World Journal of Agricultural Sciences 16 (1): 42-49, 2020
ISSN 1817-3047
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DOI: 10.5829/idosi.wjas.2020.42.49

Effect of Cattle Manure, Biochar and NPK Fertilization on *Nigella sativa* L. Productivity in Sandy Soils

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Abstract: A field experiment was carried out at Ismailia Agricultural Research Station, Ismailia Governorate, Egypt during the two consecutive seasons of 2017/2018 and 2018/2019 to evaluate the impact of some soil amendments (cattle manure and biochar) in reducing the chemical fertilization rates to 50 and 75% of recommended NPK fertilizers dose and their effects on the vegetative growth, seed and fixed oil yields as well as chemical constituents of black seed (*Nigella sativa* L.) plants under sandy soil conditions. The obtained results revealed that the application of cattle manure or biochar has a positive effect on reducing NPK fertilizers doses. Application of cattle manure (30m^3/fed.) or biochar (1kg/m^2soil) with 75% of the recommended NPK dose significantly improved growth parameters, seed yield, N, P, K, total protein and total carbohydrates percentage in the herb as well as yield of fixed oil in seeds compared to the full NPK dose and therefore, saving up to 25% of inorganic fertilizers (NPK) as well as reducing environmental risks.

Key words: *Nigella sativa* · Soil amendments · Cattle manure · Biochar · NPK fertilizers · Carbohydrates · Fixed oil

INTRODUCTION

Medicinal and aromatic plants play a major role in agriculture and industry, as they are the main source of safe drugs and raw materials for the pharmaceutical, cosmetic industries and human nutrition. One of the most important of these plants is *Nigella Sativa* L., which commonly known as black seed or black cumin. It is an annual herb from the botanical family of Ranunculaceae. The seed of *N. sativa* has over 100 different chemical components, including mucilage, crude fiber, reducing sugars, resins, alkaloids, flavonoids, organic acids, sterols, tannins and saponins, in addition to the high content of unsaturated fatty acids (especially linoleic acid and oleic acid) and proteins. It also has the yellowish volatile oil [1, 2]. Seeds of *N. sativa* revealed a broad spectrum of pharmacological activities including immunopotentiation and antihistaminic, antihypertensive, antidiabetic, anticancer, immunomodulator, analgesic, antimicrobial, anti-inflammatory, spasmolytic, bronchodilator, hepatoprotective, renal protective, gastro-protective and antioxidant properties, etc. [3, 4]. The seeds are used in the treatment of various diseases like bronchitis, diarrhea, rheumatism, asthma and skin disorders. It acts as a liver tonic, anti- diarrheal, appetite stimulant and emmenagogue. It is used in digestive disorders, to increase milk production in nursing mothers to fight parasitic infections and to strengthen immune system [5]. Also, seeds have been used in the Southeast Asia, Middle and Far East as a natural remedy to treat many diseases, including, hypertension, diabetes, hypercholes terolemia, inflammation, arthritis, tumor, gastrointestinal disturbances and gynecological disorders for over 2000 years [6-8]. Seeds are useful in the treatment of worms and skin eruptions. Roasted black seeds are given internally to stop the vomiting; fixed oil is used as an antiseptic and local anesthetic externally [9]. In addition, the seeds are extensively used as spice, condiment and aromatic, which can be added to tea, coffee, casseroles or breads. The ground seed can be mixed with honey or sprinkled on salads [8]. Seeds are also used in food like flavoring additive in the breads and pickles because it has very low level of toxicity [10].

Biochar is the solid product of burning biomass in very low or oxygen-free conditions, a process called pyrolysis. It is a black, carbon-rich and porous material

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with potentially important benefits for soils and plant growth in addition to potentially storing carbon in a stable form for hundreds of years. Benefits for soils and plant growth: Consisting of a large proportion of carbon, biochar adds soil organic matter. Chemical bonding occurs between molecules on the biochar surface and nutrients that are vital to healthy plant growth such as nitrates, ammonium, phosphates, potassium, magnesium, sodium, calcium and so on. Evidence suggests that such chemical reactions act to improve the availability of nutrients to the plant, potentially reducing loss by run-off and leaching (thus decreasing agricultural pollution of waterways). This means that added nutrients, such as from synthetic or organic fertilizers, are potentially utilized more efficiently by plants grown in soils containing suitable types of biochar [11].

Biochar is a soil amendment has the potential to increase crop yields [12, 13]. Earlier research has shown that biochar addition could improve plant growth and soil quality [14, 15]. The positive responses in crop yield to biochar addition were attributed to improving soil properties, such as a decrease in soil bulk density and subsequent increase in porosity and water holding capacity [16, 17] and improving soil fertility by reducing the acidity and increasing the availability of nutrients, thus, can be one of the best practices to overcome any biotic stress in soil and to increase the crop productivity, increase in the cation exchange capacity (CEC) which enhances the retention of basic nutrients [18, 19]. Seed weight per plant significantly increased by biochar and chemical fertilizer application, also the interaction between biochar, chemical fertilizer and water requirements significantly affected the seed yield and biological yield of *Nigella sativa* [20]. Using organic fertilizers (vermicompost and biochar) or integration of them with inorganic fertilizers produced an almost similar yield of *Origanum vulgare* as compared to 100% chemical fertilizers [21]. Application of different biochar rates had a significant effect on fresh biomass, number of leaf per hill and essential oil yield of lemon grass [22]. Biochar increased availability and uptake of N and significantly improved peanut biomass and pod yield and adsorption of soil phytotoxins as well as increased plant nutrient concentration [23-26]. Biochar addition increased the contents soil moisture, potassium and available phosphorous, which all showed a significant positive relationship with above ground biomass of maize [27]. Cultivation of maize plant on sandy soils using biochar increased yield by 150% and 98% over the control at rates of 15 and 20 t/ ha, respectively [25]. Biochar treatment could increase contents of leaf vitamins and minerals in *Telfairia occidentalis* [28]. Hardwood-derived biochar significantly improved the assimilation and uptakes of basic, macro and micronutrients and improved biosynthesis of saturated and unsaturated fatty acid contents and antioxidative properties in soybean [29].

Good agricultural and collection practices for medicinal plants is only the first step in quality assurance, on which the safety and efficacy of medicinal products directly depend upon and will also play an important role in the protection of natural resources of medicinal plants for sustainable use [30]. Inorganic fertilization though enhances productivity of plants, but adversely affects the environment and human health. Therefore, an alternative approach of chemical fertilization is necessary for enhancing black seed production without causing substantial damage to the ecosystem.

Fertilization has an important role in growth, flowering, fruits, seeds and oil yields as well as biochemical constituents of plants. Organic manuring is a good approach in agriculture practice that manipulates organic wastes to provide plants with their nutritional requirements without having undesirable impacts on the human health and environment. Using organic manuring will reduce the hazards induced by excessive application of chemical fertilizers. This type of fertilization is particularly important in the newly reclaimed lands, where it improves the chemical and physical characteristics of the soil, since it enhances water holding capacity and aeration of the soil, modification of soil pH, availability and absorption of the elements by root system as well as sustains soil fertility of macro and micro nutrients to support high crop yield [31]. On the other hand, mineral fertilizers are still traditionally applied for medicinal and aromatic plants, because the other types of fertilization (organic or biofertilization) can't provide the plant with all requirements of nutrients for reaching optimum highly vegetative growth, yield and active components, especially in sandy soils. Organic manure either alone or in combination with NPK was positively affected N, P and K content of *Hyoscyamus muticus* plants [32]. Highest level of organic and mineral fertilizers increased significantly total carbohydrates content and substituting part of the mineral fertilizer with organic manure had beneficial effect on yield with high active substance of *Plantago arenaria* plant [33].

Mineral fertilizer (NPK) considerably increased both seed yield and volatile oil per plant of *Nigella sativa* and the same increases were resulted with cattle manure and foliar fertilizer [34]. Mohamed *et al*. [35] reported that N and P fertilizers significantly enhanced growth parameters, yield and yield components in *Nigella sativa* as well as N, P and K contents. Also, Özgüven and Şekeroğlu [36] recorded that nitrogen and phosphorus fertilizations enhanced plant height, branch number, seed yield, seed weight and seed fatty oil content of black cumin. Kandil *et al.* [37] found that increasing NPK rates increased the growth, herb yield and oil yield of *Ocimum basilicum*. Moreover, Khater and Abd El-Azim [38] revealed that the treatments at 25, 50 and 75% from the recommended NPK dose recorded a significant effect on plant height, number of branches/plant, fresh and dry weights/plant as well as total proteins content in *Plantago psyllium* plant in comparison with control.

Accordingly, the objective of the present study was to investigate the effects of soil amendments (cattle manure and biochar) with reduced doses of NPK fertilizers on the vegetative growth, seed yield, chemical constituents and fixed oil of *Nigella sativa* L. plants. Moreover, to assess the impact of soil amendments in reducing NPK fertilizers rates compared to the full dose of NPK fertilizers.

MATERIALS AND METHODS

A field experiment was carried out at the experimental farm of Ismailia Agricultural Research Station, Ismailia Governorate, Egypt, during the two consecutive seasons of 2017/2018 and 2018/2019. Black seed (*Nigella sativa* L.) seeds were obtained from Medicinal and Aromatic Plants Research Department, Horticulture Research Institute, ARC, Egypt. Seeds were sown in the field on 1st October of 2017 and 2018 in both seasons. The plot area was 12 m^2 (3x4 m) with 4 rows, 60 cm apart and 20 cm between plants within the row (80 plants /plot).

Soil Properties: The experimental soil was sandy and the physical and chemical properties were: 91% sand, 2% silt, 7% clay, 7.95 pH, 0.40% organic matter, 1.4% calcium carbonate, 18 mg/kg available N, 21 mg/kg available P and 60 mg/kg available K.

Biochar Source: Biochar is the solid product of burning biomass in pyrolysis was obtained from Soil, Water and Environment Research Institute, Agricultural Research Center (ARC), Egypt. It was applied at the common rate (1kg/m^2 soil) during soil preparation for sowing.

Experiment Design and Treatments: An experiment was conducted in a randomized complete blocks design with three replicates, using seven treatments as follows:

- 100% of the recommended dose of NPK fertilizers as a control.
- Cattle manure (30 m^3/fed.) + 75% of the recommended dose of NPK fertilizers.
- Cattle manure (30 m^3/fed.) + 50% of the recommended dose of NPK fertilizers.
- Cattle manure (30 m^3/fed.) alone.
- Biochar (1kg/m^2 soil) + 75% of the recommended dose of NPK fertilizers.
- Biochar (1kg/m^2 soil) + 50% of the recommended dose of NPK fertilizers.
- Biochar (1kg/m^2 soil) alone.

The recommended doses of NPK fertilizers per feddan according to the Ministry of Agriculture in Egypt were 400kg of ammonium sulfate (20.6% N), 300kg calcium super phosphate (15.5% P_2O_5) and 75kg potassium sulfate (48% K_2O). NPK fertilizers were added to the soil as follow: the full doses of calcium super phosphate, cattle manure (CM 30 m^3/fed.) and biochar (1kg/m^2 soil) were added with soil preparation for the sowing. While ammonium sulfate and potassium sulfate were divided into three equal doses and added in the roots area, the first dose was applied after month from sowing and the other two doses were monthly applied. All plants received normal agricultural practices whenever they are needed.

Data Recorded:

A. Vegetative Growth Parameters: On 20th February, during both seasons, the vegetative parameters were taken as follows: Plant height (cm), number of branches per plant, fresh and dry weights per herb (g/plant).

B. Seed Yield Components: Seeds were collected after harvesting the capsules at the end of each season (20th April), seed weight (g)/ plant was calculated, then seed yield/ feddan (kg) was calculated at by multiplying seed weight (g)/ plant with plant number/feddan (35000 plant).

Chemical Contents of Dry Herb: N, P, K and total carbohydrates percentages were determined in the dry herb according to A.O.A.C. [39]. Total protein percentage has been calculated by multiplying the determined nitrogen percentage by a conversion factor (6.25) according to A.O.A.C. [39].

Fixed Oil Extraction: The seeds were screened and ground, then the fixed oil was extracted from the seeds according to the method described by Ma *et al*. [40] by using Soxhlet apparatus with hexane solvent. The fixed oil in seed was estimated as:

Fixed oil percentage.

Fixed Oil Yield (ml)/ plant: Fixed oil yield (L)/ feddan has been calculated by multiplying the fixed oil yield (ml)/ plant by plant number/fed. (35000 plant).

Fixed Oil Components: Samples taken from the fixed oil obtained in the second season were analyzed using gas liquid chromatography (GLC) to determine their main components as follow:

Methylation of Fatty Acids: Gas-liquid chromatographic analysis of fatty acids was done on methyl ester, which was prepared and purified by the method of Kinsella [41] with some modifications. Methyl ester was prepared by refluxing the liberated fatty acids of *Nigella sativa* seeds with sulphuric acid (5 ml 1% v/v) in dried methanol for 30 minute at 55°C. The fatty acid methyl esters were extracted several times with ether. The cumulated ether extracts were dried with anhydrous sodium sulphate, filtrated and concentrated at 55°C.

GLC of Fatty Acid Methyl Esters: Separation of fatty acid methyl esters was carried out using a capillary column which contained 15% diethyl glycol succinate DEGS. The injector port and flame ionization detector were set at 240°C. The flow rate of carrier gas, nitrogen, was 10 ml/minute. The gas chromatograph (Perkin- Elemar model 8310) had a temperature program from 100 to 190°C with an interment rate of 7°C/minute. The initial and final time were identified according to their retention time compared to those of authentic samples.

Statistical Analysis: The experiment treatments were arranged at a randomized complete blocks design (RCBD), in three replicates and the collected data were computed and statistically analyzed with analysis of variance according to Mead *et al.* [42] using SPSS (Version 22) program and the differences between the means of treatments were tested by L.S.D test at 0.05 probability level.

RESULTS AND DISCUSSION

Vegetative Growth Parameters of Black Seed Plants: Data illustrated in Table (1) reveal that the application of soil amendments (cattle manure and biochar) enhanced the vegetative growth and reduced NPK fertilizers rates in both seasons. The treatments of cattle manure or biochar with 75% of recommended NPK dose, significantly increased plant height, branch number, fresh and dry weights of black seed plant during the two seasons in comparison with the other treatments without significant differences with control (100 % NPK dose). The lowest values of these parameters were recorded with the treatment of biochar alone followed by cattle manure only without NPK fertilizers during both seasons. All vegetative growth parameters were significantly increased by increasing the NPK rate in the two seasons. Generally, the full dose of NPK fertilizers gave higher values of vegetative growth than of 50% of NPK dose, whether with cattle manure or biochar, as well as better than either cattle manure or biochar individually, for both seasons. Similar results were obtained by Mohamed *et al*. [35] and Özgüven and Şekeroğlu [36] on Nigella sativa, Jemal and Abebe [22] on lemon grass and Khater and Abd El-Azim [38] on Plantago psyllium.

Improving the vegetative growth by using cattle manure and biochar may be due to their roles as soil amendments particularly in the newly reclaimed lands, by

Table 1: Effect of cattle manure, biochar and NPK fertilizers on vegetative growth parameters of *Nigella sativa* L. during 2017/2018 and 2018/2019 seasons.

	Plant height (cm)		Branch number / plant		Fresh weight/ herb (g)		Dry weight/ herb (g)	
Treatments	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% NPK (control)	39.33	43.00	13.33	13.33	18.75	23.27	4.50	5.72
CM +75% NPK	40.17	43.33	14.00	14.00	19.17	23.42	4.71	5.65
CM +50% NPK	36.67	38.00	12.67	12.33	17.21	21.03	4.00	4.73
CM alone	32.83	31.33	8.00	9.00	13.87	15.40	3.50	4.09
Biochar + 75% NPK	39.33	42.00	13.33	14.00	19.00	21.28	4.47	5.45
Biochar + 50% NPK	36.33	37.00	12.00	11.67	18.48	18.77	4.28	4.57
Biochar alone	31.00	31.17	7.00	8.33	11.64	13.73	3.29	3.64
L.S.D. at 0.05	2.19	3.12	1.41	1.14	1.40	1.70	0.26	0.48

Table 2: Effect of cattle manure, biochar and NPK fertilizers on seed and oil yield components of *Nigella sativa* L. during 2017/2018 and 2018/2019 seasons.

Treatments	Seed yield/ plant (g) 1st season	Seed yield/ plant (g) 2nd season	Seed yield/ fed. (kg) 1st season	Seed yield/ fed. (kg) 2nd season	Oil % 1st season	Oil % 2nd season	Oil yield/ plant (ml) 1st season	Oil yield/ plant (ml) 2nd season	Oil yield/ fed. (L) 1st season	Oil yield/ fed. (L) 2nd season
100% NPK (control)	17.06	17.32	597.10	606.32	21.80	27.25	3.72	4.72	130.16	165.25
CM +75% NPK	17.87	18.58	625.33	650.20	21.55	29.03	3.85	5.31	134.74	185.85
CM +50% NPK	14.02	14.77	490.82	517.07	21.10	29.00	2.92	4.28	102.27	149.96
CM alone	9.25	9.72	323.75	340.20	18.83	22.00	1.74	2.18	60.91	76.39
Biochar + 75% NPK	17.41	17.82	609.35	623.82	22.70	26.55	3.95	4.73	138.26	165.62
Biochar + 50% NPK	13.79	14.18	482.77	496.42	18.73	22.87	2.59	3.24	90.47	113.487
Biochar alone	8.87	9.18	310.57	321.42	17.78	23.00	1.58	2.11	55.29	73.93
L.S.D. at 0.05	0.43	0.44	15.13	15.44	0.92	1.37	0.17	0.24	5.68	8.28

improving the chemical and physical characteristics of the soil, enhancing water holding capacity, aeration of the soil and modification soil pH, improving availability and absorption of the elements by roots as well as sustains soil fertility of macro and micro nutrients to support high growth and crop yield as reported by Kandeel [31]; Lu *et al.* [16]; Nelissen *et al.* [17] and Rawat *et al.* [18].

Seed Yield Components: The results presented in Table (2) show that the combined treatment of cattle manure with 75% of NPK fertilizer dose, gave a significant increase of seed yield of plant and feddan during the two seasons, in comparison with control or the other treatments, given 17.87, 18.58g/ plant as well as 625.33 and 650.20kg/ fed. for the first and second seasons, respectively. Moreover, the application of biochar with 75% of NPK fertilizers dose recorded a significant increase of seed yield per plant and feddan in the second season and non-significant increase in the first one when compared with the treatment of full dose of NPK fertilizers. The lowest yield of seeds per plant and feddan were recorded with the treatment of biochar alone for both seasons, as it produced seed yield of 8.87 and 9.18g/ plant as well as 310.57 and 321.42kg/ fed. in 1st and 2nd seasons, respectively. Furthermore, seed yields of both plant and feddan were significantly increased when NPK rate was increased for both seasons. Generally, the full dose of NPK gave higher seed yield components than of the treatment 50% of NPK dose, whether with cattle manure or biochar, as well as higher than either cattle manure or biochar individually, with significant differences in the two seasons. These results are in line with those reported by Abbaspour *et al.* [20]; Mohamed *et al.* [35] and Özgüven and Şekeroğlu [36] on *Nigella sativa* plants.

Fixed Oil Percentage and Yields: Data obtained on the fixed oil percentage and yields of *Nigella sativa* seeds as affected by the different treatments are presented in Table (2). The results pointed out that plants treated with biochar with 75% of NPK dose gave the highest values of oil percentage (22.70%) and oil yields per plant (3.95ml) and per feddan (138 liter) in the first season. While using cattle manure with the same dose of NPK (75%) gave the highest values of oil percentage, oil yields per plant and per feddan in the second one, giving 29.03%, 5.31ml and 185.85L, respectively, with significant differences comparing to the other ones under study. On the other hand, the lowest oil percentage (17.78%) and yields (1.58ml/plant and 55.29L/fed.) were recorded by using biochar alone in the first season followed by cattle manure alone in the two seasons. Furthermore, the fixed oil percentage and yields were significantly increased with increasing NPK rate in both seasons, as the application of full NPK dose gave oil percentage and yields higher than 50% of NPK dose, whether with cattle manure or biochar, as well as it was better than either cattle manure or biochar individually, with significant differences between them on both seasons. These results were in concert with those obtained by Özgüven and Şekeroğlu [36] on *Nigella sativa*.

The increase in productivity of seed and fixed oil by using of cattle manure or biochar with NPK fertilizers may be due to the roles of cattle manure and biochar in amendment of the soil, which increased the availability and uptake of the nutrients, besides increasing the water holding capacity of the soil, which reflected on the metabolic processes activation and hence, increasing the vegetative growth as previously mentioned in this work and then reflected on seed and oil productivity.

Fixed Oil Composition: Data regarding the fixed oil components during the second season were recorded in Table (3). The main identified components were four unsaturated fatty acids: oleic acid (13.22-22.62%), linoleic acid (28.75-50.10%), linolenic acid (1.22-7.73%) and arachidic acid (1.27-18.51%) and three saturated fatty acids: myristic acid (0.75-21.12%), palmitic acid (0.99-6.61%) and stearic acid (7.17-13.72%). The obtained data revealed that the application of cattle manure with 50% of NPK dose gave the highest content of stearic acid

Table 3: Effect of cattle manure, biochar and NPK fertilizers on fixed oil components of *Nigella sativa* L. during 2018/2019 season

	Components								
Treatments	Myristic acid%	Palmitic acid%	Stearic acid%	Oleic acid%	Linoleic acid%	Linolenic acid%	Arachidic acid%	Identified components %	Unidentified components %
100% NPK (control)	7.16	6.61	9.10	13.22	28.75	1.88	4.87	76.46	23.54
CM + 75% NPK	21.12	--------	9.67	17.46	37.91	1.22	2.43	89.81	10.19
CM + 50% NPK	1.50	2.59	13.72	22.62	50.10	1.25	1.27	93.05	6.95
CM alone	0.75	0.99	9.58	16.47	35.87	2.26	5.42	71.34	28.66
Biochar + 75%NPK	1.63	1.97	13.44	21.51	45.93	2.86	6.64	93.98	6.02
Biochar + 50%NPK	--------	--------	7.17	13.78	30.18	7.73	18.51	77.37	22.63
Biochar alone	1.37	1.83	11.95	19.14	40.71	2.70	6.65	84.35	15.65

Table 4: Effect of cattle manure, biochar and NPK fertilizers on chemical constituents of *Nigella sativa* L. dry herb during 2017/2018 and 2018/2019 seasons.

	Nitrogen %		Phosphorus %		Potassium %		Total protein %		Total carbohydrates %	
Treatments	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
100% NPK (control)	1.59	1.65	0.246	0.249	2.33	2.36	9.94	10.31	15.97	16.17
CM +75% NPK	1.77	1.79	0.315	0.320	2.42	2.43	11.06	11.19	16.63	16.86
CM +50% NPK	1.47	1.52	0.256	0.261	2.06	2.07	9.19	9.50	15.25	15.43
CM alone	1.42	1.49	0.262	0.267	2.13	2.14	8.87	9.31	13.84	14.23
Biochar + 75% NPK	1.69	1.74	0.295	0.300	2.38	2.39	10.56	10.88	16.25	16.20
Biochar + 50% NPK	1.54	1.56	0.279	0.284	2.16	2.17	9.62	9.75	14.56	14.97
Biochar alone	1.39	1.47	0.236	0.241	1.95	1.96	8.69	9.19	13.02	13.77
L.S.D. at 0.05	0.02	0.03	0.006	0.005	0.02	0.03	0.14	0.17	0.08	0.06

(13.72%), oleic acid (22.62%) and linoleic acid (50.10%). While, applying cattle manure with 75% of NPK dose recorded the highest myristic acid content (21.12%). The highest content of palmitic acid (6.61%) was obtained by 100% of NPK dose (control). On the other side, biochar with 50% of NPK dose recorded the highest content of linolenic acid (7.73%). Generally, biochar and cattle manure treatments whether with NPK doses or individually recorded higher values of most fatty acids than control (full NPK dose). Accordingly, the abovementioned results showed that the composition of black seed oil was altered with the NPK rate and soil amendments application. Özgüven and Şekeroğlu [36] on Nigella sativa seeds and Waqas *et al*. [29] on soybean fatty acid contents recorded similar results.

Chemical Constituents of Black Seed Herb: From the obtained results in Table (4), it could be concluded that cattle manure with 75% of NPK dose resulted in a significant increase in N, P, K, total protein and total carbohydrates percentage in the herb comparing with 100% of NPK dose or all other treatments during both seasons. Moreover, the treatment of biochar with 75% of NPK dose gave a significant increase in these constituents compared to control or the other treatments and the lowest percentages of these constituents were obtained with biochar alone in the two seasons. Furthermore, these constituents were significantly increased with increasing NPK rate in both seasons. Generally, applying NPK at the full recommended dose gave higher N, K, total protein and total carbohydrates percentages than that of 50% of NPK dose, whether with cattle manure or biochar, as well as higher than either cattle manure or biochar individually. These results agree with those obtained by Mohamed *et al.* [35] on *Nigella sativa*, Naguib and Aziz [32] on *Hyoscyamus muticus*, Hendawy [33] on *Plantago arenaria*, Waqas *et al.* [29] on soybean and Akachukwu *et al.* [28] on *Telfairia occidentalis* plants.

The positive effect of cattle manure and biochar on accumulation of N, P, K, total protein and total carbohydrates in *Nigella sativa* L. herb may be due to the role of these amendments in improving the chemical and physical characteristics of the soil, since it enhances water holding capacity and modification of soil pH and then enhancement of availability and absorption of the elements by roots, therefore, more production and accumulation of plant products.

CONCLUSION

From the obtained results of this study, it could be concluded that the application of cattle manure at 30 m^3/fed. or biochar at 1kg/m^2 of soil reduced the inorganic fertilization doses of NPK. Both soil amendments when combined with 75% of recommended NPK dose significantly increased the vegetative growth parameters as well as seed yields, fixed oil percentage and oil yields of seeds, besides the content of N, P, K, total protein and total carbohydrates in the herb and reduced the amount of inorganic fertilizers (NPK), saving up to 25% as well as reducing environmental risks.

REFERENCES

1. Akram Khan, M., 1999. Chemical composition and medicinal properties of *Nigella sativa* Linn. Inflammopharmacology, 7(1): 15-35.
2. Gilani, A.H., Q. Jabeen and M. Asad Ullah Khan, 2004. A review of medicinal uses and pharmacological activities of *Nigella sativa*. Pak. J. Biol. Sci., 7(4): 441-451.
3. Ahmad, A., A. Husain, M. Mujeeb, S.A. Khan, A.K. Najmi, N.A. Siddique, Z.A. Damanhouri and F. Anwar, 2013. A review on therapeutic potential of *Nigella sativa*: A miracle herb. Asian Pac. J. Trop. Biomed., 3(5): 337-352.
4. Sabira Sultana, H.M. Asif, N. Akhtar, A. Iqbal, H. Nazar and R. Ur Rehman, 2015. *Nigella sativa*: Monograph. Journal of Pharmacognosy and Phytochemistry, 4(4): 103-106.
5. Al-Ali, A., A.A. Alkhawajah, M.A. Randhawa and N.A. Shaikh, 2008. Oral and intraperitoneal LD^{50} of thymoquinone, an active principle of *Nigella sativa*, in mice and rats. J. Ayub. Med. Coll. Abbottabad., 20(2): 25-27.
6. Ali, B.H. and G. Blunden, 2003. Pharmacological and toxicological properties of *Nigella sativa*. Phytother. Res., 17(4): 299-305.
7. El-Tahir, K.E. and D.M. Bakeet, 2006. The black seed *Nigella sativa* Linnaeus - a mine for multi cures: a plea for urgent clinical evaluation of its volatile oil. Review Article. J.T.U. Med. Sci., 1(1): 1-19.
8. Ramadan, M.F., 2007. Nutritional value, functional properties and nutraceutical applications of black cumin (*Nigella sativa* L.): an overview. Int. J. Food. Sci. Tech., 42(10): 1208-1218.
9. Morsi, N.M., 2000. Antimicrobial effect of crude extracts of *Nigella sativa* on multiple antibiotics-resistant bacteria. Acta Microbiol. Pol., 49(1): 63-74.
10. Yarnell, E. and K. Abascal, 2011. *Nigella sativa* holy herb of the Middle East. Altern. Compl. Therap., 17(2): 99-105.
11. Shackley, S., 2015. Capacity building for efficient utilization of biomass for bioenergy & food security in the GMS [TA7833-REG]: Output 4: Knowledge Product Series Biochar. Trowbridge, Wiltshire: Landell Mills Limited, pp: 37.
12. Lehmann, J. and S. Joseph, 2009. Biochar for environmental management: Science and Technology. 1st Edition by Earthscan in UK and USA, 448 pages. https://biochar-international.org/book/.
13. Jones, D.L., J. Rousk, G. Edwards-Jones, T.H. DeLuca and D.V. Murphy, 2012. Biochar-mediated changes in soil quality and plant growth in a three year field trial. Soil Biol. Biochem., 45: 113-124.
14. Chan, K.Y., L. Van Zwieten, I. Meszaros, A. Downie, S. Joseph and A. Journal, 2007. Agronomic values of green waste biochar as a soil amendment. Aust. J. Soil Res., 45(11): 629-634.
15. Major, J., M. Rondon, D. Molina, S.J. Riha and J. Lehmann, 2010. Maize yield and nutrition during 4 years after biochar application to a Colombian savanna oxisol. Plant and Soil, 333(1): 117-128.
16. Lu, S.G., F.F. Sun and Y.T. Zong, 2014. Effect of rice husk biochar and coal fly ash on some physical properties of expansive clayey soil (Vertisol). Catena, 114: 37-44.
17. Nelissen, V., G. Ruysschaert, D. Manka'Abusi, T. D'Hose, K. De Beuf, B. Al-Barri, W. Cornelis and P. Boeckx, 2015. Impact of a woody biochar on properties of a sandy loam soil and spring barley during a two-year field experiment. Eur. J. Agron., 62: 65-78.
18. Rawat, J., J. Saxena and P. Sanwal, 2019. Biochar: A sustainable approach for improving plant growth and soil properties. Reviewed chapter. At: http://dx.doi.org/10.5772/intechopen.82151.
19. Lehmann, J., J.P. da Silva, C. Steiner, T. Nehls, W. Zech and B. Glaser, 2003. Nutrient availability and leaching in an archaeological anthrosol and a ferralsol of the central amazon basin: fertilizer, manure and charcoal amendments. Plant and Soil, 249(2): 343-357.
20. Abbaspour, F., H.R. Asghari, P. Rezvani Moghaddam, H. Abbasdokht, J. Shabahang and A. Baig Babaei, 2017. Effects of biochar application on yield and yield components of black seed (*Nigella sativa* L.) under low irrigation conditions. Iranian J. Med. and Arom. Plants, 33(5): 837-852.

21. Nikou, S., B. Mirshekari, M.P. Moandoab, V. Rashidi and A.H. Ghorttapeh, 2019. Effects of organic, chemical and integrated nutrition systems on morpho-physiological traits of oregano (*Origanum vulgare* L.). Turk. J. Field Crops, 24(1): 70-80.
22. Jemal, K. and A. Abebe, 2016. Determination of biochar rate for improved production of lemmon grass (*Cymbopogon citratuc* L.). International journal of Advanced Biological and Biomedical Research, 4(2): 149-157.
23. Xu, C.Y., S. Hosseini-Bai, Y. Hao, R.C.N. Rachaputi, H. Wang, Z. Xu and H. Wallace, 2015. Effect of biochar amendment on yield and photosynthesis of peanut on two types of soils. Environ. Sci. Pollut. Res., 22: 6112-6125.
24. Rogovska, N., D.A. L aird, S.J. Rathke and D.L. Karlen, 2014. Biochar impact on midwestern mollisols and maize nutrient availability. Geoderma, 230/231: 340-347.
25. Uzoma, K.C., M. Inoue, H. Andry, H. Fujimaki, A. Zahoor and E. Nishihara, 2011. Effect of cow manure b iochar on maize productivity under sandy soil condition. Soil Use and Management, 27(2): 205-212.
26. Woldetsadik, D., P. Drechsel, B. Marschner, F. Itanna and H. Gebrekidan, 2017. Effect of biochar derived from faecal matter on yield and nutrient content of lettuce (*Lactuca sativa*) in two contrasting soils. Environ. Syst. Res., 6(2): 12.
27. Pandit, N.R., J. Mulder, S.E. Hale, V. Martinsen, H.P. Schmidt and G. Cornelissena, 2018. Biochar improves maize growth by alleviation of nutrient stress in a moderately acidic low-input Nepalese soil. Science of the Total Environment, 625: 1380-1389.
28. Akachukwu, D., M.A. Gbadegesin, P.C. Ojimelukwe and C.J. Atkinson, 2018. Biochar remediation improves the leaf mineral composition of *Telfairia occidentalis* grown on gas flared soil. Plants, 7(3): 57-66.
29. Waqas, M., Y. Kim, A. Khan, R. Shahzad, S. Asaf, M. Hamayun, S. Kang, M.A. Khan and I. Lee, 2017. Additive effects due to biochar and endophyte application enable soybean to enhance nutrient uptake and modulate nutritional parameters. J. Zhejiang Univ-Sci., B. (Biomed & Biotechnol), 18(2): 109-124.
30. WHO, World Health Organization. Guidelines on good agricultural and collection practices (GACP) for medicinal plants. Geneva, pp: 80.
31. Kandeel, A.M., 2003. Improving growth and active ingredients content of some medicinal plants through cultural practices. Review Article. Hort. Dep. Agric. Fac., Ain shams Univ., Egypt.
32. Naguib, N.Y. and E.E. Aziz, 2003. Yield and quality of *Hyoscyamus muticus* L. in relation to some fertilizer treatments. Egypt. J. Hort., 30(1/2): 1-17.
33. Hendawy, S.F., 2008. Comparative study of organic and mineral fertilization on *Plantago arenaria* plant. J. Appl. Sci. Res., 4(5): 500-506.
34. El-Kadi, B.M., G.T. Mousa, M.M. Gad and E.F. Ali, 2014. Effect of fertilization and plant density on seed and oil productions of *Nigella sativa* L. Assiut J. Agric. Sci., 45(2): 81-90.
35. Mohamed, S.A., R.A. Medani and E.R. Khafaga, 2000. Effect of nitrogen and phosphorus applications with or without micronutrients on black cumin (*Nigella sativa* L.) plants. Annals of Agric. Sci., Cairo, 3(Special issue): 1323-1338.
36. Özgüven, M. and N. Şekeroğlu, 2007. Agricultural practices for high yield and quality of black cumin (*Nigella sativa* L.) cultivated in Turkey. Acta Horticulturae, 756: 329-338.
37. Kandil, M.A.M., M.E. Khatab, S.S. Ahmed and E. Schnug, 2009. Herbal and essential oil yield of Genovese basil (*Ocimum basilicum* L.) grown with mineral and organic fertilizer sources in Egypt. Journal für Kulturpflanzen, 61(12): 443-449.
38. Khater, R.M. and W.M. Abd El-Azim, 2016. Effect of fertilization and humic acid treatments on seeds production of *Plantago psyllium* L. Egyptian J. Desert Res., 66(1): 95-114.
39. A.O.A.C., 2005. Association of Official Agricultural Chemists. Official methods of analysis. 18th Ed. Washington, D.C. USA.
40. Ma, C., C. Liu, A. F. Ahmed, Y. Niu and W. Kang, 2019. Optimum extraction technology for the seed oil of *Nigella sativa* L. Journal of Food Quality Volume 2019, Article ID 2592731.
41. Kinsella, J.E., 1966. Metabolic patterns of fatty acid of *Periplanteta americana* L. during its embryonic development. Can. J. Biochem., 44(2): 247-258.
42. Mead, R., R.N. Curnow and A.M. Hasted, 1993. "Statistical Methods in Agriculture and Experimental Biology" (2nd Ed.). Chapman & Hall/CRC, London, pp: 415.