



ISSN: 0975-833X

Available online at <http://www.journalcra.com>

INTERNATIONAL JOURNAL  
OF CURRENT RESEARCH

International Journal of Current Research  
Vol. 14, Issue, 10, pp.22423-22426, October, 2022  
DOI: <https://doi.org/10.24941/ijcr.44079.10.2022>

## RESEARCH ARTICLE

### OPTIMIZATION OF SOWING DATES ON GROWTH, YIELD, AND QUALITY OF FENNEL (*FOENICULUM VULGARE* MILL.) VARIETIES

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#### ARTICLE INFO

##### Article History:

Received 10<sup>th</sup> July, 2022  
Received in revised form  
27<sup>th</sup> August, 2022  
Accepted 19<sup>th</sup> September, 2022  
Published online 19<sup>th</sup> October, 2022

##### Key words:

Sowing Dates,  
*Foeniculum vulgare*,  
Varieties,  
Yield and Quality

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Citation: Sheryl Sendur, K.C. Meena, I. S. Naruka, Nitin Soni, O.P. Singh, Kachouli, B.K. and Patidar, B.K. 2022. "Optimization of Sowing Dates on Growth, Yield, and Quality of Fennel (*Foeniculum vulgare* Mill.) Varieties". *International Journal of Current Research*, 14, (10), 22423-22426.

## INTRODUCTION

Fennel (*Foeniculum vulgare* Mill.) is a perennial herb of the family Apiaceae grown for its edible shoots, leaves and seeds. Fennel is one of the important cash crop of the Apiaceae family. Fennel is Native of southern Europe and Asia Minor where it is cultivated from ancient times. All parts of the fennel plant are aromatic and used in flavouring. Fennel is also sometimes used as a diuretic. Besides, the fruits were used as carminative and the roots, as purgative (Bhagora et al, 2021). Fennel oil is also used as an important ingredient in several allopathic as well as ayurvedic medicines which are used in diseases viz., cholera, bile disturbance, nervous disorder, constipation, dysentery and diarrhoea. Its seeds are also used in making pickles, garnishing, meat dishes, sauces, pastries etc. and as a flavouring agent in culinary preparations of confectionaries, cordials and liquors. In India fennel is cultivated over an area of 82,731 ha with the production of 1,39,760 tonnes, 2019-2020 (Spice Board, 2020). The export of fennel seeds from India has witnessed growth at a noteworthy rate over the past few years.

#### ABSTRACT

A field experiment was conducted at Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, RVSKVV, Mandsaur, (M.P.) during the Rabi season 2019-20 in RBD-Factorial with replicated three times. Result revealed that the maximum plant height (40.02, 108.17 and 193.65 cm) and dry weight (3.66, 15.88 and 107.96 g) were found in AF-2 and they were also maximum (42.81, 112.81 and 195.42 cm & 3.80, 17.88 and 109.59 g) when crop was sown on 20<sup>th</sup> October. Under the interaction too maximum (43.55, 115.48 and 198.03 cm & 3.93, 18.37 and 108.66) in the treatment combination D<sub>1</sub>V<sub>2</sub> (20<sup>th</sup> October + V<sub>2</sub>-AF-2) at 60, 90, 120 DAS and at harvest, respectively. In the yield and yield attributes, the primary (3.20), secondary (14.01) and tertiary (12.01) umbels and umbelletes per primary (37.74), secondary (29.90) and tertiary (13.24) umbels, umbel dry weight (8.59), test weight (8.41), seed yield (17.43), straw yield (27.00) and harvest index (36.74) had maximum in AF-2 and they were maximum (3.45, 14.41, 12.65, 39.37, 31.03, 13.54, 9.19, 8.65, 18.50, 28.96 and 37.91) respectively when fennel crop was sown on 20<sup>th</sup> October. Under the interaction of different treatment they were also obtained maximum (3.51, 14.97, 12.78, 36.69, 31.14, 13.93, 39.83, 9.83, 8.77, 19.25, 29.81 and 39.06) respectively in the treatment combination D<sub>1</sub>V<sub>2</sub> (20<sup>th</sup> October + V<sub>2</sub>-AF-2). The highest chlorophyll in leaves at 60 (1.43) & 90 (1.54) DAS and volatile oil in seed (1.23) had in fennel variety AF-2. However, Crop sown on 20<sup>th</sup> October they were also maximum (1.67, 1.79 & 1.36) at 60 & 90 DAS and volatile oil in seed respectively. Among the different infections 20<sup>th</sup> October + AF-2 had maximum chlorophyll at 60 (1.70) & 90 (1.81) DAS and volatile oil in seed (1.37) over other combinations.

The date of sowing of fennel is an important factor by which we come to know that which date of sowing is appropriate for better growth, yield and quality of the plant. 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 yield and quality (Shambhu et al, 2019). All the physiological process in the plants other than photochemical depend on temperature modifications in environment. The optimum sowing date paves the way for better use of time, light, temperature, precipitation and other factors (Moosavi, 2014).

## MATERIALS AND METHODS

In the course of presenting the result of experiment conducted at the Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Mandsaur during the year 2019-2020. The treatment accompanied with four different date of sowing viz., 20<sup>th</sup> October, 30<sup>th</sup> October, 10<sup>th</sup> November and 20<sup>th</sup> November against two cultivars viz. V<sub>1</sub>-(AF-1) and V<sub>2</sub>-(AF-2) of fennel crop in the Factorial

Randomized Block Design with three replications to assessed for growth, yield and quality characters under field condition. All the parameters were recorded at 60, 90 days after sowing and at harvest. The experimental data were subjected to statistical analysis using analysis of variance technique suggested by Panse and Sukhatme (1985). Where the “F” test was found significant at 5 % level of significance, the critical differences for the treatment’s comparison were worked out.

## RESULTS AND DISCUSSION

**Growth attributes:** Result revealed from Table 1 that the maximum plant height (40.02, 108.17 and 193.65 cm) was recorded in fennel variety AF-2 and the minimum (37.28, 104.50 and 189.02 cm) in AF-1 at 60, 90 DAS and at harvest respectively. However, it was maximum (42.81, 112.81 and 195.42 cm) when fennel crop sown on 20<sup>th</sup> October and as compared to other dates of sowing. During the interactions of 20<sup>th</sup> October + AF-2 had maximum plant height (43.55, 115.48 and 198.03 cm) over other combinations at 60, 90 DAS and at harvest respectively.

This may be due to the fact that delay sowing could not have given sufficient time for vegetative growth, resulted in poor plant canopy which adversely affected the plant height. These results are in the agreement with the findings of Baruah *et al.* (2001), Mohan *et al.* (2001), Nath *et al.* (2008), and Moosavi *et al.* (2014) and Ramgiri *et al.* (2020) in fennel. Moreover, the maximum dry weight (3.66, 15.88 and 107.96 g) was found in AF-2 and the minimum (3.49, 14.40 and 105.97g) in AF-1 at 60, 90 DAS and at harvest respectively. In the different dates of sowing the maximum dry weight (3.80, 17.88 and 111.10 g) recorded when crop was sown on 20<sup>th</sup> October and the minimum (3.29, 11.16 and 101.50 g) on 20<sup>th</sup> November at 60, 90 DAS and at harvest respectively.

The interaction effect of 20<sup>th</sup> October + AF-2 had highest dry weight (3.93, 18.37 and 112.87 g) and minimum (3.19, 10.98, 100.67 g) in 20<sup>th</sup> November + AF-1 at 60, 90 DAS and at harvest respectively. This may be due to the fact that delay sowing could not have given sufficient time for vegetative growth, resulted in poor plant canopy which adversely affected the biomass production. Similar results were reported by Patel *et al.* (2018) and Dhillon *et al.* (2019) in fennel.

Table 1. Effect of sowing dates on plant height and dry weight of fennel varieties

| Treatments                                       | Plant height (cm) |             |             | Dry weight (g) |             |             |
|--|-------------------|-------------|-------------|----------------|-------------|-------------|
|  | 60 DAS            | 90 DAS      | At Harvest  | 60 DAS         | 90 DAS      | At Harvest  |
| <b>Main treatments (Varieties)</b>               |                   |             |             |                |             |             |
| V <sub>1</sub> - Ajmer fennel-1                  | 37.28             | 104.50      | 189.02      | 3.49           | 14.40       | 105.97      |
| V <sub>2</sub> - Ajmer Fennel-2                  | 40.02             | 108.17      | 193.65      | 3.66           | 15.58       | 107.96      |
| S.Em. ±  | <b>0.36</b>       | <b>0.51</b> | <b>0.60</b> | <b>0.02</b>    | <b>0.20</b> | <b>0.25</b> |
| CD at 5 %  | <b>1.09</b>       | <b>1.54</b> | <b>1.81</b> | <b>0.07</b>    | <b>0.61</b> | <b>0.77</b> |
| <b>Sub treatments (Date of sowing)</b>           |                   |             |             |                |             |             |
| D <sub>1</sub> - 20 <sup>th</sup> Oct.           | 42.81             | 112.81      | 195.42      | 3.80           | 17.88       | 111.10      |
| D <sub>2</sub> - 30 <sup>th</sup> Oct.           | 41.44             | 111.34      | 193.72      | 3.68           | 16.51       | 109.59      |
| D <sub>3</sub> - 10 <sup>th</sup> Nov.           | 36.03             | 103.21      | 192.37      | 3.54           | 14.41       | 105.66      |
| D <sub>4</sub> - 20 <sup>th</sup> Nov.           | 34.30             | 97.98       | 183.84      | 3.29           | 11.16       | 101.50      |
| S.Em. ±  | <b>0.42</b>       | <b>0.59</b> | <b>0.69</b> | <b>0.03</b>    | <b>0.23</b> | <b>0.29</b> |
| CD at 5 %  | <b>1.26</b>       | <b>1.78</b> | <b>2.09</b> | <b>0.08</b>    | <b>0.70</b> | <b>0.88</b> |
| <b>Interactions (Varieties × Date of sowing)</b> |                   |             |             |                |             |             |
| D <sub>1</sub> V <sub>1</sub>                    | 42.07             | 110.13      | 192.81      | 3.66           | 17.39       | 109.33      |
| D <sub>1</sub> V <sub>2</sub>                    | 43.55             | 115.48      | 198.03      | 3.93           | 18.37       | 112.87      |
| D <sub>2</sub> V <sub>1</sub>                    | 40.71             | 108.39      | 190.36      | 3.60           | 16.03       | 108.66      |
| D <sub>2</sub> V <sub>2</sub>                    | 42.18             | 114.30      | 197.07      | 3.76           | 16.99       | 110.51      |
| D <sub>3</sub> V <sub>1</sub>                    | 33.73             | 102.40      | 189.58      | 3.52           | 13.21       | 105.20      |
| D <sub>3</sub> V <sub>2</sub>                    | 38.34             | 104.02      | 195.16      | 3.56           | 15.61       | 106.12      |
| D <sub>4</sub> V <sub>1</sub>                    | 32.59             | 97.07       | 183.33      | 3.19           | 10.98       | 100.67      |
| D <sub>4</sub> V <sub>2</sub>                    | 36.00             | 98.88       | 184.36      | 3.38           | 11.34       | 102.32      |
| S.Em. ±  | <b>0.59</b>       | <b>0.83</b> | <b>0.97</b> | <b>0.04</b>    | <b>0.33</b> | <b>0.41</b> |
| CD at 5%   | <b>1.79</b>       | <b>2.52</b> | <b>2.96</b> | <b>0.11</b>    | <b>0.99</b> | <b>1.25</b> |

Table 2: Effect of sowing dates on umbels, umbelletes and umbels dry weight of fennel varieties

| Treatments                                       | Umbel (plant <sup>-1</sup> ) |             |             | Umbelletes (umbel <sup>-1</sup> ) |             |             | Umbel Dry weight (g) |
|--|------------------------------|-------------|-------------|-----------------------------------|-------------|-------------|----------------------|
|  | Primary                      | Secondary   | Tertiary    | Primary                           | secondary   | Tertiary    |                      |
| <b>Main treatments (Varieties)</b>               |                              |             |             |                                   |             |             |                      |
| V <sub>1</sub> - Ajmer fennel-1                  | 3.11                         | 13.50       | 11.44       | 36.93                             | 29.08       | 12.80       | 7.63                 |
| V <sub>2</sub> - Ajmer fennel-2                  | 3.20                         | 14.01       | 12.01       | 37.74                             | 29.90       | 13.24       | 8.59                 |
| S.Em. ±  | <b>0.01</b>                  | <b>0.09</b> | <b>0.04</b> | <b>0.12</b>                       | <b>0.16</b> | <b>0.05</b> | <b>0.09</b>          |
| CD at 5 %  | <b>0.03</b>                  | <b>0.28</b> | <b>0.13</b> | <b>0.38</b>                       | <b>0.49</b> | <b>0.16</b> | <b>0.27</b>          |
| <b>Sub treatments (Date of sowing)</b>           |                              |             |             |                                   |             |             |                      |
| D <sub>1</sub> - 20 <sup>th</sup> Oct.           | 3.45                         | 14.41       | 12.65       | 39.37                             | 31.03       | 13.54       | 9.19                 |
| D <sub>2</sub> - 30 <sup>th</sup> Oct.           | 3.20                         | 14.08       | 12.05       | 38.75                             | 30.26       | 13.39       | 8.59                 |
| D <sub>3</sub> - 10 <sup>th</sup> Nov.           | 3.11                         | 13.61       | 11.40       | 36.51                             | 28.56       | 12.96       | 7.84                 |
| D <sub>4</sub> - 20 <sup>th</sup> Nov.           | 2.88                         | 12.92       | 10.78       | 34.70                             | 28.11       | 12.21       | 6.83                 |
| S.Em. ±  | <b>0.01</b>                  | <b>0.11</b> | <b>0.05</b> | <b>0.14</b>                       | <b>0.19</b> | <b>0.06</b> | <b>0.10</b>          |
| CD at 5 %  | <b>0.04</b>                  | <b>0.32</b> | <b>0.15</b> | <b>0.43</b>                       | <b>0.56</b> | <b>0.19</b> | <b>0.31</b>          |
| <b>Interactions (Varieties × Date of sowing)</b> |                              |             |             |                                   |             |             |                      |
| D <sub>1</sub> V <sub>1</sub>                    | 3.38                         | 13.86       | 12.53       | 39.05                             | 30.92       | 13.16       | 8.55                 |
| D <sub>1</sub> V <sub>2</sub>                    | 3.51                         | 14.97       | 12.78       | 39.69                             | 31.14       | 13.93       | 9.83                 |
| D <sub>2</sub> V <sub>1</sub>                    | 3.16                         | 14.06       | 11.60       | 38.40                             | 29.49       | 13.18       | 8.38                 |
| D <sub>2</sub> V <sub>2</sub>                    | 3.23                         | 14.10       | 12.51       | 39.10                             | 31.04       | 13.61       | 8.80                 |
| D <sub>3</sub> V <sub>1</sub>                    | 3.10                         | 13.29       | 11.09       | 36.34                             | 28.44       | 12.87       | 7.24                 |
| D <sub>3</sub> V <sub>2</sub>                    | 3.13                         | 13.94       | 11.72       | 36.68                             | 28.69       | 13.04       | 8.44                 |
| D <sub>4</sub> V <sub>1</sub>                    | 2.82                         | 12.80       | 10.53       | 33.91                             | 27.48       | 12.01       | 6.36                 |
| D <sub>4</sub> V <sub>2</sub>                    | 2.94                         | 13.03       | 11.03       | 35.48                             | 28.73       | 12.40       | 7.30                 |
| S.Em. ±  | <b>0.02</b>                  | <b>0.15</b> | <b>0.07</b> | <b>0.20</b>                       | <b>0.26</b> | <b>0.09</b> | <b>0.15</b>          |
| CD at 5 %  | <b>0.05</b>                  | <b>0.46</b> | <b>0.21</b> | <b>0.61</b>                       | <b>0.80</b> | <b>0.27</b> | <b>0.44</b>          |

Table 3. Effect of sowing dates on yield attributes and quality traits of fennel varieties

| Treatments                                       | Test weight (g) | Seed yield (q ha <sup>-1</sup> ) | Straw Yield (q ha <sup>-1</sup> ) | Harvest Index (%) | Chlorophyll content of |        | Volatile oil content of seed (ml per 100 g seed) |
|--|-----------------|----------------------------------|-----------------------------------|-------------------|------------------------|--------|--|
|  |                 |                                  |                                   |                   | 60 DAS                 | 90 DAS |  |
| <b>Main treatments (Varieties)</b>               |                 |                                  |                                   |                   |                        |        |  |
| V <sub>1</sub> - Ajmer fennel-1                  | 8.07            | 16.68                            | 25.73                             | 34.88             | 1.39                   | 1.51   | 1.18   |
| V <sub>2</sub> - Ajmer fennel-2                  | 8.41            | 17.43                            | 27.00                             | 36.74             | 1.43                   | 1.54   | 1.23   |
| S.Em. ±  | 0.05            | 0.13                             | 0.18                              | 0.27              | 0.01                   | 0.00   | 0.00   |
| CD at 5 %  | 0.16            | 0.40                             | 0.55                              | 0.81              | 0.02                   | 0.01   | 0.02   |
| <b>Sub treatments (Date of sowing)</b>           |                 |                                  |                                   |                   |                        |        |  |
| D <sub>1</sub> - 20 <sup>th</sup> Oct.           | 8.65            | 18.50                            | 28.96                             | 37.91             | 1.67                   | 1.79   | 1.36   |
| D <sub>2</sub> - 30 <sup>th</sup> Oct.           | 8.54            | 18.06                            | 27.26                             | 36.77             | 1.64                   | 1.74   | 1.33   |
| D <sub>3</sub> - 10 <sup>th</sup> Nov.           | 8.07            | 17.01                            | 26.74                             | 35.07             | 1.26                   | 1.34   | 1.20   |
| D <sub>4</sub> - 20 <sup>th</sup> Nov.           | 7.69            | 14.63                            | 22.51                             | 33.48             | 1.07                   | 1.23   | 0.94   |
| S.Em. ±  | 0.06            | 0.15                             | 0.21                              | 0.31              | 0.01                   | 0.01   | 0.01   |
| CD at 5 %  | 0.18            | 0.46                             | 0.64                              | 0.93              | 0.03                   | 0.02   | 0.02   |
| <b>Interactions (Varieties × Date of sowing)</b> |                 |                                  |                                   |                   |                        |        |  |
| D <sub>1</sub> V <sub>1</sub>                    | 8.52            | 17.75                            | 28.11                             | 36.77             | 1.64                   | 1.78   | 1.35   |
| D <sub>1</sub> V <sub>2</sub>                    | 8.77            | 19.25                            | 29.81                             | 39.06             | 1.70                   | 1.81   | 1.37   |
| D <sub>2</sub> V <sub>1</sub>                    | 8.44            | 17.85                            | 27.16                             | 36.56             | 1.61                   | 1.71   | 1.31   |
| D <sub>2</sub> V <sub>2</sub>                    | 8.64            | 18.27                            | 27.36                             | 36.98             | 1.67                   | 1.77   | 1.34   |
| D <sub>3</sub> V <sub>1</sub>                    | 8.00            | 16.89                            | 26.29                             | 34.25             | 1.27                   | 1.32   | 1.19   |
| D <sub>3</sub> V <sub>2</sub>                    | 8.14            | 17.13                            | 27.19                             | 35.90             | 1.26                   | 1.36   | 1.21   |
| D <sub>4</sub> V <sub>1</sub>                    | 7.32            | 14.21                            | 21.36                             | 31.92             | 1.04                   | 1.23   | 0.88   |
| D <sub>4</sub> V <sub>2</sub>                    | 8.06            | 15.05                            | 23.65                             | 35.03             | 1.09                   | 1.24   | 0.99   |
| S.Em. ±  | 0.09            | 0.21                             | 0.30                              | 0.44              | 0.01                   | 0.01   | 0.01   |
| CD at 5 %  | 0.26            | 0.65                             | 0.90                              | 1.32              | 0.04                   | 0.02   | 0.02   |

**Yield and yield attributes:** The result from Table 2 & 3 that the maximum primary, secondary and tertiary umbels (3.20, 14.01 and 12.01) were recorded in fennel variety AF-2 and minimum (3.11, 13.50 and 11.44) by AF-1 respectively. However, they were highest (3.45, 14.41 and 12.65) when the crop was sown on 20<sup>th</sup> October and lowest (2.88, 12.92 and 10.78) on 20<sup>th</sup> November respectively. During the interaction of 20<sup>th</sup> October + AF-2 had maximum primary, secondary and tertiary umbels (3.51, 14.97 and 12.78) as compared to other combinations. Lower in number of umbel with delay in sowing can be attributed to the rise in temperature during the plant growth period and long days Ghanbariodivi *et al.* (2013). Which is affect vegetative growth period and tumbling fewer branches possibly caused reduction in leaf area index and production of photosynthets and consequently decreasing the assembly of reproductive organs such as umbel per plant Rassam *et al.*, 2007. Similar results were reported by Dhillon *et al.* (2019) and Askar *et al.* (2013) and Tamboli *et al.* (2020). The maximum umbelletes per primary, secondary and tertiary umbels (37.74, 29.90 and 13.24) were recorded in fennel variety AF-2 and they were minimum (36.93, 29.08 and 12.80) in AF-1 respectively.

Among the dates of sowing, the highest umbelletes per primary, secondary and tertiary umbels (39.37, 31.03 and 13.54) were recorded when fennel crop was sown on 20<sup>th</sup> October respectively over other dates. The interaction effect of treatments combination 20<sup>th</sup> October + AF-2 recorded maximum umbelletes per primary, secondary and tertiary umbel (39.69, 31.14 and 13.93) respectively as compared to other combinations. The maximum number of umbelletes per umbel in the early sown crop may be because of sufficient time available for the growth and development of crop. Similar observations were also recorded by Butra *et al.* (2002), Sudeep *et al.* (2005), Nath *et al.* (2008) and Ramgiri *et al.* (2020) in fennel. Moreover, the maximum umbel dry weight, test weight, seed yield, straw yield and harvest index (8.59, 8.41, 17.43, 27.00 and 36.74) were recorded in fennel variety AF-2 respectively and they were minimum in AF-1. However, the maximum umbel dry weight, test weight, seed yield, straw yield and harvest index (9.19, 8.65, 18.50, 28.96 and 37.91) were recorded when fennel crop sown on 20<sup>th</sup> October respectively over other dates of sowing. The interaction effect of treatments combination 20<sup>th</sup> October + AF-2 had maximum umbel dry weight, test weight, seed yield, straw yield and harvest index (9.83, 8.77, 19.25, 29.81 and 39.06) respectively among the combinations. Similar results were given by Askar *et al.* (2013), Dhillon *et al.* (2019) in fennel. The yield was reduced during the later sowing dates as the plants did not have

satisfactory time for vegetative growth and entered the reproductive phase at a faster rate thus forces maturity due to high temperature during seed development. These results collaborate with the findings of Ayub *et al.* (2008), Nath *et al.* (2008) and Askar *et al.* (2013) in fennel. The earlier date of sowing increased the duration of growth period, number of effective branches and length of core stem so that accumulated highest of biomass and reproductive attributes such as umbel, umbelet and fruit per plant were produced in this condition which finally triggered an increase in seed and biological yield. This result is in agreement with findings of Zhelgakov *et al.* 2008 on *Coriandrum sativum* L., Malhotra and Vashishtha 2007 on *Anethum graveolens* and Ghorbani *et al.* 2009 on *Cuminumcyminum*. Also, Soleimani *et al.* 2010 reported 29.9% decrease in fennel yield due to the delay in sowing date from March 25 to May 5. The above findings are in close conformity with the results of Yogi *et al.* (2013) and Askaret *et al.* (2013) in fennel

**Quality attributes:** The maximum chlorophyll in leaves at 60 (1.43) & 90 (1.54) DAS and volatile oil in seed (1.23) were recorded in fennel variety AF-2 and the minimum (1.39, 1.51 and 1.18) in AF-1 respectively. However, the maximum chlorophyll in leaves at 60 (1.67) & 90 (1.79) DAS and volatile oil in seed (1.36) were recorded when fennel crop sown on 20<sup>th</sup> October among the dates of sowing. The interaction effect of treatments combination 20<sup>th</sup> October + AF-2 had maximum chlorophyll in leaves at 60 (1.70) & 90 (1.81) DAS and volatile oil in seed (1.37) over other combinations (Table 3). This may due to fact the delay in sowing did not give sufficient time for the vegetative growth and development of crop which resulted in poor plant canopy and adversely affected the all the quality parameters. These results collaborate with the results of Askaret *et al.* (2013), Yogi *et al.* (2013) and Ramgiri *et al.* (2020) in fennel.

## CONCLUSION

On the basis of one year of research, it could be concluded that, the variety V<sub>2</sub>-(AF-2) and date of sowing 20<sup>th</sup> October are the best combination for the higher growth, yield and quality of fennel.

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