Journal of Kerbala for Agricultural Sciences Issue (3), Volume (10), (2023)

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

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https://doi.org/10.59658/jkas.v10i3.1250

Received: July 30, 2023

Accepted: Aug. 30, 2023

Published: Sept. 10, 2023

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^o 34' 307"; N, Long. 45^o 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^o 22'; N, Long. 45^o 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 m^2 (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

Period	Qlyasan Location			Kanipanka Location		
	Temp. C°		Rainfall mm	Temp. C°		Rainfall mm
	Max.	Min.		Max.	Min.	
2020 Nov	20.9	15.7	204.2	23.8	16.2	172.1
Dec	16.3	10.1	21	22.7	14.6	14.5
2021 Jan	15.3	9.0	65.4	20.1	13.4	53.3
Feb	17.5	11.0	71.4	27.2	12.5	41.4
Mar	20.2	14.0	30.4	28.4	14.1	20.9
Apr	29.4	21.7	10.7	30.4	15.2	3.8
May	35.4	27.9	4.2	33.1	20.2	0.0
Jun	40.0	31.3	0.0	39.3	34.3	0.0
Total			407.3			306

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

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

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.

$$\text{Oil } \% = \frac{[(W_2 - W_1) \times 100]}{S} \qquad \text{Eq. (1)}$$

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% × The seed yield (Kg ha^{-1}) Eq. (2)

Extraction of Essential Oil

A 100 g seeds powdered of each treatment of *Nigella sp*. was placed in the hydro-distillation 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.

$$\text{Essential oil } (ml/g) = \frac{\text{Volume of the Essential Oil in the Clevenger (ml)}}{\text{Weight of the Sample (g)}} \qquad \text{Eq. (3)}$$

The essential oil yield (Kg ha^{-1}) = Essential oil% × The seed yield (Kg ha^{-1}) Eq. (4)

Statistical Analysis

For the (2×5) 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 ($p \leq 0.01$). However, the weight of capsules $plant^{-1}$, essential oil yield, and total seed yield were found to be significant ($p \leq 0.05$). *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 ($p \leq 0.01$) to the species, while the traits weight of seeds plant^{-1}, and 1000 seeds weight exhibited significant responses ($p \leq 0.05$). *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 ($p \leq 0.01$), 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}, and 8.780 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

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

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 ($p \leq 0.01$) 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 ($p \leq 0.05$) 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. 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 the 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 ($p \leq 0.01$) 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

Fertilizer / Traits	No. of seed capsules^{-1}	No. of capsules Plant^{-1}	Wt. of capsules Plant^{-1} (g)	Wt. of seeds Plant^{-1} (g)	1000 seeds wt. (g)	Seeds yield (Kg ha^{-1})	Fixed oil yield (Kg ha^{-1})	Essential oil yield (Kg ha^{-1})
Qlyasan Location								
Control	53.240	6.311	1.211	0.883	1.437	492.463	98.573	6.566
NPK	56.056	7.596	1.633	1.009	1.883	532.970	118.905	7.413
1% O.M	61.382	9.664	1.322	1.034	2.222	576.850	113.790	7.957
2% O.M	55.444	11.745	1.922	1.618	2.762	620.608	144.489	9.136
3% O.M	45.824	9.711	1.483	1.435	2.183	530.295	108.681	7.509
LSD $(p\leq0.05)$	6.997	0.907	0.469	0.462	0.639	29.896	12.259	0.517
LSD $(p\leq0.01)$	9.587	1.243	n.s	n.s	0.875	40.961	16.796	0.709
Kanipanka Location								
Control	47.342	6.480	1.150	0.748	1.733	544.362	99.293	7.432
NPK	50.671	8.868	1.600	1.653	3.100	593.128	127.717	8.433
1% O.M	56.537	9.672	1.938	1.335	2.783	633.378	142.557	8.874
2% O.M	62.882	12.411	1.522	2.345	2.533	697.792	175.906	10.629
3% O.M	54.269	9.609	1.620	1.907	2.650	636.667	140.695	9.309
LSD $(p\leq0.05)$	4.104	0.792	0.378	0.312	n.s	38.688	13.936	0.654
LSD $(p\leq0.01)$	5.622	1.085	0.518	0.428	n.s	53.006	19.094	0.896
Average of both Locations								
Control	50.291	6.396	1.180	0.816	1.585	518.413	98.933	6.999
NPK	53.363	8.232	1.616	1.331	2.492	563.049	123.311	7.923
1% O.M	58.960	9.668	1.630	1.185	2.503	605.114	128.173	8.416
2% O.M	59.163	12.078	1.722	1.981	2.648	659.200	160.197	9.882
3% O.M	50.046	9.660	1.551	1.671	2.417	583.481	124.688	8.409
LSD $(p\leq0.05)$	1.906	0.480	0.178	0.199	0.370	22.615	8.013	0.344
LSD $(p\leq0.01)$	2.556	0.643	0.239	0.267	0.496	30.324	10.744	0.461

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^{-1}, and the weight of seeds plant^{-1} was found to be significant ($p\leq0.05$). 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 ($p \leq 0.05$) 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 ($p \leq 0.01$) 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

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

N. arven-sis	Control	52.119	5.400	1.122	0.766	1.333	484.827	95.845	6.363
	NPK	56.593	6.527	1.688	0.563	1.567	518.950	105.154	7.113
	1% O.M	57.676	9.440	0.922	0.700	1.933	563.743	108.409	7.831
	2% O.M	46.704	11.073	1.433	0.744	1.923	614.760	127.804	9.062
	3% O.M	35.377	8.711	1.455	0.850	1.700	513.857	97.180	7.092
LSD $_{(p\leq0.05)}$		**9.895**	**n.s**	**n.s**	**0.653**	**n.s**	**n.s**	**n.s**	**n.s**
LSD $_{(p\leq0.01)}$		**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**	**n.s**
Kanipanka Location									
N. Sativa	**Control**	**50.107**	**7.739**	**1.255**	**0.897**	**1.867**	**583.300**	**118.037**	**8.109**
	NPK	53.409	9.736	1.811	1.710	2.600	603.590	135.686	8.611
	1% O.M	60.831	9.903	1.810	1.443	3.267	660.390	155.878	9.643
	2% O.M	66.498	12.744	2.077	2.500	3.467	727.150	188.091	11.344
	3% O.M	61.750	10.222	1.962	2.007	3.067	685.333	157.046	10.388
N. arven-sis	Control	44.578	5.222	1.044	0.599	1.600	505.423	80.549	6.755
	NPK	47.933	8.000	1.388	1.597	3.600	582.667	119.747	8.256
	1% O.M	52.244	9.441	2.066	1.227	2.300	606.367	129.235	8.106
	2% O.M	59.266	12.077	0.966	2.190	1.600	668.433	163.721	9.915
	3% O.M	46.789	8.996	1.277	1.807	2.233	588.000	124.345	8.229
LSD $_{(p\leq0.05)}$		n.s	n.s	0.535	n.s	1.274	n.s	n.s	n.s
LSD $_{(p\leq0.01)}$		n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
Average of both Locations									
N. Sativa	Control	52.234	7.480	1.277	0.948	1.703	541.700	109.669	7.438
	NPK	54.464	9.201	1.694	1.583	2.400	575.290	134.170	8.162
	1% O.M	62.959	9.896	1.766	1.406	2.888	625.173	137.525	8.863
	2% O.M	65.341	12.580	2.244	2.495	3.533	676.803	174.632	10.277
	3% O.M	59.010	10.466	1.737	2.013	2.867	616.033	138.614	9.158
N. arven-sis	Control	48.348	5.311	1.083	0.683	1.467	495.125	88.197	6.559
	NPK	52.263	7.263	1.538	1.080	2.583	550.808	112.451	7.684
	1% O.M	54.960	9.441	1.494	0.963	2.117	585.055	118.822	7.969
	2% O.M	52.985	11.575	1.199	1.467	1.762	641.597	145.762	9.488
	3% O.M	41.083	8.854	1.366	1.328	1.967	550.928	110.763	7.660
LSD $_{(p\leq0.05)}$		2.696	0.679	0.252	0.281	0.523	n.s	n.s	n.s
LSD $_{(p\leq0.01)}$		3.615	0.910	0.338	0.377	0.701	n.s	n.s	n.s

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 ($p\leq0.01$) response to these effects, except for the 1000 seeds weight which showed only a significant response ($p\leq0.05$). 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 (6): Means of some seed yield and its component traits affected by locations

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

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

1) Bhattarai, S., Chaudhary, R. P., Quave, C. L. and Taylor, R. S. (2010). The use of medicinal plants in the trans-himalayan arid zone of Mustang district, Nepal. Journal of Ethnobiology and Ethnomedicine, 6(1): 1-11.
2) Al-Saedi, S. R., 2023. Antibacterial Activity of the Aqueous and Methanol Extracts of *Nigella sativa* Seeds in Mice. Journal of Kerbala for Agricultural Sciences, 10(2): 51-57.
3) Al-Mowsowy, A. J. (2023). Extending the shelf life of soft cheese using nanoencapsulation. Journal of Kerbala for Agricultural Sciences, 10(1): 57-67.
4) Bita, A., Rosu, A. F., Calina, D., Rosu, L., Zlatian, O., Dindere, C. and Simionescu, A. (2012). An alternative treatment for candida infections with Nigella sativa extracts. European Journal of Hospital Pharmacy: Science and Practice, 19(2): 162-162. http://dx.doi.org/10.1136/ejhpharm-2012-000074.203.
5) Mohammed, H. A. (2018). Supplementation *Nigella sativa* seeds and Thymus vulgaris leaves powder in broiler diet and effect on chemical composition of main carcass parts. Journal of Kerbala for Agricultural Sciences, 5(3):14-22.
6) Padhye, S., Banerjee, S., Ahmad, A., Mohammad, R. and Sarkar, F. H. (2008). From here to eternity-the secret of Pharaohs: Therapeutic potential of black cumin seeds and beyond. Cancer therapy, 6(b): 495.
7) Ashfaq, S., Khan, N. T. and Ali, G. M. (2021). *Nigella sativa* (Kalonji), its essential oils and their therapeutic potential. Biomedical Journal of Scientific & Technical Research, 33(1): 25448-25454. Doi:10.26717/BJSTR.2021.33.005335

8) Bashandy, S. (1996). Effect of *Nigella sativa* oil on liver and kidney functions of adult and senile rats. Egyptian journal of pharmaceutical sciences, 37(1-6): 313-327.

9) Shaterzadeh-Yazdi, H., Noorbakhsh, M. F., Samarghandian, S. and Farkhondeh, T. (2018). An overview on renoprotective effects of thymoquinone. Kidney Diseases, (4)2: 74-82. https://doi.org/10.1159/000486829

10) Thakur, S., Kaurav, H. and Chaudhary, G. (2021). *Nigella sativa* (Kalonji): A black seed of miracle. International Journal of Research and Review, 8(4): 342-357. DOI: https://doi.org/10.52403/ijrr.20210441

11) Li, Y., Kong, D., Fu, Y., Sussman, M. R. and Wu, H. (2020). The effect of developmental and environmental factors on secondary metabolites in medicinal plants. Plant Physiology and Biochemistry, 148, pp.80-89. https://doi.org/10.1016/j.plaphy.2020.01.006

12) Figueiredo, A. C., Barroso, J. G., Pedro, L. G. and Scheffer, J. J. (2008). Factors affecting secondary metabolite production in plants: volatile components and essential oils. Flavour and Fragrance journal, 23(4): 213-226. https://doi.org/10.1002/ffj.1875

13) Ashraf, M., Ali, Q. and Iqbal, Z. (2006). Effect of nitrogen application rate on the content and composition of oil, essential oil and minerals in black cumin (*Nigella sativa* L.) seeds. Journal of the Science of Food and Agriculture, 86, 871-876. doi.org/10.1002/jsfa.2426

14) Ozguven, M., Şener, B., Orhan, I., Şekeroglu, N., Kirpik, M., Kartal, M., Peşin, I. and Kaya, Z. (2008). Effects of varying nitrogen doses on yield, yield components and artemisinin content of *Artemisia annua* L. Industrial Crops and Products, (27): 60-64. https://doi.org/10.1016/j.indcrop.2007.07.012

15) Maske, S., Munde, G. and Maske, N. (2015). Effect of manures and fertilizer on brinjal (*Solanum melongena* L.) CV Krishna. BIOINFOLET-A Quarterly Journal of Life Sciences, 12: 678-679.

16) Page, A. L., Miller, R. H. and Keeney, D. R. (1982). Methods of Soil Analysis. 2nd Edn.,Amercen Society of Agronomy.of Botany, (38): 499-509.

17) Ahmed, R. M. (2018). Oil Percent and Unsaturated Fatty Acid Response of Rapeseed Cultivars to Nitrogen and Phosphorus Fertilizers in Two Different Sowing Date. Journal Tikrit University. For Agricultural Sciences, 18(4): 29-38.

18) Shnrwe, B. M. and Ahmed, R. M. (2022). Response of yield and chemical composition of black cumin to different fertilizer in Sulaimani region. Iraqi Journal of Agricultural Sciences, 53(4): 901-910. https://doi.org/10.36103/ijas.v53i4.1602

19) Al-Rawi, K. M. and Abdul Aziz, M. (1980). Design and analysis of agricultural experiments. University of Al Mosul. Directorate of Dar Al Kutub for Printing and Publishing, 19, 487.

20) Muhammad, A. G., Ahmed, R. M. and Muhammed, K. E. (2017). Response of growth, yield, and oil content of two Black seed species to nitrogen fertilizer in Sulaimani District. Euphrates Journal of Agriculture Science-9 (4): 18-52.

21) Rasool, A. A., and A. G. M. Rashid (2014). Effect of nitrogen fertilization and gibberellic acid spray on seed yield and oil content of black seed (*Nigella sativa* L.). Journal of Zankoy Sulaimani-Part A, 16, 355-362.

22) Isha Verma, IS. Naurka and Roopali Patel. (2022). Effect of different doses of NPK fertilizer on yield characters of nigella (*Nigella sativa* L.). The Pharma Innovation Journal, 11(4): 1139-1144.

23) Aziz E. E., M. M. El-Danasoury and L. E. Craker. (2010). Impact of sulfur and ammonium sulphate on dragonhead plants grown in newly reclaimed soil. Journal of Herbs Spices Medecinal Plants, 16(2): 126-135. doi.org/10.1080/10496475.2010.508973

24) Zheljazkov V. D., C. L. Cantrell, T. Astatkie, and J. B. Cannon (2011). Lemongrass productivity, oil content, and composition as a function of nitrogen, sulfur, and harvest time. Agronomy Journal, 103(3): 805-812. https://doi.org/10.2134/agronj2010.0446

25) Sharma, T., A. Kaur, S. Saajan, and R. Thakur (2020). Effect of nitrogen on growth and yield of medicinal plants: A review paper. Europian Journal of Mol. Clin. Med, 7: 2771-2776.

26) Ewulo, B. S. (2005). Effect of poultry dung and cattle manure on chemical properties of clay and sandy clay loam soil. Journal of Animal and Veterinary Advances, 4(10): 839-841.

27) Tuncturk, M., Tuncturk, R., Yildirim, B., Tuncturk, M., Tuncturk, R. and Yildirim, B. (2011). The effects of varying phosphorus doses on yield and some yield components of black cumin (*Nigella sativa* L.). Advances in Environmental Biology, (5)2: 371-374.

28) Ozguven, M., Şener, B., Orhan, I., Şekeroglu, N., Kirpik, M., Kartal, M., Peşin, I. and Kaya, Z. (2008). Effects of varying nitrogen doses on yield, yield components and artemisinin content of *Artemisia annua* L. Industrial Crops and Products, (27): 60-64. https://doi.org/10.1016/j.indcrop.2007.07.012

29) Sreenivasa, M., Naik, N. and Bhat, S. (2010). Beejamrutha: A source for beneficial bacteria. Karnataka Journal of Agricultural Sciences, 22 (5): 1038-1040.