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# Effect of Some Agricultural Practices on Cumin (*Cuminum Cyminum* L.) Productivity under Rainfed Conditions of Jordan

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## ABSTRACT

A study was conducted to investigate the effect of planting dates, nitrogen fertilizer levels and seeding rates on the yield and some growth characters of cumin *Cuminum cyminum* L. The experiment was a split-split plot with randomized complete block design with three replications and implemented during the growing season of 2004/2005 at two locations; Mushaqar and Maru experimental stations. The results at Maru revealed that early sowing on December 1 resulted in an increase in fruit yield by 26% and 64%, and an increase in biological yield by 31% and 68% as compared to sowing on December 29 and January 31, respectively. Also early sowing resulted in an increase in plant height, number of branches per plant, number of umbels per plant, number of seeds per umbel, number of seeds per plant, but a decrease in weight of 1000 seed. Plants received 20 kg and 40 kg N $ha^{-1}$ at Maru gave higher fruit yield by 22% and 27%, and higher biological yield by 17% and 28% as compared to unfertilized plants. At Maru, 30 kg $ha^{-1}$ seeding rate gave the highest fruit yield and biological yield. At Mushaqar location, the differences between the evaluated treatments were not significant.

**KEYWORDS:** Cumin, *Cuminum cyminum* L., crop management, medicinal and herbal plants.

## 1. INTRODUCTION

Cumin (*Cuminum cyminum* L.) is a small annual herb, belongs to the *umbelliferae* family, native to the Mediterranean region. Cumin is primary cultivated in Europe, Asia, Middle East and North Africa. India and Iran are the largest cumin exporters, whereas Turkey, Iran and Syria are the main producers in the region (Al-Wareh *et al*.1993; Grieve, 2005; Anonymous, 2005b).

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The seed is widely used as a food flavoring agent in cheeses, pickles, sausages, soups and bean dishes, and has several important medicinal uses; it is beneficial to the digestive system and acts as a stimulant to the sexual organs, used in coughs as painkiller and to treat rotten teeth. It is also used in the treatment of flatulence and bloating, reducing intestinal gas, and in treatment of insomnia, colds, fevers and to improve milk production (Anonymous, 2005a). Cumin is also used in veterinary practices (Li *et al*, 2004).

Cumin has been grown in Jordan in very limited areas, there is a good opportunity to expand in herbal plants cultivation (including cumin) in Jordan because of it's adaptation to the rainfed production system and its high economic return, which is higher than that obtained from other rainfed crops currently under cultivation such as wheat, lentil and chickpea (Khairallah, 1998).

Very few published work is available on cumin cultivation world wide, and no information available on the cultivation practices of cumin under Jordan environmental conditions. Therefore, this research was conducted to find out the proper planting date, nitrogen fertilization levels, seeding rates and the best combination among them that will give the highest cumin productivity under wheat-based rainfed production system of Jordan.

## 2. MATERIALS AND METHODS

### 2.1 Location

The study was conducted under rainfed conditions during the growing season of 2004/2005 at two agricultural research stations; Mushaqar and Maru. Both stations belong to the National Center for Agricultural Research and Technology Transfer (NCARTT). Maru station is about 100 km north Amman, with a longitude of 35° 53` 00 East, latitude of 32° 36` 25 North and elevation of 520m.. Whereas, Mushaqar station is about 28 km south-west of Amman, with longitude of 35° 46` 30 East, latitude of 31° 47` 35 North and an elevation of 790 m. The annual long term average rainfall is 407 mm for Maru and 319 mm for Mushaqar. However, the amounts of rainfall received during the growing seasons when the experiments were conducted, were 431mm for Maru and 462 mm for Mushaqar.

### 2.2 Experimental design and treatments

The experiment was a split-split plot using a randomized complete block design with three replications. Three planting dates occupied the main plots, three fertilization treatments occupied the sub-plot and four seed rates applied to the sub-sub plots. Sowing was performed in the following dates:

| Date | Mushaqar | Maru |
|---|---|---|
| 1 | December 2, 2004 | December 1, 2004 |
| 2 | December 30, 2004 | December 29, 2004 |
| 3 | January 17, 2005 | January 31, 2005 |

Three levels of nitrogen was broadcasted at planting in the form of urea (46%N); without nitrogen (control), 20 kg nitrogen $ha^{-1}$, and 40 kg nitrogen $ha^{-1}$. The four seeding rates used were 15, 20, 25, and 30 kg $ha^{-1}$, which are equivalent to 526, 688, 860 and 1032 plants $m^{-2}$, respectively. The sub-sub plot consisted of 6 rows, 4 meters long and 18 cm apart. The cumin seeds are a Syrian local variety, which is grown by farmers in Jordan in the last few years.

### 2.3 Characters Measured

**On Plot Basis**

Days to emergence, days to flowering and days to maturity, plant height, Biological yield and grain yield, weight of 1000 seed, harvest index.

**On Plant Basis**

At maturity, ten plants were selected randomly from the inner rows of every sub-sub plot to measure the following characteristics:
Branch number per plant, Number of umbels per plant, Number of seeds per umbel, Number of seeds per plant.

**Heat Units (Growing Degree-Days) to Emergence, to Flowering and to Maturity**

The specific heat requirement for a plant to grow and develop, is the accumulated heat when the temperature for a 24-hour period is one degree above the minimum threshold (base temperature). The heat units were measured according to the following equation (Sinebo, 2002):

Heat units = $\{(T_{max}.\ °C + T_{min}.\ °C)/2\} - T_{base}$.

$T_{max}$ = Maximum daily temperature

$T_{min}$ = Minimum daily temperature

$T_{base}$ = Minimum threshold temperature

Since the base temperature for cumin is not reported in the literature, we used the base temperature for barley, which is 5°C.

**2.4 Statistical Analysis**

Data was analyzed using Gen Stat program (Eighth Edition), Treatments means were compared using Least Significant Difference (LSD) at 5 % probability according to Steel and Torrie (1980). The correlation coefficients among the studied characters were calculated using Gen Stat program. The relationships and regression equations of treatment effect on some characters were conducted, using Excel program for treatments with significant F values only.

## 3. RESULTS

### 3.1 Fruit yield, biological yield and harvest index

**Fruit yield**

At Maru, sowing early on December 1 resulted in 26% and 64% higher fruit yield as compared to sowing on December 29 and January 31, respectively. In the contrary to that, sowing on December 30 at Mushaqar resulted in 3.5% lower fruit yield as compared to sowing later on January 17 (Table 1). The relationship between planting date and fruit yield at Maru, was linear and highly significant and negative (Fig. 1).

Nitrogen fertilization increased fruit yield at both locations, however, the increase at Mushaqar was not significant (Table 1). The highest fruit yield was obtained with 40 kg N ha$^{-1}$ and the lowest was with no fertilizer application. At Maru, the increase in fruit yield was about 22% for plants received 20 kg N ha$^{-1}$ and 27% for plants received 40 kg N ha$^{-1}$ as compared with unfertilized plants. While the increase at Mushaqar was about 5% and 8% for the two rates, respectively. The relationship between nitrogen fertilizer levels and fruit yield at Maru was curvilinear and highly significant (Fig. 2).

The highest fruit yield at Maru was obtained with a seeding rate of 30 kg ha$^{-1}$, which exceeded the yield under the seeding rate of 15 kg ha$^{-1}$ by 18%. While at Mushaqar, the highest yield was obtained with a seeding rate of 25 kg ha$^{-1}$, which was about 20% higher than the yield obtained with a seeding rate of 15 kg ha$^{-1}$ (Table 1).

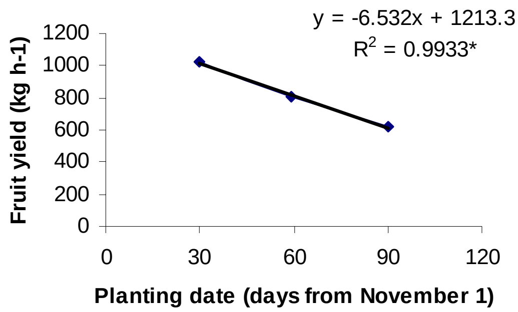


**Figure 1: Relationship between planting dates and fruit yield of cumin (kg ha$^{-1}$) grown at Maru. * = significant at 5%.**

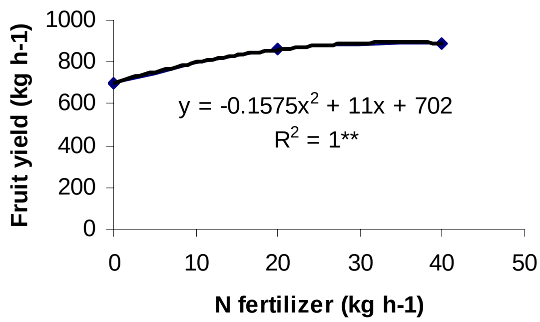


**Figure 2: Relationship between nitrogen fertilizer levels and fruit yield of cumin (kg ha$^{-1}$) grown at Maru. ** = significant at 1%.**

**Biological Yield**

At Maru, sowing early on December 1 resulted in 31% and 68% higher biological yield as compared to sowing on December 29 and January 31, respectively (Table 1). The relationship between planting date and biological yield at Maru was significant curvilinear relationship (Fig. 3).

Nitrogen fertilization increased biological yield at both locations, the increase was significant at Maru but not at Mushaqar (Table 1). The relationship between nitrogen fertilizer levels and biological yield at Maru was curvilinear and highly significant (Fig. 4).

**Table (1): Main effects of planting dates, N fertilizer levels and seeding rates on fruit yield, biological yield (kg $ha^{-1}$) and harvest index of cumin grown at Maru during the growing season of 2004/2005.**

| Planting date* | Maru | | | Mushaqar | | |
|---|---|---|---|---|---|---|
| | fruit yield | Biological yield | Harvest index (%) | fruit yield | Biological yield | Harvest index (%) |
| D1 | 1021 | 2199 | 46.4 | - | - | - |
| D2 | 809 | 1674 | 48.3 | 614 | 1352 | 45.4 |
| D3 | 621 | 1309 | 47.4 | 636 | 1438 | 44.2 |
| LSD 0.05 | 195 | 386 | n.s | n.s | n.s | n.s |
| Nitrogen level (kg N $ha^{-1}$) | | | | | | |
| 0 | 702 | 1501 | 46.8 | 599 | 1320 | 45.4 |
| 20 | 859 | 1753 | 49.0 | 629 | 1444 | 43.6 |
| 40 | 890 | 1929 | 46.1 | 648 | 1420 | 45.6 |
| LSD 0.05 | 125 | 244 | n.s | n.s | n.s | n.s |
| Seeding rate (kg $ha^{-1)}$ | | | | | | |
| 15 | 754 | 1530 | 49.3 | 572 | 1266 | 45.2 |
| 20 | 815 | 1734 | 47.0 | 625 | 1400 | 44.6 |
| 25 | 810 | 1762 | 46.0 | 688 | 1516 | 45.4 |
| 30 | 889 | 1884 | 47.2 | 616 | 1396 | 44.1 |
| LSD 0.05 | 116 | 222 | 3.3 | n.s | n.s | n.s |

* Planting Dates:

Maru: D1= Dec. 1, 2004, D2= Dec. 29, 2004, and D3= Jan. 31, 2005.

Mushaqar: D1= Not available, D2= Dec. 30, 2004, and D3= Jan. 17, 2005.

n.s = not significant.

Increasing seeding rate increased biological yield significantly at Maru; biological yield of the crop sown at a seeding rate of 20, 25 and 30 kg $ha^{-1}$ was about 113%, 115% and 123% of that sown at a rate of 15 kg $ha^{-1}$. While at Mushaqar, the highest biological yield was for crop sown at a rate of 25 kg $ha^{-1}$, followed by 20 kg $ha^{-1}$ which gave 120% and 110% of the lowest biological yield obtained under a rate of 15 kg $ha^{-1}$, respectively Table (1). The relationship between seeding rate and biological yield at Maru was curvilinear and significant (Fig. 5).

**Harvest Index**

Harvest index at both locations was not affected significantly by the three treatments or any of their interactions except the interaction between planting date, nitrogen fertilizer level and seeding rate at Maru location

**3.2 Yield Components**

**Number of Branches Per Plant**

Early sowing increased number of branches per plant at Maru, and decreased it at Mushaqar (Tables 2 and 3). The highest number of branches at Maru was recorded for plants sown on December 1, which was 25% higher than the lowest value, when plants were sown on December 29. While at Mushaqar, the highest number was recorded for plants sown on January 17, which was about 6% higher than the lowest value for plants sown on

December 30. On the other hand, nitrogen fertilization resulted in increasing the number of branches per plant at both locations. The highest number of branches was for plants received 40 kg nitrogen $ha^{-1}$ and the lowest number was when no fertilizer was applied. Increasing plant density decreased number of branches per plant at both locations. The highest number of branches was recorded for plants sown at 15 kg seeds $ha^{-1}$ and the lowest number was for plants sown at 30 kg seeds $ha^{-1}$.

**Number of Umbels Per Plant**

At Maru, early sowing on December 1 resulted in 57% and 24% greater number of umbels per plant as compared to sowing on December 29 and January 31, respectively (Table 2).

Increasing nitrogen fertilizer level increased number of umbels per plant at both locations; however, the increase at Mushaqar was not significant (Tables 2 and 3). Number of umbels per plant decreased as seeding rate increased at both locations.

**Number of Seeds Per Umbel**

At Maru, early sowing on December 1 resulted in 2.5% and 23.3% more seeds per umbel as compared to sowing on December 29 and on January 31, respectively (Table 2). While at Mushaqar, delaying sowing from December 30 to January 17 increased number of seeds per umbel by about 20.7% (Table 3). The highest number of seeds per umbel at Maru was resulted from the addition of 40 kg nitrogen $ha^{-1}$, and the lowest value was with 20 kg nitrogen $ha^{-1}$ (Table 2), while at Mushaqar, plants received no nitrogen fertilizer gave the highest number of seeds per umbel, and the lowest number was for plants received 20 kg nitrogen $ha^{-1}$ (Table 3).

**Table (2): Main effects of planting dates, nitrogen fertilizer levels and seeding rates on yield components of cumin grown at Maru during the growing season of 2004/2005.**

| Planting date | Branch $plant^{-1}$ | Umbels $plant^{-1}$ | Seed $umbel^{-1}$ | Seed $plant^{-1}$ | 1000 seed weight (gm) | Plant height (cm) |
|---|---|---|---|---|---|---|
| Dec. 1, 2004 | 2.98 | 13.04 | 26.06 | 344.1 | 2.83 | 20.91 |
| Dec. 29, 2004 | 2.39 | 8.32 | 25.43 | 212.4 | 3.16 | 17.22 |
| Jan. 31, 2005 | 2.40 | 10.50 | 21.14 | 222.5 | 3.37 | 16.11 |
| LSD | 0.11 | 0.48 | 1.54 | 42.9 | 0.08 | 1.88 |
| Nitrogen level (kg N $ha^{-1}$) | | | | | | |
| 0 | 2.49 | 10.13 | 24.19 | 250.9 | 3.15 | 17.72 |
| 20 | 2.58 | 10.69 | 24.12 | 258.3 | 3.09 | 17.41 |
| 40 | 2.71 | 11.04 | 24.32 | 269.7 | 3.01 | 19.11 |
| LSD | 0.10 | 0.53 | n.s | n.s | 0.06 | 0.90 |
| Seeding rate (kg $ha^{-1}$) | | | | | | |
| 15 | 2.92 | 11.52 | 24.40 | 285.3 | 3.14 | 17.43 |
| 20 | 2.66 | 10.76 | 23.78 | 257.3 | 3.19 | 18.13 |
| 25 | 2.44 | 10.50 | 23.42 | 249.9 | 3.09 | 18.44 |
| 30 | 2.34 | 9.71 | 25.24 | 246.1 | 3.06 | 18.33 |
| LSD | 0.09 | 0.50 | 0.84 | 18.6 | 0.07 | 0.47 |

n.s = not significant

**Table (3): Main effects of planting dates, N fertilizer levels and seeding rates on yield components of cumin sown at Mushaqar during the growing season of 2004/2005.**

| Planting date | Branch plant$^{-1}$ | Umbel plant$^{-1}$ | Seed umbrl$^{-1}$ | Seed plant$^{-1}$ | 1000 seed weight (gm) | Plant height (cm) |
|---|---|---|---|---|---|---|
| Dec. 30, 2004 | 2.31 | 12.18 | 10.26 | 126.9 | 2.67 | 18.11 |
| Jan. 17, 2005 | 2.44 | 11.83 | 12.39 | 146.0 | 2.72 | 15.47 |
| LSD | 0.07 | n.s | n.s | n.s | n.s | 0.52 |
| Nitrogen level (kg N ha$^{-1}$) | | | | | | |
| 0 | 2.24 | 11.41 | 11.40 | 131.2 | 2.72 | 16.48 |
| 20 | 2.30 | 11.83 | 11.26 | 133.3 | 2.72 | 16.62 |
| 40 | 2.59 | 12.78 | 11.32 | 144.7 | 2.65 | 17.27 |
| LSD | 0.18 | n.s | n.s | n.s | n.s | 0.29 |
| Seeding rate (kg ha$^{-1}$) | | | | | | |
| 15 | 2.61 | 12.93 | 11.49 | 150.8 | 2.71 | 16.28 |
| 20 | 2.48 | 12.14 | 11.05 | 131.5 | 2.72 | 16.60 |
| 25 | 2.28 | 11.43 | 11.62 | 134.6 | 2.67 | 17.49 |
| 30 | 2.13 | 11.52 | 11.14 | 128.8 | 2.68 | 16.79 |
| LSD | 0.13 | n.s | n.s | n.s | n.s | 0.29 |

n.s = not significant

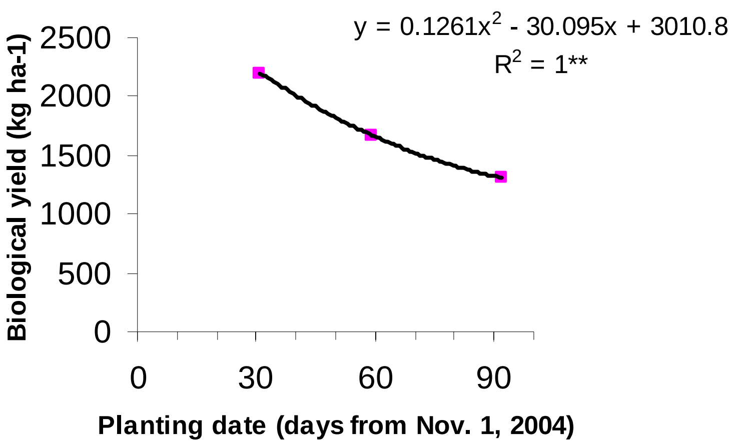


**Figure 3: Relationship between planting dates and biological yield of cumin (kg ha$^{-1}$) grown at Maru. ** = significant at 1%.**

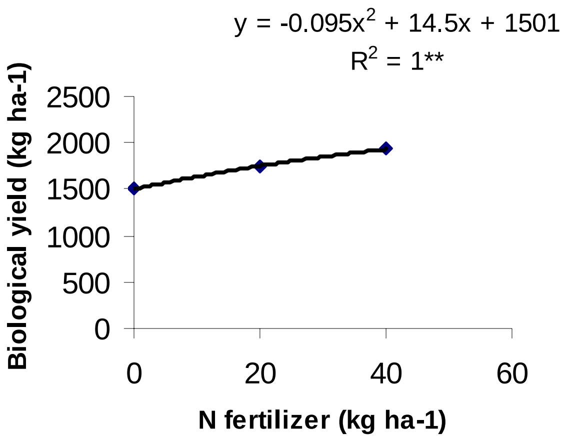


**Figure 4: Relationship between nitrogen fertilizer levels and biological yield of cumin (kg ha$^{-1}$) grown at Maru. ** = significant at 1%.**

The highest number of seeds per umbel at Maru was recorded when the crop was sown at a rate of 30 kg ha$^{-1}$, and the lowest value was under 25 kg seeding rate ha$^{-1}$. While at Mushaqar, the highest number of seeds per umbel was when the crop was sown at a rate of 25 kg ha$^{-1}$, and the lowest value was at a rate of 20 kg seeds ha$^{-1}$ (Tables 2 and 3).

**Weight of 1000 Seeds**

At Maru, the increase in 1000 seed weight for plants sown on January 31 was about 19% and 6.6% over those sown on December 1 and December 29, respectively. While the increase at Mushaqar was about 1.9% for plants sown on January 17 over those sown on December 30.

Nitrogen fertilization decreased the weight of 1000 seeds at both locations; however, the decrease was not significant. The highest weight of 1000 seeds was recorded for plants without N fertilization while the lowest value was for plants received 40 kg N ha$^{-1}$ (Tables 2 and 3).

At Maru, the highest weight of 1000 seeds was obtained with 20 kg seeding rate ha$^{-1}$ which was not different from that obtained with 15 kg seeding rate ha$^{-1}$, but higher than the lowest weight obtained at 30 kg seeds ha$^{-1}$ by about 4% Table (2). While at Mushaqar, the highest weight was obtained with 20 kg seeds ha$^{-1}$ and the lowest was with 25 kg seeds ha$^{-1}$, however, the differences were not significant (Table 3).

**3.3 Plant Height**

At Maru, plants sown on December 1 were significantly the tallest, with about 21.5% and 29.8% taller than those sown on December 29 and January 31, respectively (Table 2). At Mushaqar, delaying sowing from December 30 to January 17 decreased plant height by about 14.4% (Table 3).

Tallest plants were recorded with 40 kg N ha$^{-1}$ at both locations. At Maru, plants received 40 kg N ha$^{-1}$ were about 9.8% taller than the shortest plants which were recorded under 20 kg N ha$^{-1}$. While at Mushaqar, plants received 40 kg N ha$^{-1}$ were about 4.8% taller than the shortest plants under no N fertilizer. At both locations, the tallest plants were recorded with seeding rate of 25 kg seeds ha$^{-1}$, while the shortest plants were recorded with 15 kg ha$^{-1}$ (Tables 2 and 3).

### 3.4 Days to Emergence, Days to Flowering, Days to Maturity, and the Accumulated Heat Units

**Days to Emergence**

Number of days and accumulated heat units required to emergence, to flowering and to maturity are presented in Table (4).

At both locations the longest period required to emergence was for plants sown on late December. At Maru, the number of days needed to emergence among plants sown on December 1 and January 31 was very close. The accumulated heat units needed to emergence at Maru, were increased by early sowing; an increase of 73% and 90.7% for plants sown on December 1, as compared to those sown on December 29 and January 31, respectively. At Mushaqar, delaying sowing from December 2 to December 30 increased the accumulated heat units required to emergence by 62%, but delaying sowing to January 17 decreased it by 18%.

**Days to Flowering**

At Maru, delaying sowing from December 1 to December 29 and January 31 decreased the period required to flowering by 27.6% and 43.8%, respectively, while the accumulated heat units required to flowering decreased by 10.9% and 6.3%, respectively. At Mushaqar, delaying sowing from December 30 to January 17 reduced the period by 10%, but increased the accumulated heat units by 15.4%.

**Days to Maturity**

At Maru, delaying sowing from December 1 to December 29 and January 31 decreased the period required to maturity by 20.6% and 36.6%, respectively, and decreased the heat units by 3.7% and 6.4%, respectively. At Mushaqar, delaying sowing from December 39 to January 17 decreased the period required to maturity by 7.3%, but increased the accumulated heat units by 8.6%.

### 3.5 Correlation among the studied characters

The highest association value was found between fruit yield and biological yield at both locations ($r^2$ = 0.88 and 0.84 for Maru and Mushaqar, respectively). Fruit yield was positively and significantly correlated with yield component characters at Maru but not at Mushaqar location, except for 1000 seed weight where the correlation was negative. Similar trend to fruit yield, biological yield was also correlated with the other traits at Maru but not at Mushaqar, with $r^2$ values close to what was reported earlier with fruit yield.

The most important correlations among yield components are between branches number with number of umbels plant$^{-1}$, seeds umbel$^{-1}$, seeds plant$^{-1}$ and with a negative correlation with 1000 seed weight. In fact, 1000 seed weight has a negative correlation with almost all the studied traits (Table 5).

## 4. DISCUSSION

Early sowing resulted in an extended growth period where the plant had around 131 days from emergence to maturity as compared to 104 days for plants sown on December 29 and only 83 days for plants sown on January 31 (Table 5). They also have more accumulated heat units than those recorded in the second and third planting dates. The extended growth period and the higher accumulated temperatures during the growing season of the plants sown in the first planting date, allow the plants to better utilize soil moisture, nutrients and solar radiation, which resulted in more dry matter accumulation as grain yield and biological yield. This was reflected on the effect of early sowing on the yield components of the crop; early sowing at Maru resulted in an increase in the number of branches, umbels, seeds per umbel and total number of seeds per plant (Table 2), and also taller plants, which contributed to more grain yield and biological yield. In fact, fruit yield and biological yield were positively and significantly correlated with yield components characters except for 1000 seed weight, where the correlation was negative. The coefficient of determination ($r^2$) of these associations ranged from 0.08 for umbels plant$^{-1}$ to 0.24 for seeds umbrella$^{-1}$ (Table 5) which indicated that the direct contribution of these yield components to fruit yield were substantial and important in the attempt to improve cumin grain yield. The negative correlation between grain yield and 1000 seed weight is rather expected because as number of seeds per plant increases the weight of the single seed tend to decrease.

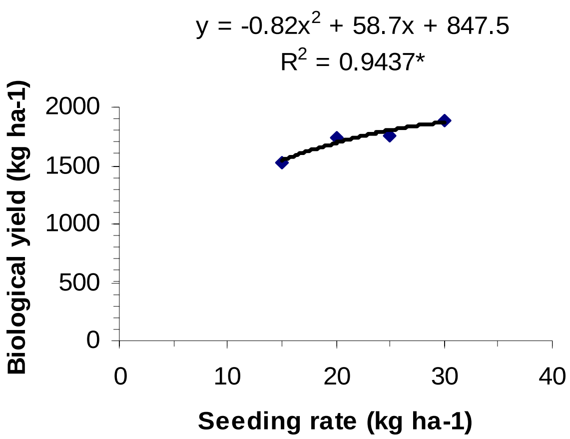


**Figure 5: Relationship between seeding rates and biological yield of cumin (kg ha$^{-1}$) grown at Maru. * = significant at 5%.**

The relationship between fruit yield and planting date in Maru was linear, negative relationship (Fig. 1). The regression equation predicts a decrease of 6.53 kg fruit with each day delay in planting after December 1 which is the first planting date. These results are in agreement with those of Bianco *et al*. (1994) in a study conducted on fennel plant in south Italy, they reported that delaying sowing from August to September decreased number of branches per plant from three to two, and decreased fruit yield from 1600 to 900 kg ha$^{-1}$. Also the results were in line with those of Yousaf *et al*. (2002) working on canola plant at Bahawalpur, Pakistan, who reported that late planting adversely affect yield and yield components due to its effect on growth, because different growth stages required enough time for their development. For example, they reported that the best sowing date was October 11 which gave 2111 kg seed ha$^{-1}$ as compared to 1914 kg ha$^{-1}$ and 1806 kg ha$^{-1}$ for those sown on October 21 and October 31, respectively.

Sowing on December 1 resulted in a relatively lower harvest index values as compared to sowing on December 29 and January 3 (Table 1), which showed that early planting contributed more to the vegetative growth than to fruit production, however, the high vegetative growth in early sowing resulted in supporting more fruit production and eventually more fruit yield was produced. This could be also observed with the strong positive correlation between fruit yield and biological yield (Table 5) and for the two locations. Biological yield has an $r^2$ value with fruit yield of 0.84 for Mushaqar and 0.88 for Maru location, which is the highest among all traits associations with fruit yield. It is, however, worth mentioning that fruit yield is part of biological yield and thus, such strong association is expected especially if the environmental conditions and the growing season are favorable for both traits; vegetative and fruit production. It is important, however, to realize that the growing season was very favorable at Maru in term of available soil moisture (428 mm annual rainfall), and prevailing temperature. It will be interesting to observe the behavior of the plants if a terminal moisture stress occurred, which is common in the rainfed areas of Jordan, which is expected to affect the magnitudes and the partitioning of the assimilates to fruit and straw. The results were in agreement with those recorded by D'Antuono *et al*. (2002), where they reported that delay sowing of black cumin from March to May increased harvest index from 28.6% to 33%.

At Mushaqar location, the results were the opposite of what have been reported at Maru. Plant growth cycle was disrupted by the effect of around zero temperature occurred on the night of March 26, which resulted in a complete damage of plants sown on December 1 and some damage to plants sown on December 30. However, plants sown late on January 17 was less affected by the low temperature. Our observations, that the most affected plants were those which had more vegetative growth. Plants in the second planting date survived, however, they were severely damaged more than plants in the third planting date due to their advanced growth stage. In addition to that, the accumulated heat units from emergence to maturity in the third planting date were greater by 83 units (Table 4) which is rather unexpected, but may be due to the very short interval between the second and third planting dates at Mushaqar.

The positive relationship between nitrogen fertilizer and both fruit and biological yield was expected, since nitrogen fertilization increased the most important characters contributed to yield. For example, the 40 kg N $ha^{-1}$ increased number of branches per plant by 8.8%, increased plant height by 7.8% and increased number of umbels per plant by 9%, as compared to unfertilized plants (Table 1). Our results were in line with those of Randhawa *et al*. (1996) who reported that increasing applied N fertilizer from 0 kg N $ha^{-1}$ to 60, 90 and 120 kg N $ha^{-1}$ increased grain yield of dill seed from 546 to 866, 1078 and 1079 kg $ha^{-1}$, and they reported that this increase in seed yield was due to the favorable effect of N application on yield attributing characters like branching, number of umbels $plant^{-1}$ and plant height. Similar to our results were also recorded by Naqi Shah *et al*. (2004) in a study conducted on mustard plant at Tandojam, Pakistan, they reported that 150-75 kg $ha^{-1}$ NP fertilizer combination resulted in the highest seed yield (1503 kg $ha^{-1}$) as compared to 933, 1260, 1325, 1401 and 1433 kg $ha^{-1}$ for control, 50-15, 75-30, 100-45 and 125-60 kg NP $ha^{-1}$, respectively.

The increase in fruit yield and biological yield with increasing N fertilizer levels was in quadratic fashion (Fig. 2 and Fig. 4), the high $r^2$ for both yield components at both locations, indicates a close relationship between grain yield, biological yield and N fertilization (Hakan, 2003). Response of fruit yield and biological yield of cumin to 20 kg N $ha^{-1}$ indicates that it was adequate for the high fruit and straw yield production within the results obtained in this experiment, and that its capacity to respond to applied N above 20 kg $ha^{-1}$ was not efficient.

It is well known that as plants per unit area increase, more competition will be occurred between plants on the soil moisture and nutrients, and as a result, single plant yield will decrease. However, the yield per unit area might increase due to the increase in the number of plants. This was found to be true under this study, where the higher seeding rate gave greater fruit yield and significantly greater biological yield (Table 1). Some times, however, an economic assessment should be carried out to find if the increase in yield could compensate for the extra cost of doubling the seed rates. Similar to these results are those of Bianco *et al*. (1994) on fennel, where increased plant density from 1.7 plant $m^{-2}$ to 5 plants $m^{-2}$ increased fruit yield from 1025 to 1647 kg $ha^{-1}$, and those of Randhawa *et al*.(1996) on dill seed, where increasing row spacing from 30 to 60 cm decreased fruit yield from 1214 to 863 kg $ha^{-1}$, and Donaldson *et al*. (2001) in a trial conducted at Washington, USA, where increased plant population of wheat from 65 plants $m^{-2}$ to 130 and 195 plants $m^{-2}$ increased straw yield of wheat from 4.5 ton $ha^{-1}$ to 5.0 and 5.25 ton $ha^{-1}$ respectively.

Dry matter accumulation takes place at a slower rate until the crop reaches full ground coverage and then increases at a much faster rate. Angadi *et al*. (2003) working on canola plant at semiarid region of Canada reported that the delay in attaining full ground coverage with lower population, prevents canola plants from efficiently utilize the solar radiation and was related to a lower biomass.

It is important to point out that early sowing of cumin gives a higher yield, however, cumin plant is sensitive to near zero temperature at the late vegetative growth stage, therefore, it is important to avoid planting cumin at areas known to be exposed to frost especially with early sowings. However, it is recommended to investigate the response of cumin to later planting dates after January, to find out the latest date for planting cumin under rainfed conditions of Jordan, which can produce economical yield, taking into consideration its sensitivity to low temperature.

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**Table (4): Number of days and accumulated heat units required to emergence, to flowering and to maturity of cumin grown at Maru and Mushaqar during the growing season of 2004/2005.**

| | Maru | | | Mushaqar | | |
|---|---|---|---|---|---|---|
| Planting date | Dec. 1, 2004 | Dec. 29, 2004 | Jan. 31, 2005 | Dec. 2, 2004 | Dec. 30, 2004 | Jan. 17, 2005 |
| Emergence date | Dec. 27, 2004 | Jan. 29, 2005 | Feb. 27, 2005 | Dec. 27, 2004 | Jan. 31, 2005 | Feb. 15, 2005 |
| Days to emergence (days)* | 27 | 32 | 28 | 26 | 33 | 30 |
| Heat units to emergence | 225 | 130 | 118 | 77 | 125 | 63 |
| Flowering date | Apr. 10, 2005 | Apr. 15, 2005 | Apr. 26, 2005 | ---**--- | Apr. 19, 2005 | Apr. 27, 2005 |
| Days to flowering (days)* | 105 | 76 | 59 | ----**--- | 79 | 71 |
| Heat units to flowering | 603 | 537 | 565 | ----**--- | 544 | 628 |
| Maturity date | May 6, 2005 | May 13, 2005 | May 20, 2005 | ----**--- | May 20, 2005 | May 27, 2005 |
| Days to maturity (days)* | 131 | 104 | 83 | ----**--- | 110 | 102 |
| Heat units to maturity | 930 | 895 | 870 | ----**--- | 950 | 1032 |

* Starting from date of emergence.

** Plants of the first planting date were damaged by frost.

**Table (5): Coefficient of linear correlation among different plant character of cumin grown at Maru and Mushaqar during the growing season of 2004/2005.**

| | FY | BY | HI | Br $P^{-1}$ | Um $P^{-1}$ | S $Um^{-1}$ | S $p^{-1}$ | 1000 SW | PH |
|---|---|---|---|---|---|---|---|---|---|
| FY | 1.00 | 0.937**<br>(0.919**) | 0.159<br>(0.44**) | 0.399**<br>(0.012) | 0.281**<br>(0.028) | 0.494**<br>(0.155) | 0.44**<br>(0.114) | -0.51**<br>(-0.115) | 0.533**<br>(0.147) |
| BY | | 1.00 | -0.13<br>(0.105) | 0.406**<br>(-0.055) | 0.279**<br>(-0.028) | 0.423**<br>(0.155) | 0.409**<br>(0.071) | -0.532**<br>(-0.177) | 0.559**<br>(0.128) |
| HI | | | 1.00 | 0.04<br>(0.128) | 0.024<br>(0.182) | 0.199*<br>(0.070) | 0.105<br>(0.183) | 0.071<br>(0.039) | -0.036<br>(0.007) |
| Br $P^{-1}$ | | | | 1.00 | 0.708**<br>(0.488**) | 0.252**<br>(0.21) | 0.663**<br>(0.441**) | -0.415**<br>(-0.061) | 0.439**<br>(-0.188) |
| Um $P^{-1}$ | | | | | 1.00 | 0.250**<br>(0.076) | 0.90**<br>(0.676**) | -0.34**<br>(-0.127) | 0.464**<br>(0.013) |
| S $Um^{-1}$ | | | | | | 1.00 | 0.631**<br>(0.773**) | -0.493**<br>(0.014) | 0.474**<br>(-0.234) |
| S $P^{-1}$ | | | | | | | 1.00 | -0.497**<br>(-0.082) | 0.587**<br>(-0.125) |
| 1000 SW | | | | | | | | 1.00 | -0.639**<br>(-0.272*) |
| PH | | | | | | | | | 1.00 |

FY: Fruit yield, BY: biological yield, HI: harvest index, Br $P^{-1}$: number of branches per plant, Um $P^{-1}$: umbels per plant, S $Um^{-1}$: seeds per umbrella, S $P^{-1}$: seeds per plant, SW: 1000 seed weight, PH: plant height,

( ): values for Mushaqar. Number of observations was 108 for Maru, and 72 for Mushaqar. *, **: significant at 5% and 1%, respectively.

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# تأثير بعض العمليات الزراعية على إنتاجية محصول الكمون تحت ظروف الزراعة المطرية في الأردن

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## ملخـص

تم تنفيذ البحث في الأردن خلال الموسم الزراعي 2005/2004 في محطتي المشقر و مرو. تكونت المعاملات من ثلاثة مواعيد زراعة ، و ثلاثة مستويات من السماد النيتروجيني و أربعة معدلات بذار. تم توزيع المعاملات في التجربة بطريقة القطع المنشقة باستعمال تصميم القطع العشوائية الكاملة بثلاثة مكررات.

دلت النتائج في محطة مرو على أن الزراعة المبكرة في 12/1 أدت إلى زيادة في إنتاج الثمار بنسبة 26% و 64%, وزيادة في الإنتاج البيولوجي بنسبة 31% و 68% مقارنة مع الزراعة في 12/29 و 1/31 على التوالي. كما أدت الزراعة المبكرة إلى زيادة كل من ارتفاع النبات، وعدد الأفرع الرئيسية للنبات، وعدد النورات للنبات، وعدد البذور للنورة، وعدد البذور للنبات، فيما أدت إلى نقص في وزن الألف بذرة. وأدى تبكير الزراعة إلى زيادة في دورة حياة النبات؛ فقد استمرت دورة حياة النباتات المزروعة في موعد الزراعة الأول مدة 158 يوماً مقارنة مع 134 يوماً و111 يوماً لكل من نباتات الموعدين الثاني والثالث على التوالي. عدد الوحدات الحرارية المجمعة لنباتات الموعد الأول كان 1155 وحدة مقارنة مع 1025 و 988 وحدة لنباتات الموعدين الثاني و الثالث على التوالي.

في المشقر أدى تدني درجة الحرارة ليلة 2005/3/26 إلى ما حول الصفر المئوي إلى موت النباتات المزروعة في الموعد الأول في 12/2, وتدني إنتاجية الموعدين التاليين. كانت النباتات المزروعة في 12/30 أطول من النباتات المزروعة في 1/17 ولكنها أقل في عدد الأفرع. استمرت دورة حياة النباتات المزروعة في 12/30 إلى 143 يوماً جمعت خلالها 950 وحدة حرارية, مقارنة مع 132 يوماً، و1032 وحدة حرارية للنباتات المزروعة في 1/17.

أدت إضافة السماد النيتروجيني في محطة مرو بمعدل 20 و 40 كغم/هكتار إلى زيادة في إنتاج الثمار بمقدار 22% و 27%، و زيادة في الإنتاج البيولوجي بمقدار 17% و 28% مقارنة بالمعاملات التي لم تسمد.

دلت النتائج في محطة مرو على أن الكمون المزروع بمعدل بذار 30 كغم/هكتار كان الأعلى في إنتاج الثمار والإنتاج البيولوجي، بينما أعطى معدل البذار 15 كغم/هكتار عددا أكبر من الأفرع الرئيسية للنبات، وعددا أكبر من النورات للنبات وعددا أكبر من البذور للنبات، لكن وزن الألف بذرة كان الأعلى عند معدل البذار 20 كغم/هكتار. أما في المشقر فكان الذي تأثر بمعدل البذار طول النبات وعدد الأفرع للنبات؛ فقد سجلت أطول النباتات عند معدل البذار 25 كغم/هكتار, أما معدل البذار 15 كغم/هكتار فقد أعطى أكبر عدد من الأفرع للنبات.

**الكلمات الدالة**: الكمون, الزراعة المطرية, النباتات الطبية.

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