Effect of Planting Date and Nitrogen Application Level on Production Yield and Oil Content in Dill Plant

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ABSTRACT

A complete randomized block design with three replications was conducted at two consecutive growing seasons (2014-2015 and 2015-2016) to evaluate the influence of planting date and nitrogen application level on growth parameters and oil yield production of dill plant. Experimental factors included three planting dates (15th of October, 15th of November and 15th of December) and five levels of nitrogen fertilizer application (i.e urea) application (0, 30, 60, 90 and 120 kg/hectare). Both studied factors significantly influenced growth parameters (plant height, number of branches per plant, number of umbrellas per plant, 1000 seed weight, above ground biomass yield, seed yield and harvest index) and oil yield and oil percentage. The results indicated that early planting date (15th of October) has a positive influence on all studied parameters in this study. Furthermore, this study showed that addition of nitrogen fertilizers significantly improved all studied parameters. Comparing the influence of the two studied factors, it seems that planting date when compared to nitrogen fertilizer application has more pronounced influence on all studied production parameters of dill plant.

Key words: Farmer, Growth, Peroid, Pharmaceutical industry, Season.

INTRODUCTION

Dill is considered as an annual important aromatic plant that originates from the Mediterranean and West Asia (Ahl and Omer, 2016). Dill plant has many important uses in food and pharmaceutical industry (Callan et al., 2007). In food industry, dill plant is used in salad making, as a spices and in sea food recipes (Lisiewska et al., 2006). In pharmaceutical industry, dill is shown to reduce incidence of many disease. Due to it economical importance, cultivation strategies are important to maximize production yield of this valuable crop. Growing dill plants in middle of October (early planting date) has been reported to maximize production yield and this has been attributed to suitable growing conditions and lower exposure to diseases (Singh and Randhawa, 1991). Furthermore, early dill planting help to avoid the exposure of heat stress which is known to significantly affect plant growth and development (Berry and Bjorkman, 1980). Fertilizer application such as urea is also an important management practices that is adapted to increase crop yield (Murthy et al., 2015; Ezung et al., 2018; Keteku et al., 2019; Abdelaal et al., 2019). Nitrogen plays an important role in plant growth and development through enhancement of many bio-reactions such as photosynthesis process. Magnitude of N utilization is influenced by many factors such as soil type, soil pH, soil temperature and water availability, level of nitrogen in the soil and extent of nitrogen volatilization (Cameron and Moir, 2013; Gojon, 2017). Overuse of Nitrogen based fertilizers has been reported recently to cause significant economic losses and detrimental effect on environment (Gojon, 2017). No research has been performed to examine the influence of growing date and level of nitrogen fertilizer application on dill growth and production yield in Jordan. The aim of this study was to investigate the effects of growing date and level of urea addition on the growth characteristics and oil yield of dill plant.

MATERIALS AND METHODS

Site description

Two field experiments were performed during growing season 2014-2015 and 2015-2016 at Ghor Alsafi-Jordan Valley (lat. Long. And elevation) on dill (Anethum graveolens). Climate information from planting date to harvest are shown in Table 1 for both growing seasons (2014-2015 and 2015-2016). The soil was ploughed in both growing seasons before planting dill seeds. The experiment was performed in sandy loam soil (17.1% clay, 31.1% silt and 50.2 % sand) that contains 1.74 organic matters. Physicochemical properties of investigated soil are shown in Table 2.

Treatments and design

The experiment consisted of three planting dates (15th of October (SD1), 15th of November (SD2) and 15th of December (SD3)) and five levels of N fertilizer application (0, 30, 60, 90 and 120 kg/hectare) and three replications. Table 2 shows the soil Physicochemical properties of the experiment site.
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### RESULTS AND DISCUSSION

Effect of planting date on plant morphology parameters (plant height and number of branches per plant and number of umbels per plant) during both growing seasons (2014-2015 and 2015-2016) are shown in Table 3 and Table 4, respectively. Early planting date significantly improved morphological parameters during both growing seasons and was lowest at late planting date. For example, plant height was highest (108.12 cm) in early planting date and was lowest (67.46 cm) in late growing date by the end of first growing season. Similar response trend were noticed for the parameters: number of branches per plant, number of umbels per plant and number of seeds per umbel in both growing seasons (Table 3 and Table 4). For all measured morphological parameters, intermediate growing date resulted in intermediate results in both growing seasons (Table 3 and Table 4). The results of this study showed that planting date plays an important role in initiating early plant growth and development before plant being exposed to harsh environmental conditions. In both growing seasons, average recorded temperature during early planting date seems to be higher (ideal) than late planting date (Table 1).

At same irrigation level, soil temperature has been reported to accelerate germination of seed by enhancing water uptake (Unver and Tilki, 2012). Furthermore, plant exposure to longer day length (sunlight), as the case in early planting date, has been reported to accelerate plant growth and reduced time to flowering (Putievsky 1983).

Effect of N fertilization level on plant morphology is clearly noticed in this study. Adding urea fertilizer significantly increased all morphological parameters in both growing seasons; being highest for high nitrogen application and lowest when no fertilizer was added (Table 3 and Table 4). The increase in nitrogen fertilizer application may led to increase in plant height due to the importance of its effect on the formation of chlorophyll (Evans et al., 1989). Chlorophyll is known to enhance the biological processes and activity of photosynthesis, which in turn increases the plant vegetative growth (Evans et al., 1989). These results

| Test                  | Soil           |
|-----------------------|----------------|
| Soil texture          | Sandy loam     |
| pH                    | 7.52           |
| EC (ds m⁻¹)           | 107            |
| CaCO₃ (%)             | 26             |
| Organic matter        | 2.24           |
| Total N (%)           | 0.078          |
| NaHCO₃(mg kg⁻¹)       | 11             |
| Phosphorus (ppm)      | 5.2            |
| Potassium (ppm)       | 394            |

(urea (N=46%) (no addition (NL0), 30 kg ha⁻¹ (NL1), 60 kg ha⁻¹ (NL2), 90 kg ha⁻¹ (NL3) and 120 kg ha⁻¹ (NL4). The experimental plot consisted of 6 rows (distance between each consecutive rows is 0.5 m). Plot size was 3 m². The experimental design was randomized complete block design with factorial concept (three planting dates and five levels of fertilizer applications) with 3 replications. Split equal doses of urea fertilizers were applied at two times intervals (30 days and 45 days from planting date) using a fertigator connected to drip irrigation system.

Data collection and analysis

All cultivation and agronomic practices were maintained similar for all plots. From each plot, eight plants were randomly selected for recording the following measurements: number of branches per plant, plant height, number of umbrella per plant, number of seeds per plant, 1000 seed weight, above ground biomass, seed yield and harvest index. Harvest index were calculated by dividing seed weight over above ground biomass. Oil percentage was analyses according to the procedure described by (Guenther, 1961). Oil yield was calculated by dividing amount of oil yield produced over grown area.

Statistical analysis

Two ways analysis of variance was used for data analysis by using SAS statistical package (SAS, 2003). Differences between measured means were compared by using least significant difference (LSD) at P<0.05 (Steel and Torrie, 1980).

### Table 1: Environment/climate conditions (Air temperature, rain precipitation and relative humidity) during the two consecutive growing season (2014-2015 and 2015-2016) (data represented as means).

| Month | 2014-2015 | 2015-2016 |
|-------|-----------|-----------|
|       | Air Temperature (°C) | Relative humidity (%) | Rain precipitation (mm) |
| Oct.  | 25.83     | 27.24     | 36.0       | 40.0       | 0.0       |
| Nov.  | 21.58     | 22.98     | 48.7       | 49.1       | 0.0       |
| Dec.  | 18.30     | 16.23     | 57.9       | 59.9       | 0.0       |
| Jan.  | 14.80     | 19.91     | 60.7       | 61.5       | 0.0       |
| Feb.  | 17.02     | 20.42     | 51.0       | 48.2       | 0.0       |
| Mar.  | 21.94     | 22.28     | 44.1       | 40.4       | 0.0       |
| Apr.  | 26.80     | 25.22     | 29.3       | 30.2       | 0.0       |
| May.  | 32.59     | 30.36     | 24.3       | 25.1       | 0.0       |

### Table 2: Soil physiochemical properties at the experimental site.

| Test                  | Soil           |
|-----------------------|----------------|
| Soil texture          | Sandy loam     |
| pH                    | 7.52           |
| EC (ds m⁻¹)           | 107            |
| CaCO₃ (%)             | 26             |
| Organic matter        | 2.24           |
| Total N (%)           | 0.078          |
| NaHCO₃(mg kg⁻¹)       | 11             |
| Phosphorus (ppm)      | 5.2            |
| Potassium (ppm)       | 394            |

Effect of planting date and fertilization level on plant morphology

Effect of planting date on plant morphology parameters (plant height and number of branches per plant and number of umbels per plant) during both growing seasons (2014-2015 and 2015-2016) are shown in Table 3 and Table 4, respectively. Early planting date significantly improved morphological parameters during both growing seasons and was lowest at late planting date. For example, plant height was highest (108.12 cm) in early planting date and was lowest (67.46 cm) in late growing date by the end of first growing season. Similar response trend were noticed for the parameters: number of branches per plant, number of umbels per plant and number of seeds per umbrella in both growing seasons (Table 3 and Table 4). For all measured morphological parameters, intermediate growing date resulted in intermediate results in both growing seasons (Table 3 and Table 4). The results of this study showed that planting date plays an important role in initiating early plant growth and development before plant being exposed to harsh environmental conditions. In both growing seasons, average recorded temperature during early planting date seems to be higher (ideal) than late planting date (Table 1). At same irrigation level, soil temperature has been reported to accelerate germination of seed by enhancing water uptake (Unver and Tilki, 2012). Furthermore, plant exposure to longer day length (sunlight), as the case in early planting date, has been reported to accelerate plant growth and reduced time to flowering (Putievsky 1983).

Effect of N fertilization level on plant morphology is clearly noticed in this study. Adding urea fertilizer significantly increased all morphological parameters in both growing seasons; being highest for high nitrogen application and lowest when no fertilizer was added (Table 3 and Table 4). The increase in nitrogen fertilizer application may led to increase in plant height due to the importance of its effect on the formation of chlorophyll (Evans et al., 1989). Chlorophyll is known to enhance the biological processes and activity of photosynthesis, which in turn increases the plant vegetative growth (Evans et al., 1989). These results
are consistent with the outcome of Naghera, et al. (2000) and Mahfouz and Sharaf-Eldin (2007). Similar trend response in morphological changes is noticed in both growing seasons.

**Effect of planting date and N fertilization level on dill production parameters**

Effect of planting date on production parameters per hectare (biological yield, number of seed, harvesting index and 1000 kernel weight) during both growing seasons (2014-2015 and 2015-2016) are shown in Table 3 and Table 4, respectively. Early planting date significantly improved all production parameters during both growing seasons and was lowest at late planting date. Biological yield in first growing season (2014-2015) was highest (7037.87 kg/hectare) in early planting date and was lowest (3968.46 kg/hectare) at late planting date whereas intermediate (5896.75 kg/hectare) at intermediate planting date. Similar responses trend were noticed for measured production parameters in the second growing season (2015-2016). For all measured production parameters, intermediate growing date resulted in intermediate measurements in both growing seasons (Table 5). Positive influence of early planting date on growth parameters could be attributed to enhancement of morphological growth discussed above.

Effect of different N fertilization levels on production parameters are clearly noticed in this study. Adding N fertilizer significantly increases all production parameters; being highest for high fertilizer application and lowest when no fertilizers added in both growing seasons (Table 3 and Table 4). Vegetative growth is of a great importance to

| Table 3: Effect of planting date and level of N fertilizers on growth parameters in first growing season 2014-2015. |
|---------------------------------------------------------------|
| **Treatments** | **Plant height (cm)** | **Number of branches plant**<sup>1</sup> | **Number of umbels plant**<sup>1</sup> | **Number of seeds umbel**<sup>1</sup> | **1000 Seed weight (g)** |
| **Planting date** |  |  |  |  |
| SD1<sup>1</sup> | 108.12a | 7.37a | 41.29a | 283.23a | 1.402a |
| SD2<sup>1</sup> | 95.37b | 5.57b | 36.01b | 244.41b | 1.396b |
| SD3<sup>1</sup> | 67.46c | 4.97c | 23.64c | 243.50b | 1.392c |
| LSD(0.05) | 19.86 | 0.75 | 3.93 | 35.28 | 0.21 |
| **Nitrogen levels** |  |  |  |  |
| NLo<sup>2</sup> | 80.76e | 5.25e | 29.54e | 249.65e | 1.394e |
| NL1<sup>2</sup> | 87.75d | 5.70d | 31.80d | 256.03d | 1.395d |
| NL2<sup>2</sup> | 92.06c | 5.99c | 34.11c | 258.57c | 1.397c |
| NL3<sup>2</sup> | 94.99b | 6.27b | 35.77b | 259.66b | 1.398b |
| NL4<sup>2</sup> | 96.03a | 6.66a | 37.02a | 261.32a | 1.399a |
| LSD(0.05) | 20.82 | 0.73 | 3.72 | 31.62 | 0.19 |

<sup>1</sup>15<sup>th</sup> of October (SD1), 15<sup>th</sup> of November (SD2), 15<sup>th</sup> of December (SD3).

<sup>2</sup>No urea addition (NLo), 30 kg ha<sup>-1</sup> (NL1), 60 kg ha<sup>-1</sup> (NL2), 90 kg ha<sup>-1</sup> (NL3) and 120 kg ha<sup>-1</sup> (NL4).

| Table 4: Effect of planting date and level of N fertilizers on growth parameters in the second growing season 2015-2016. |
|---------------------------------------------------------------|
| **Treatments** | **Plant height (cm)** | **Number of branches plant**<sup>1</sup> | **Number of umbels plant**<sup>1</sup> | **Number of seeds umbel**<sup>1</sup> | **1000 Seed weight (g)** |
| **Planting date** |  |  |  |  |
| SD1<sup>1</sup> | 123.37a | 8.29a | 46.85a | 289.89a | 1.413a |
| SD2<sup>1</sup> | 106.30b | 6.18b | 36.01b | 244.41b | 1.396b |
| SD3<sup>1</sup> | 71.83c | 5.51c | 23.64c | 243.50b | 1.392c |
| LSD(0.05) | 25.42 | 0.82 | 4.28 | 36.26 | 0.26 |
| **Nitrogen levels** |  |  |  |  |
| NLo<sup>2</sup> | 91.25e | 5.82e | 33.43e | 255.87d | 1.408d |
| NL1<sup>2</sup> | 98.07d | 6.33d | 35.92d | 264.60c | 1.409c |
| NL2<sup>2</sup> | 101.45c | 6.71c | 38.46c | 266.50b | 1.409c |
| NL3<sup>2</sup> | 105.18b | 7.04b | 40.33b | 266.63b | 1.411b |
| NL4<sup>2</sup> | 106.55a | 7.40a | 41.52a | 269.25a | 1.412a |
| LSD(0.05) | 21.24 | 0.74 | 4.11 | 39.47 | 0.22 |

<sup>1</sup>15<sup>th</sup> of October (SD1), 15<sup>th</sup> of November (SD2), 15<sup>th</sup> of December (SD3).

<sup>2</sup>No urea addition (NLo), 30 kg ha<sup>-1</sup> (NL1), 60 kg ha<sup>-1</sup> (NL2), 90 kg ha<sup>-1</sup> (NL3) and 120 kg ha<sup>-1</sup> (NL4).
farmers as plant leaves are sold in pharmaceutical industry as a valuable herb (Pino et al., 1995). Thus and from economical perspective, herbage yield per growing season is of a great importance for farmers. Dill plant is a biennial plant (Wander and Bouwmeester, 1998) can be cut many times in suitable growing conditions. These results suggest that early planting date can maximize biological yield under current growing conditions. However, further studies must be conducted to evaluate the influence on planting date and cutting intensity on dill biological yield.

Effect of planting date and fertilization level on oil production yield and oil content in seed

Essential oils in dill seeds play an important role in human health and thus it is necessary to adapt cultivation practices in order to increase its yield (Shekofteha and Salari, 2016).

Effect of planting date and nitrogen level on oil production per hectare and oil content in seed during both growing seasons (2014-2015 and 2015-2016) are shown in Table 6. Early planting date significantly increased oil production and oil percentage in seeds during both growing seasons (Table 6). For example, early planting date in first growing season (i.e 2014-2015) had the highest oil production and oil percentage (22.27 kg/hectare and 1.682%, respectively) and was lowest at late planting date (8.24 kg/hectare and 1.281%, respectively). Intermediate growing date result in intermediate results (13.33kg/hectare and 1.353%, respectively) (Table 6). Similar trend in oil production and oil percentage were noticed in both growing seasons (2014-2015 and 2015-2016). Level of nitrogen fertilizer application is positively correlated with oil production and oil content in seed.

**Table 5:** Effect of planting date and level of N fertilizers on production parameters in first and second growing seasons 2014-2015 and 2015-2016.

| Treatments | Above ground biomass (kg ha\(^{-1}\)) | Seeds yield (kg ha\(^{-1}\)) | Harvest Index (%) | Above ground biomass (kg ha\(^{-1}\)) | Seeds yield (kg ha\(^{-1}\)) | Harvest index (%) |
|------------|----------------------------------|----------------------------|-----------------|----------------------------------|----------------------------|-----------------|
| **Planting date** |                                    |                            |                 |                                   |                            |                 |
| SD1*       | 7037.87 a                         | 1313.07 a                  | 18.61 a         | 8228.79 a                        | 1536.92 a                  | 18.63 a         |
| SD2*       | 5896.75 b                         | 980.31 b                   | 16.59 b         | 6879.51 b                        | 1148.49 b                  | 16.62 b         |
| SD3*       | 3968.46 c                         | 643.53 c                   | 16.21 c         | 4571.76 c                        | 754.34 c                   | 16.49 c         |
| LSD(0.05)  | 223.16                            | 54.28                      | 2.36            | 162.14                           | 56.72                      | 2.18            |
| **Nitrogen levels** |                                   |                            |                 |                                   |                            |                 |
| NL0**      | 4976.95 e                         | 828.47 e                   | 16.51 e         | 5836.84 e                        | 970.27 e                   | 16.48 e         |
| NL1**      | 5408.87 d                         | 931.33 d                   | 17.07 d         | 6325.16 d                        | 1090.82 d                  | 17.09 d         |
| NL2**      | 5779.77 c                         | 1008.99 c                  | 17.24 c         | 6725.92 c                        | 1181.56 c                  | 17.38 c         |
| NL3**      | 5965.81 b                         | 1050.03 b                  | 17.34 b         | 6933.41 b                        | 1231.52 b                  | 17.55 b         |
| NL4**      | 6040.32 a                         | 1076.03 a                  | 17.53 a         | 7008.85 a                        | 1258.75 a                  | 17.72 a         |
| LSD(0.05)  | 184.68                            | 44.52                      | 2.43            | 154.82                           | 52.46                      | 2.48            |

*15th of Octobar (SD1), 15th of November (SD2), 15th of December (SD3).

**No urea addition (NL0), 30 kg ha\(^{-1}\) (NL1), 60 kg ha\(^{-1}\) (NL2), 90 kg ha\(^{-1}\) (NL3) and 120 kg ha\(^{-1}\) (NL4).

**Table 6:** Effect of planting date and level of N fertilizers on oil yield and oil content in first and second growing seasons.

| Treatments | Yield (kg ha\(^{-1}\)) | Oil% | Yield (kg ha\(^{-1}\)) | Oil% |
|------------|-----------------|-----|-----------------|-----|
| **Planting date** |                  |     |                  |     |
| SD1*       | 22.27 a          | 1.682 a | 27.75 a          | 1.79 a |
| SD2*       | 13.33 b          | 1.353 b | 16.93 b          | 1.46 b |
| SD3*       | 8.24c            | 1.281 c | 9.66 c           | 1.28 c |
| LSD(0.05)  | 1.84             | 0.082 | 2.43             | 0.17 |
| **Nitrogen levels** |              |     |                  |     |
| NL0**      | 10.92 e          | 1.302 e | 13.52 e          | 1.37 d |
| NL1**      | 13.42 d          | 1.405 d | 16.76 d          | 1.49 c |
| NL2**      | 15.61 c          | 1.491 c | 19.18 c          | 1.55 b |
| NL3**      | 16.35 b          | 1.497 b | 20.33 b          | 1.57 a |
| NL4**      | 16.77 a          | 1.501 a | 20.78 a          | 1.57 a |
| LSD(0.05)  | 1.43             | 0.078 | 1.38             | 0.15 |

*15th of Octobar (SD1), 15th of November (SD2), 15th of December (SD3).

**No urea addition (NL0), 30 kg ha\(^{-1}\) (NL1), 60 kg ha\(^{-1}\) (NL2), 90 kg ha\(^{-1}\) (NL3) and 120 kg ha\(^{-1}\) (NL4).
seed in both growing seasons. These results could be attributed to higher seed yield with increasing N application level. Essential oil content in this study is lower than those reported in other studies. Essential oil contents in dill seed have been reported to range from 2.1% and 5.6% (Embong et al., 1977; Gonzalez-Garcia et al., 2009; Singh, 2012).

CONCLUSION
It can be concluded that N fertilizer applications and early planting date (under Jordanian conditions) of dill plant has a positive influence on overall plant growth performance and oil production yield.

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