	Seed weight $umbel^{-1}$ (g)	1000-seeds weight (g)	Seed yield ha^{-1} (ton)
S_1	82.76 d	1.38 b	5.83 ab	1.23 b
S_2	85.28 c	1.33 bc	5.96 a	1.35 a
S_3	86.70 b	1.27 c	5.73 b	1.17 c
S_4	88.43 a	1.48 a	5.39 c	1.13 d
$LSD_{(0.05)}$	0.5495	0.0603	0.1833	0.0145
CV %	3.79	2.47	3.63	2.37

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability. Here, Sowing time: S_1 – First week of November, S_2 – Last week of November, S_3 – First week of December and S_4 – Last week of December.

Table 6. Effect of different nutrients on seed weight $umbel^{-1}$, seed yield $plot^{-1}$, seed yield ha^{-1} and 1000-seed weight of fennel (*Foeniculum vulgare*)

Treatments	DAS to first flower	Seed weight $umbel^{-1}$ (g)	1000-seeds weight (g)	Seed yield ha^{-1} (ton)
T_0	88.45 a	0.88 d	5.49 c	0.63 d
T_1	86.79 b	1.17 c	5.65 bc	0.93 c
T_2	84.64 c	1.49 b	5.81 ab	1.33 b
T_3	83.30 d	1.92 a	5.97 a	1.99 a
$LSD_{(0.05)}$	0.5495	0.0603	0.1833	0.0145
CV %	3.79	2.47	3.63	2.37

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability. Here, Nutrient: T_0 - Control, T_1 - Vermicompost (2.50 t ha^{-1}), T_2 - NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}), T_3 - Vermicompost (2.50 t ha^{-1}) + NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}).

The combined effect of different sowing time and nutrients application was also found to be statistically significant in this respect (Table 7). The maximum seed yieldha^{-1} (2.34 ton) was recorded from S_2T_3 (last week of November with Vermicompost 2.50 t ha^{-1} + $N_{80}P_{50}K_{60}$ kg ha^{-1}) treatment combination. On the other hand, the minimum seed yieldha^{-1} (0.58 ton) was observed from S_4T_0 (last week of December with control) treatment combination of fennel.

Table 7. Combined effect of different sowing time and nutrients on seed weight $umbel^{-1}$, seed yield $plant^{-1}$, seed yield $plot^{-1}$, seed yield ha^{-1} and 1000-seeds weight of fennel (*Foeniculum vulgare*)

Treatments	DAS to first flower	Seed weight umbel^{-1} (g)	1000-seeds weight (g)	Seed yield plant^{-1}(g)	Seed yield ha^{-1} (ton)
S_1T_0	85.68 fg	0.89 fg	5.61 c-g	15.53 j	0.65 j
S_1T_1	84.60 gh	1.18 e	5.78 b-e	22.33 h	0.93 h
S_1T_2	80.57 j	1.63 c	5.80 b-e	32.13 e	1.34 e
S_1T_3	80.20 j	1.84 b	6.12 ab	47.73 b	1.99 b
S_2T_0	87.53 de	0.78 g	5.67 c-g	16.13 j	0.67 j
S_2T_1	86.731 ef	1.09 e	5.88 b-e	23.20 g	0.97 g
S_2T_2	84.27 h	1.36 d	5.92 b-d	34.07 d	1.42 d
S_2T_3	82.60 i	2.09 a	6.38 a	56.04 a	2.34 a
S_3T_0	89.73 b	0.90 f	5.53 e-g	14.73 k	0.61 k
S_3T_1	86.73 ef	1.11 e	5.60 d-g	22.20 h	0.93 h
S_3T_2	85.53 g	1.40 d	5.80 b-e	31.13 f	1.29 f
S_3T_3	84.80 gh	1.68 c	5.97 bc	43.93 c	1.80 c
S_4T_0	90.83 a	0.95 f	5.13 h	13.80 l	0.58 l
S_4T_1	89.09 bc	1.32 d	5.35 gh	21.33 i	0.89 i
S_4T_2	88.20 cd	1.57 c	5.71 c-f	30.47 f	1.27 f
S_4T_3	85.60 g	2.08 a	5.40 f-h	43.33 c	1.81 c
$LSD_{(0.05)}$	1.0991	0.1206	0.3666	0.6967	0.029
CV%	3.79	2.47	3.63	2.37	2.37

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability. Here, Sowing time: S_1 – First week of November, S_2 – Last week of November, S_3 – First week of December, S_4 – Last week of December and Nutrient: T_0 - Control, T_1 - Vermicompost (2.50 t ha^{-1}), T_2 - NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}), T_3 - Vermicompost (2.50 t ha^{-1}) + NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1}).

Conclusion: It was revealed that Last week of November sowing gave higher yield of fennel seed with higher values in most of the yield attribute parameters. Among the nutrient application treatments, vermicompost (2.50 t ha^{-1}) + NPK ($N_{80}P_{50}K_{60}$ kg ha^{-1})] was high yielder than other nutrient treatments. Among the interactions, S_2T_3 and S_1T_3 were superior in most of the growth and yield attributing parameters along with grain yield.

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