Influence of various fertilizer types on yield and component traits of black cumin

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Abstract

Two experiments were conducted in the autumn season of 2019-2020 to investigate the impact of two species belonging to the *Nigella* genus under various fertilization conditions. Both experiments followed the Randomized Complete Block Design (RCBD) and were replicated three times at the Qlyasan and Kanipanka location. The results of the average of both locations, it was observed that *N.* *sativa* outperformed *N.* *arvensis* in terms of seed yield, fixed oil yield and essential oil yield, achieving 607, 138, and 8 kg ha⁻¹, respectively. Notably, when a 2% organic manure application was utilized, higher seed yield, fixed oil yield, and essential oil yield were achieved at 659, 160, and 9 kg ha⁻¹, respectively. The most favorable outcomes of 676 kg ha⁻¹ for seed yield, 174 kg ha⁻¹ for fixed oil yield, and 10 kg ha⁻¹ for essential oil yield were attained through a combination of *N.* *sativa* and the application of 2% organic manure fertilization. Comparatively, the Kanipanka location demonstrated greater results than the Qlyasan location, with seed yields of 621 kg ha⁻¹, fixed oil yields of 137 kg ha⁻¹, and essential oil yields of 8 kg ha⁻¹.

Keywords: Medicinal plants, Black cumin species *Nigella sativa*, *Nigella arvensis*, Organic manure, NPK, fixed oil yield, and essential oil yield.

Introduction

In the early days of modern medicine, plant-derived phytochemicals were the first line of defense for sustaining health and battling diseases [1]. The genus *Nigella* belongs to the Ranunculaceae family [2], which includes numerous plants with notable aromatic characteristics and therapeutic value, including Black Cumin (*Nigella* sp.), which has been used in food and pharmaceutical compositions for generations [3]. *Nigella sativa*, hailing from the Mediterranean area [4 and 5], is indigenous to North Africa, southern Europe, and parts of southwest Asia [6]. Among the earliest cultivated plants, *N.* *sativa* seeds were purportedly discovered in the tomb of Tutankhamun [7]. This medicinal herb, black cumin, possesses curative properties for a range of conditions such as diabetes, inflammatory conditions, rheumatism, heightened immune cell activity, and improved liver and kidney performance in older individuals [8]. It
contains many compounds, such as fixed oils, essential oils, proteins, carbohydrates, crude fiber, minerals, ash, vitamins, alkaloids, and moisture. It contains other constituents like resin, carotene, tannins, sterols, and glucosides [9 and 10]. Soil conditions, climate, and genetic sources are the main factors affecting plant growth and development, as well as physiological growth, active substance synthesis, and the quantity and quality of secondary metabolites [11]. Environmental factors have a more pronounced influence on the productivity and quality of medicinal plants compared to other types of plants. In the field of medicinal and aromatic plants, maintaining high standards is imperative, not just high yields. Therefore, if these plants fail to meet a certain quality threshold, they cannot be cultivated, regardless of their potential for high production. Consequently, these plants should only be cultivated in regions suitable for their specific ecological requirements [12]. One approach to dealing with inadequate soil and environmental conditions is the careful selection of plant species that can thrive. This selection process can involve various strategies for applying fertilizers, including organic options [13 and 14]. Organic fertilizers are not only ecologically sound but also contribute to improving soil quality by affecting its structure, texture, water retention capacity, and cation exchange capability. Additionally, these fertilizers contain vital micronutrients, essential macro-elements, and beneficial microorganisms [15]. This study accesses to evaluate the impact of varying fertilizer supplies (both inorganic and organic) on the yield and its constituent components of Black Cumin species.

Materials and Methods

This study was carried out across two locations in Sulaimani reign: Qlyasan Agricultural Research Station / College of Agricultural Engineering Sciences / University of Sulaimani (Lat. 35° 34’ 307”; N, Long. 45° 21’ 992”; E, 765 MASL, 2 Km North West of Sulaimani city) and Kanipanka Nursery Station / Sulaimani Agricultural Directorate / Ministry of Agriculture and Water Recourses (Lat. 35° 22'; N, Long. 45° 43'; E, 550 MASL, 35 Km East of Sulaimani city). The study was conducted during the autumn seasons of 2020 and 2021. Meteorological data for both locations are provided in Table (1).

The experiment designed contains two primary factors. Firstly, it involved two species of black cumin (Nigella sativa and Nigella arvensis), procured from an Iranian seed from an Iranian company of seed registration PAKAN BAZR. Secondly, the study encompassed fertilization treatment, including: no fertilizer application, NPK Fertilizer (18;18;18) at a rate of 250 Kg ha⁻¹, and various concentrations (1%, 2% and 3%) of Full Green Granular (comprising 10% nitrogen, 10% P2O5, 5% calcium, 5% magnesium, 0.5% sulfur, 0.02% boron, 1% iron, 1% manganese, 1% zinc, and 56% organic matter). The field experiment was arranged using a factorial Randomized Complete Block Design (RCBD) approach, with each treatment replicated three times. Within each block, there were 10 uniform experimental plots measuring 1 m² (1×1) m and 0.5 m apart from each other. For both species of Black cumin, the seeds were directly sown
in the plots in fall 2020 at a seeding rate of 15 Kg ha$^{-1}$. The field was prepared for cultivation, involving irrigation prior to plowing using a moldboard plow and harrow. Weed management was performed manually as required, and all other cultural practices were consistently applied across all treatments. Chemical and physical properties of the soil at a depth of 50 cm were assessed in both locations Table 2, following the methodology outlined in reference [16].

**Table (1):** Metrological data of growing season 2020-2021 at Qlyasan, and Kanipanka locations

<table>
<thead>
<tr>
<th>Period</th>
<th>Qlyasan Location</th>
<th>Kanipanka Location</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temp. C$^\circ$</td>
<td>Rainfall mm</td>
</tr>
<tr>
<td></td>
<td>Max.</td>
<td>Min.</td>
</tr>
<tr>
<td>Nov 2020</td>
<td>20.9</td>
<td>15.7</td>
</tr>
<tr>
<td>Dec</td>
<td>16.3</td>
<td>10.1</td>
</tr>
<tr>
<td>Jan 2021</td>
<td>15.3</td>
<td>9.0</td>
</tr>
<tr>
<td>Feb</td>
<td>17.5</td>
<td>11.0</td>
</tr>
<tr>
<td>Mar</td>
<td>20.2</td>
<td>14.0</td>
</tr>
<tr>
<td>Apr</td>
<td>29.4</td>
<td>21.7</td>
</tr>
<tr>
<td>May</td>
<td>35.4</td>
<td>27.9</td>
</tr>
<tr>
<td>Jun</td>
<td>40.0</td>
<td>31.3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>407.3</td>
</tr>
</tbody>
</table>

**Table (2):** Soil analysis of both locations of the study

<table>
<thead>
<tr>
<th>Soil Properties</th>
<th>Qlyasan Location</th>
<th>Kanipanka Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>P. S. D</td>
<td>Silty clay</td>
<td>Clay</td>
</tr>
<tr>
<td>Sand (g/Kg)</td>
<td>58.3</td>
<td>41.6</td>
</tr>
<tr>
<td>Silt (g/Kg)</td>
<td>420.7</td>
<td>429.2</td>
</tr>
<tr>
<td>Clay (g/Kg)</td>
<td>521.0</td>
<td>529.2</td>
</tr>
<tr>
<td>pH</td>
<td>7.13</td>
<td>7.64</td>
</tr>
<tr>
<td>E.C. (dS/m)</td>
<td>0.61</td>
<td>0.54</td>
</tr>
<tr>
<td>Organic Matter (g/Kg)</td>
<td>21.60</td>
<td>27.8</td>
</tr>
<tr>
<td>Total Nitrogen (mg/Kg)</td>
<td>1.07</td>
<td>1.03</td>
</tr>
</tbody>
</table>

**Studied Traits**
- Seed yield and yield components traits
- Number of seeds capsules$^{-1}$
- Number of capsules plant$^{-1}$
- Weight of capsules plant$^{-1}$
- Weight of seeds plant$^{-1}$ (g)
- 1000 seed weight (g).
- Seed yield (Kg ha$^{-1}$)
- Fixed oil yield (Kg ha$^{-1}$)
- Essential oil yield (Kg ha\(^{-1}\))

**Extraction of Fixed Oil**

Each treatment's harvested seeds, weighing two grams each, were ground into powder using an electric blender. An automated Soxhlet apparatus was employed for oil extraction, utilizing n-hexane (BDH, UK) as the solvent [17]. The oil content was determined through the subsequent calculation.

\[
\text{Oil} \%= \frac{[(W_2 - W_1) \times 100]}{S} \tag{1}
\]

\(W_1\) = The weight of the empty flask (g).
\(W_2\) = The weight of the flask and the extracted oil (g)
\(S\) = The weight of the sample.

**Oil Yield (Kg ha\(^{-1}\))**

The total oil yield (Kg ha\(^{-1}\)) = Oil\% \times \text{The seed yield (Kg ha}^{-1}\) \tag{2}

**Extraction of Essential Oil**

A 100 g seeds powdered of each treatment of *Nigella sp.* was placed in the hydrodistillation apparatus (Clevenger device) for 4 hours at 100 °C [18]. The amount of essential oil was determined using the following equation after the volatile oil was collected and stored at 4 °C until usage.

\[
\text{Essential oil (ml/g)} = \frac{\text{Volume of the Essential Oil in the Clevenger (ml)}}{\text{Weight of the Sample (g)}} \tag{3}
\]

The essential oil yield (Kg ha\(^{-1}\)) = Essential oil\% \times \text{The seed yield (Kg ha}^{-1}\) \tag{4}

**Statistical Analysis**

For the (2x5) factorial experiment with RCBD, the analysis of variance was carried out as a general test. For both locations, a combined analysis of variance across locations was carried out, and the means were tested using the least significant difference (L.S.D.) test with a significant level of 0.05 and 0.01 as confirmed by [17 and 19].

**Result and Discussion**

**Yield and yield component traits**

**Effect of black cumin species on studied traits**

The mean of seed yield and yield component traits of Black cumin influenced by species in both locations, and their average Table 3. At Qlyasan location, the number of seeds capsules\(^{-1}\), number of capsules plant\(^{-1}\), weight of seeds plant\(^{-1}\), 1000 seeds weight, and fixed oil yield exhibited highly significant effects (p\(\leq0.01\)). However, the weight of capsules plant\(^{-1}\), essential oil yield, and total seed yield were found to be
significant (p≤0.05). *N. sativa* outperformed *N. arvensis* in all studied traits. The high production of yield components such as the number of seeds capsules⁻¹ with 59.084 seeds, number of capsules plant⁻¹ with 9.781 g, weight of seeds plant⁻¹ with 1.667g, weight of capsules plant⁻¹ with 1.704 g and 1000 seeds weight with 2.503 g resulted in substantial seeds yield of 562.047 Kg ha⁻¹, fixed oil yield of 126.896 Kg ha⁻¹ and essential oil yield of 7.940 Kg ha⁻¹.

Concerning the Kanipanka location the traits number of seed capsules⁻¹, number of capsules Plant⁻¹, weight of capsules plant⁻¹, seed yield, fixed oil yield, and essential oil yield showed highly significant responses (p≤0.01) to the species, while the traits weight of seeds plant⁻¹, and 1000 seeds weight exhibited significant responses (p≤0.05). *N. sativa* demonstrated superior performance, producing maximum values of 58.519 seeds, 10.069 capsules, 1.783 g of seeds, 1.711 g capsule⁻¹, 2.853 g 1000 seeds, 651.953 Kg ha⁻¹ of seeds yield, 150.948 Kg ha⁻¹ of fixed oil yield, and 9.619 Kg ha⁻¹ of essential oil yield.

At the average of both locations, all of the traits displayed highly significant effects (p≤0.01), with species *N. sativa* surpassing *N. arvensis* in the number of seed capsules⁻¹, number of capsules plant⁻¹, the weight of seeds plant⁻¹, and 1000 seeds weight, seed yield, fixed oil yield, and essential oil yield. *N. sativa* achieved maximum values of 58.802 seeds 9.925 capsules, 1.744 g, 1.689 g, 2.678 g, 607.000 Kg ha⁻¹, and 138.992 Kg ha⁻¹ respectively. These results were in agreement with the results obtained by [20 and 21].

**Table (3):** Means of some seed yield and its component traits of two Black cumin species

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of seed capsules⁻¹</th>
<th>No. of capsules Plant⁻¹</th>
<th>Wt. of capsules plant⁻¹ (g)</th>
<th>Wt. of seeds plant⁻¹ (g)</th>
<th>1000 seeds wt. (g)</th>
<th>Seeds yield (Kg ha⁻¹)</th>
<th>Fixed oil yield (Kg ha⁻¹)</th>
<th>Essential oil yield (Kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Qlyasan Location</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><em>N. sativa</em></td>
<td>59.084</td>
<td>9.781</td>
<td>1.704</td>
<td>1.667</td>
<td>2.503</td>
<td>562.047</td>
<td>126.896</td>
<td>7.940</td>
</tr>
<tr>
<td><em>N. arvensis</em></td>
<td>49.694</td>
<td>8.230</td>
<td>1.324</td>
<td>0.725</td>
<td>1.691</td>
<td>539.227</td>
<td>106.879</td>
<td>7.492</td>
</tr>
<tr>
<td>LSD (p≤0.05)</td>
<td>4.425</td>
<td>0.574</td>
<td>0.297</td>
<td>0.292</td>
<td>0.404</td>
<td>18.908</td>
<td>7.753</td>
<td>0.327</td>
</tr>
<tr>
<td>LSD (p≤0.01)</td>
<td>6.063</td>
<td>0.786</td>
<td>n.s</td>
<td>0.400</td>
<td>0.554</td>
<td>n.s</td>
<td>10.622</td>
<td>n.s</td>
</tr>
<tr>
<td><strong>Kanipanka Location</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><em>N. sativa</em></td>
<td>58.519</td>
<td>10.069</td>
<td>1.783</td>
<td>1.711</td>
<td>2.853</td>
<td>651.953</td>
<td>150.948</td>
<td>9.619</td>
</tr>
<tr>
<td><em>N. arvensis</em></td>
<td>50.162</td>
<td>8.747</td>
<td>1.348</td>
<td>1.484</td>
<td>2.267</td>
<td>590.178</td>
<td>123.520</td>
<td>8.252</td>
</tr>
<tr>
<td>LSD (p≤0.05)</td>
<td>2.595</td>
<td>0.501</td>
<td>0.239</td>
<td>0.198</td>
<td>0.570</td>
<td>24.468</td>
<td>8.814</td>
<td>0.414</td>
</tr>
<tr>
<td>LSD (p≤0.01)</td>
<td>3.556</td>
<td>0.686</td>
<td>0.328</td>
<td>n.s</td>
<td>n.s</td>
<td>33.524</td>
<td>12.076</td>
<td>0.567</td>
</tr>
<tr>
<td><strong>Average of both Locations</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><em>N. sativa</em></td>
<td>58.802</td>
<td>9.925</td>
<td>1.744</td>
<td>1.689</td>
<td>2.678</td>
<td>607.000</td>
<td>138.922</td>
<td>8.780</td>
</tr>
<tr>
<td><em>N. arvensis</em></td>
<td>49.928</td>
<td>8.489</td>
<td>1.336</td>
<td>1.104</td>
<td>1.979</td>
<td>564.703</td>
<td>115.199</td>
<td>7.872</td>
</tr>
<tr>
<td>LSD (p≤0.05)</td>
<td>1.206</td>
<td>0.303</td>
<td>0.113</td>
<td>0.126</td>
<td>0.234</td>
<td>14.303</td>
<td>5.068</td>
<td>0.218</td>
</tr>
<tr>
<td>LSD (p≤0.01)</td>
<td>1.617</td>
<td>0.407</td>
<td>0.151</td>
<td>0.169</td>
<td>0.314</td>
<td>19.179</td>
<td>6.795</td>
<td>0.292</td>
</tr>
</tbody>
</table>
Effect of fertilizer on studied traits

Data in Table (4) illustrates the means of yield, and its components traits of black cumin in both locations and their average as affected by fertilizer. The effect of fertilizer was highly significant (p≤0.01) for the number of seed capsules\(^{-1}\), number of capsules plant\(^{-1}\), 1000 seeds weight, the seeds yield, fixed oil yield, and essential oil yield. However, it was significant (p≤0.05) for the weight of capsules plant\(^{-1}\), and the weight of seeds plant\(^{-1}\) in the Qlyasan location. Regarding the traits, the number of seed capsules\(^{-1}\) reached its maximum value of 61.382 seeds with 1% organic manure application, while the minimum value of 45.824 seeds was obtained with 3% organic manure application. However, the 2% organic manure application outperformed other treatments for the number of capsules plant\(^{-1}\), the weight of capsules plant\(^{-1}\), the weight of seeds plant\(^{-1}\), 1000 seeds weight, seeds yield, the fixed oil yield, and essential oil yield, reaching 11.745 capsules, 1.922 g, 1.618 g, 2.762 g, 620.608 Kg ha\(^{-1}\), 144.489 Kg ha\(^{-1}\) and 9.136 Kg ha\(^{-1}\) respectively. However, the control treatment yielded the minimum values of 6.311 capsules, 1.211 g, 0.883 g, 1.437 g, 429.463 Kg ha\(^{-1}\), 98.573 Kg ha\(^{-1}\), and 6.566 Kg ha\(^{-1}\) respectively.

Concerning the Kanipanka and the average of both locations, the effect of fertilizer was examined, and the results were found to be highly significant (p≤0.01) on all of the yield and yield component traits except for the trait 1000 seeds weight which showed no significant difference at Kanipanka location. Concerning the Kanipanka location, the treatment of 2% organic manure resulted in the maximum values of number of seeds capsule\(^{-1}\) (62.882 seeds), number of capsules plant\(^{-1}\) (12.411 capsules), weight of seeds plant\(^{-1}\) (2.345 g), seed yield (697.729 Kg ha\(^{-1}\)), fixed oil yield (175.906 Kg ha\(^{-1}\)), and essential oil yield (10.629 Kg ha\(^{-1}\)). In contrast, the control treatment yielded the lowest values for these traits with 47.342 seeds, 6.480 capsules, 0.748 g, 544.362 Kg ha\(^{-1}\), 99.293 Kg ha\(^{-1}\), and 7.432 Kg ha\(^{-1}\), respectively. The treatment with 1% organic manure showed the highest value of 1.938 g for the weight of capsules plant\(^{-1}\), while the control treatment recorded the lowest value of 1.150 g for the same trait.

Regarding the average of both locations, the number of seed capsules\(^{-1}\) recorded a high value of 59.163 seeds with 2% organic manure application, while the lowest value of 50.046 seeds was obtained with 3% organic manure application. Concerning the 2% organic manure application, the traits including the number of capsules plant\(^{-1}\) with 12.078 capsules, weight of capsules plant\(^{-1}\) with 1.772 g, weight of seeds plant\(^{-1}\) with 1.981 g, 1000 seed weight with 2.648 g resulted in the highest seeds yield of 659.200 Kg ha\(^{-1}\), fixed oil yield of 160.197 Kg ha\(^{-1}\), and essential oil yield of 9.882 Kg ha\(^{-1}\). Conversely, the control treatment resulted in the lowest values of 6.396 capsules, 1.180 g, 0.816 g, 1.585 g, 518.413 Kg ha\(^{-1}\), respectively. One of the foremost determinants for enhancing plant productivity is the provision of appropriate plant nutrition. In a broader context, the utilization of fertilizers has proven to enhance plant biomass during various stages of plant growth. These outcomes align harmoniously with findings
corroborated by previous research [22]. Fertilizers assume a pivotal role in the facilitation of plant growth and advancement. In the context of medicinal plants, the application of organic fertilizers serves as a catalyst for augmenting plant yields and the synthesis of crucial oils and active compounds [23 and 24]. Conversely, the improper application of nitrogen-rich fertilizers and a deficiency in soil organic matter exerts a detrimental influence on plant yield and chemical composition. Moreover, the excessive utilization of nitrogen-based fertilizers also imparts adverse effects on plant structure and the broader environment encompassing soil and irrigation systems. Generally, any factor influencing the process of photosynthesis holds the potential to impact seed production [25].

Table (4): Means of some seed yield and its component traits affected by fertilizer application

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>No. of seed capsules Plant⁻¹</th>
<th>No. of capsules Plant⁻¹</th>
<th>Wt. of seed capsules Plant⁻¹ (g)</th>
<th>Wt. of seeds Plant⁻¹ (g)</th>
<th>1000 seeds wt. (g)</th>
<th>Seeds yield (Kg ha⁻¹)</th>
<th>Fixed oil yield (Kg ha⁻¹)</th>
<th>Essential oil yield (Kg ha⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>53.240</td>
<td>6.311</td>
<td>1.211</td>
<td>0.883</td>
<td>1.437</td>
<td>492.463</td>
<td>98.573</td>
<td>6.566</td>
</tr>
<tr>
<td>NPK</td>
<td>56.056</td>
<td>7.596</td>
<td>1.633</td>
<td>1.009</td>
<td>1.883</td>
<td>532.970</td>
<td>118.905</td>
<td>7.413</td>
</tr>
<tr>
<td>1% O.M</td>
<td>61.382</td>
<td>9.664</td>
<td>1.322</td>
<td>1.034</td>
<td>2.222</td>
<td>576.850</td>
<td>113.790</td>
<td>7.957</td>
</tr>
<tr>
<td>2% O.M</td>
<td>55.444</td>
<td>11.745</td>
<td>1.922</td>
<td>1.618</td>
<td>2.762</td>
<td>620.608</td>
<td>144.489</td>
<td>9.136</td>
</tr>
<tr>
<td>3% O.M</td>
<td>45.824</td>
<td>9.711</td>
<td>1.483</td>
<td>1.435</td>
<td>2.183</td>
<td>530.295</td>
<td>108.681</td>
<td>7.509</td>
</tr>
<tr>
<td>LSD (p≤0.05)</td>
<td>6.997</td>
<td>0.907</td>
<td>0.469</td>
<td>0.462</td>
<td>0.639</td>
<td>29.896</td>
<td>12.259</td>
<td>0.517</td>
</tr>
<tr>
<td>LSD (p≤0.01)</td>
<td>9.587</td>
<td>1.243</td>
<td>n.s</td>
<td>n.s</td>
<td>0.875</td>
<td>40.961</td>
<td>16.796</td>
<td>0.709</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Traits</th>
<th>Qlyasan Location</th>
<th>Kanipanka Location</th>
<th>Average of both Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>47.342</td>
<td>6.480</td>
<td>1.150</td>
</tr>
<tr>
<td>NPK</td>
<td>50.671</td>
<td>8.868</td>
<td>1.600</td>
</tr>
<tr>
<td>1% O.M</td>
<td>56.537</td>
<td>9.672</td>
<td>1.938</td>
</tr>
<tr>
<td>2% O.M</td>
<td>62.882</td>
<td>12.411</td>
<td>2.522</td>
</tr>
<tr>
<td>3% O.M</td>
<td>54.269</td>
<td>9.609</td>
<td>1.620</td>
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<tr>
<td>LSD (p≤0.05)</td>
<td>4.104</td>
<td>0.792</td>
<td>0.378</td>
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<tr>
<td>LSD (p≤0.01)</td>
<td>5.622</td>
<td>1.085</td>
<td>0.518</td>
</tr>
</tbody>
</table>

Combination of species and fertilizer

Results in Table (5) show the combination effect between Black cumin species and fertilizer on seed yield and its components traits at Qlyasan, Kanipanka, and the average of both locations. At Qlyasan locations, no significant effects were recorded for the combination of Black cumin species and fertilizer treatments on all of the traits, except for the number of seed capsules Plant⁻¹, and the weight of seeds Plant⁻¹ was found to be significant (p≤0.05). The combination between *N. sativa* and 1% organic manure
gave the highest value of 65.088 capsules, while the lowest value of 35.377 capsules was obtained by the combination between *N. arvensis* and 3% organic manure for the number of seed capsules\(^{-1}\). *N. sativa* and 2% organic manure combination gave the maximum value of 2.491g, and the minimum value of 0.563 g was recorded due to the combination between *N. arvensis* and NPK fertilizer for the weight of seeds plant\(^{-1}\).

Concerning the Kanipanka location, the combination effect between species and fertilizer was significant (p≤0.05) on the weight of capsules plant\(^{-1}\) and 1000 seeds weight. However, the combination effect did not significant for the other traits. The traits weight of capsules plant\(^{-1}\) exhibited a maximum value of 2.077 g with the combination between *N. sativa* and 2% organic manure, while the minimum value of 0.966 was obtained by the combination treatment between *N. arvensis* and 2% organic manure. The combination treatment between *N. arvensis* and NPK fertilizer produced the maximum value of 3.600 g for the traits 1000 seeds weight, while both combinations between *N. arvensis* and the control, and *N. arvensis* and 2% organic manure treatment, resulted in the minimum value of 1.600 g.

At the average of both locations, the combination effect between species and fertilization was highly significant (p≤0.01) for the number of seed capsules\(^{-1}\), number of capsules plant\(^{-1}\), weight of seeds plant\(^{-1}\), weight of capsules plant\(^{-1}\) and 1000 seeds weight, while it was not significant for the other traits. Among the different combinations studied, the combination between *N. sativa* and 2% organic manure resulted in the maximum number of seeds capsule\(^{-1}\) (65.341 seeds), whereas the minimum number of seeds capsule\(^{-1}\) (41.083 seeds) was observed for the combination between *N. arvensis* and 3% organic manure. The combination between *N. sativa* and 2% organic manure exhibited the highest number of capsules plant\(^{-1}\) (12.580 capsules), weight of capsules plant\(^{-1}\) (2.244 g), and 1000 seeds weight (3.533 g). In contrast, the combination between *N. sativa* and control yielded the lowest values for these traits (7.480 capsules, 1.227g, 1.703g, and 2249.483 Kg ha\(^{-1}\) respectively). Regarding the weight of seeds plant\(^{-1}\) reached its highest value (2.495 g) when *N. sativa* interacted with 2% organic manure, while the combination of *N. arvensis* with the control resulted in the lowest value (0.683 g). Fluctuation in results was obtained by combination between Species and fertilization, the results indicate that using both fertilization (chemical and organic) with the species treatment gave an increase in yield and their component, which was similar to the results of by [26 and 27].

**Table (5):** Means of some seed yield and its component traits affected by the combination between Black cumin species and fertilizer application

<table>
<thead>
<tr>
<th>Species Traits</th>
<th>Fertilizer</th>
<th>No. of seed capsules(^{-1})</th>
<th>No. of capsules Plant(^{-1})</th>
<th>Wt. of capsules plant(^{-1}) (g)</th>
<th>Wt. of seeds Plant(^{-1}) (g)</th>
<th>1000 seeds wt. (g)</th>
<th>Seeds yield (Kg ha(^{-1}))</th>
<th>Fixed oil yield (Kg ha(^{-1}))</th>
<th>Essential oil yield (Kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>N. Sativa</td>
<td>Control</td>
<td>54.360</td>
<td>7.222</td>
<td>1.299</td>
<td>1.000</td>
<td>1.540</td>
<td>500.100</td>
<td>101.302</td>
<td>6.768</td>
</tr>
<tr>
<td></td>
<td>NPK</td>
<td>55.518</td>
<td>8.665</td>
<td>1.577</td>
<td>1.455</td>
<td>2.200</td>
<td>546.990</td>
<td>132.655</td>
<td>7.714</td>
</tr>
<tr>
<td></td>
<td>1% O.M</td>
<td>65.088</td>
<td>9.888</td>
<td>1.722</td>
<td>1.369</td>
<td>2.510</td>
<td>589.957</td>
<td>119.171</td>
<td>8.082</td>
</tr>
<tr>
<td></td>
<td>2% O.M</td>
<td>64.184</td>
<td>12.416</td>
<td>2.411</td>
<td>2.491</td>
<td>3.600</td>
<td>626.457</td>
<td>161.173</td>
<td>9.210</td>
</tr>
<tr>
<td></td>
<td>3% O.M</td>
<td>56.271</td>
<td>10.711</td>
<td>1.511</td>
<td>2.020</td>
<td>2.667</td>
<td>546.733</td>
<td>120.182</td>
<td>7.927</td>
</tr>
</tbody>
</table>

179
Effect of locations on studied traits

The effects of different locations on the studied traits are illustrated in Table 6. The traits weight of seeds plant\(^{-1}\), seeds yield, fixed oil yield, and essential oil yield exhibited a highly significant (p≤0.01) response to these effects, except for the 1000 seeds weight which showed only a significant response (p≤0.05). The Kanipanka location outperformed the Qlyasan location for the traits weight of seeds plant\(^{-1}\), and 1000 seed weight with the values of 1.598 g, and 2.560 g, respectively. The surpassed Kanipanka location for growth traits reflected in yield component and seed yield which produced the highest values for most of the yield components and especially seed yield, fixed oil yield, and essential oil yield with 621.065, 137.234, and 8.935 Kg ha\(^{-1}\), respectively. The Kanipanka location exhibited better performance in terms of seed yield, and fixed and essential oil yield. This could be attributed to favorable environmental conditions, particularly the moderate temperature. The provided meteorological data in Table (1) further supports this observation. Black cumin plant growth is hindered when the soil temperature drops from 15°C to 25°C. To achieve a profitable yield and obtain high-quality essential oil from black cumin, it is advantageous to have a warm, sunny, and dry autumn season and the soil pH should be slightly alkaline to neutral, ranging from 7.0 to 8.5 [28 and 29].

<table>
<thead>
<tr>
<th>N. arvensis</th>
<th>Control</th>
<th>NPK</th>
<th>1% O.M</th>
<th>2% O.M</th>
<th>3% O.M</th>
<th>LSD (p≤0.05)</th>
<th>LSD (p≤0.01)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>52.119</td>
<td>5.400</td>
<td>1.122</td>
<td>0.766</td>
<td>1.333</td>
<td>484.827</td>
<td>95.845</td>
</tr>
<tr>
<td></td>
<td>56.593</td>
<td>6.527</td>
<td>1.688</td>
<td>0.563</td>
<td>1.567</td>
<td>518.950</td>
<td>105.154</td>
</tr>
<tr>
<td>1% O.M</td>
<td>57.676</td>
<td>9.440</td>
<td>0.922</td>
<td>0.700</td>
<td>1.933</td>
<td>563.743</td>
<td>108.409</td>
</tr>
<tr>
<td>2% O.M</td>
<td>46.704</td>
<td>11.073</td>
<td>1.433</td>
<td>0.744</td>
<td>1.923</td>
<td>614.760</td>
<td>127.804</td>
</tr>
<tr>
<td>3% O.M</td>
<td>35.377</td>
<td>8.711</td>
<td>1.435</td>
<td>0.850</td>
<td>1.700</td>
<td>513.857</td>
<td>97.180</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>N. Sativa</th>
<th>Control</th>
<th>NPK</th>
<th>1% O.M</th>
<th>2% O.M</th>
<th>3% O.M</th>
<th>LSD (p≤0.05)</th>
<th>LSD (p≤0.01)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50.107</td>
<td>7.739</td>
<td>1.255</td>
<td>0.897</td>
<td>1.867</td>
<td>583.300</td>
<td>118.037</td>
</tr>
<tr>
<td></td>
<td>53.409</td>
<td>9.736</td>
<td>1.811</td>
<td>1.710</td>
<td>2.600</td>
<td>603.590</td>
<td>135.686</td>
</tr>
<tr>
<td>1% O.M</td>
<td>60.831</td>
<td>9.903</td>
<td>1.810</td>
<td>1.443</td>
<td>3.267</td>
<td>660.390</td>
<td>155.878</td>
</tr>
<tr>
<td>2% O.M</td>
<td>66.498</td>
<td>12.744</td>
<td>2.077</td>
<td>2.500</td>
<td>3.467</td>
<td>727.150</td>
<td>188.091</td>
</tr>
<tr>
<td>3% O.M</td>
<td>61.750</td>
<td>10.222</td>
<td>1.962</td>
<td>2.007</td>
<td>3.067</td>
<td>685.333</td>
<td>157.046</td>
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</table>

<table>
<thead>
<tr>
<th>N. arvensis</th>
<th>Control</th>
<th>NPK</th>
<th>1% O.M</th>
<th>2% O.M</th>
<th>3% O.M</th>
<th>LSD (p≤0.05)</th>
<th>LSD (p≤0.01)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>44.578</td>
<td>5.222</td>
<td>1.044</td>
<td>0.599</td>
<td>1.600</td>
<td>505.423</td>
<td>80.549</td>
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<tr>
<td></td>
<td>47.933</td>
<td>8.000</td>
<td>1.388</td>
<td>1.597</td>
<td>3.600</td>
<td>582.667</td>
<td>119.747</td>
</tr>
<tr>
<td>1% O.M</td>
<td>52.244</td>
<td>9.441</td>
<td>2.066</td>
<td>1.227</td>
<td>2.300</td>
<td>606.367</td>
<td>129.235</td>
</tr>
<tr>
<td>2% O.M</td>
<td>59.266</td>
<td>12.077</td>
<td>0.966</td>
<td>2.190</td>
<td>1.600</td>
<td>668.433</td>
<td>163.721</td>
</tr>
<tr>
<td>3% O.M</td>
<td>46.789</td>
<td>8.996</td>
<td>1.277</td>
<td>1.807</td>
<td>2.233</td>
<td>588.000</td>
<td>124.345</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Kanipanka Location</th>
<th>LSD (p≤0.05)</th>
<th>LSD (p≤0.01)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1.700</td>
<td>1.923</td>
</tr>
<tr>
<td>NPK</td>
<td>2.013</td>
<td>2.495</td>
</tr>
<tr>
<td>1% O.M</td>
<td>2.868</td>
<td>3.533</td>
</tr>
<tr>
<td>2% O.M</td>
<td>3.344</td>
<td>4.457</td>
</tr>
<tr>
<td>3% O.M</td>
<td>4.016</td>
<td>5.114</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average of both Locations</th>
<th>LSD (p≤0.05)</th>
<th>LSD (p≤0.01)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.281</td>
<td>0.523</td>
</tr>
<tr>
<td>NPK</td>
<td>0.850</td>
<td>1.122</td>
</tr>
<tr>
<td>1% O.M</td>
<td>1.923</td>
<td>2.560</td>
</tr>
<tr>
<td>2% O.M</td>
<td>2.933</td>
<td>3.560</td>
</tr>
<tr>
<td>3% O.M</td>
<td>3.577</td>
<td>4.133</td>
</tr>
</tbody>
</table>
Table (6): Means of some seed yield and its component traits affected by locations

<table>
<thead>
<tr>
<th>Locations</th>
<th>No. of seed capsules (^4)</th>
<th>No. of capsules Plant (^4)</th>
<th>Wt. of capsules Plant (^3) (g)</th>
<th>Wt. of seeds Plant (^3) (g)</th>
<th>1000 seeds wt. (g)</th>
<th>Seeds yield (Kg ha(^{-1}))</th>
<th>Fixed oil yield (Kg ha(^{-1}))</th>
<th>Essential oil yield (Kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qlyasan</td>
<td>54.389</td>
<td>9.005</td>
<td>1.514</td>
<td>1.196</td>
<td>2.097</td>
<td>550.637</td>
<td>116.888</td>
<td>7.716</td>
</tr>
<tr>
<td>Kanipanka</td>
<td>54.340</td>
<td>9.408</td>
<td>1.566</td>
<td>1.598</td>
<td>2.560</td>
<td>621.065</td>
<td>137.234</td>
<td>8.935</td>
</tr>
<tr>
<td>LSD ((p\leq0.05))</td>
<td>n.s</td>
<td>n.s</td>
<td>n.s</td>
<td>0.104</td>
<td>0.444</td>
<td>19.102</td>
<td>5.539</td>
<td>0.245</td>
</tr>
<tr>
<td>LSD ((p\leq0.01))</td>
<td>n.s</td>
<td>n.s</td>
<td>n.s</td>
<td>0.172</td>
<td>n.s</td>
<td>31.677</td>
<td>9.185</td>
<td>0.406</td>
</tr>
</tbody>
</table>

According to the results obtained, we can conclude that both species are adaptable to Kurdistan climate. *N. sativa* species was more suitable for seed production and oil content. The application of 2% organic manure was sufficient to improve yield and its components as well. The combination effect of *N. sativa* and 2% organic manure produce maximum values for most of the growth, seed yield, and oil yield. Due to the availability of environmental conditions, particularly favorable temperature and soil fertility, the Kanipanka location recorded better values for most of the traits compared to the Qlyasan location.

References


