Response of Two Purple basil (Ocimum basilicum L.) Cultivars Grown Under Field Conditions to Different Rates of NPK Foliar Fertilization

Ali Sabah Alhasan¹, Majeed Kadhem Abbas¹ and Dalal Tareq Al-Ameri¹
¹Department of Horticulture Science & Landscape Architecture, College of Agriculture, University of Al-Qadisiyah, Iraq.
Email: ali.alhasan@qu.edu.iq

Abstract
A field experiment has been used two purple cultivars of basil (Ocimum basilicum L.) during summer of 2019 at Al-Diwaniyah Station for Crop Cultivation and Development, Al-Diwaniyah city, Iraq, to study the effect of different rates of NPK on some vegetative characters and oil yield. The treatments comprised different rates (0, 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 g.L⁻¹) of NPK foliar fertilization which were applied after 50 DAP. Obtained results revealed that NPK had significant effect on all parameters tested in both cultivars. Red Rubin cultivar showed a linear relationship between all parameters tested and NPK rates. However, only one parameter; plant height, showed this relationship in Dark Opal cultivar at which, all other four parameters showed polynomial relationship. The maximum values for the parameters were obtained at the 3.0 g.L⁻¹ NPK treatment for Red Rubin cultivar and at 1.5-2.5 g.L⁻¹ NPK treatments in most parameters for Dark Opal. It can be concluded that NPK application had a pronounced beneficial effect on basil plant.

Keywords: purple basil, NPK fertilizer, plant biomass, essential oil.

1. Introduction
Basil (Ocimum basilicum L.) is one of the oldest spices and is one of herbaceous annual plants, which belongs to the family of Lamiaceae [1]. Basil is referred to as a royal herb or king of herb, which is utilized in cooking, cosmetics, medicinal purposes, and a fragrant. Basil is also grown in gardens and containers as an ornamental plant [2]. Basil is originated in the subtropical and tropical parts of Africa, Asia, and South America and cultivated in various regions of the world [3, 4]. Leaves and seeds are the useful parts of basil plants that are utilized for different medicinal purposes and biopesticides [5-8]. Basil species and varieties differ in the essential oil components, which are produced and stored in glandular trichomes of leaves [8, 9]. The essential oil of basil contains linalool, methyl chavicol, methyl cinnamate, and eugenol [1, 10]. These essential oil components are influenced by environmental conditions, genetic factors, and nutrient [11, 12]. Other cultivars of basil contain a high concentration of anthocyanin, which is the red-blue plant pigment and does different functions in plants. This plant pigment can protect plants from UV radiation and insects and also provides different health benefits to customers, including anticarcinogenic, anti-inflammatory, and neuroprotective influences [13].

In recent years, basil production in the world has significantly increased due to rising consumer demand. Thus, basil is cultivated in home gardens, commercial greenhouses, commercial fields, hydroponic facilities, and soilless substrates [14]. However, within each of these systems, nutrition deficiency can occur, especially under high soil pH [15]. Thus, applying macro and micro-nutrients is required for increasing plant growth and the production of essential oil. Plant requires nitrogen, phosphorus, and potassium in high amounts to create chlorophyll, protein, enzymes, amino acids, cell membranes, and nucleic acids. These plant nutrients also play important roles in photosynthesis, respiration, transpiration, and osmotic regulation in the basil plants and other aromatic plants [16, 17]. However, applying NPK fertilizer to basil plants grown in the alkalinity soil exhibited a low influence on the growth of plant because these macro-nutrients can be lost in different ways, like fixations. Therefore, foliar fertilization is an important agricultural practice to increase basil growth under high soil pH. Different studies exhibited that NPK foliar fertilization employed to different medicinal and aromatic plants increase the plant growth, seed yield, and improve the quality of essential oils. For instance, these were reported in the case of Nigella sativa [18], roselle [19], mangrove [20],
mint [22], basil [23] and Japanese mint [24]. Under different environmental conditions, several investigations have been carried out on the inorganic fertilizers influence on growth and essential oil of basil plants, and there is a lack of information on the influence of NPK foliar fertilization. Hence, the major usage of this field study is to check the impact of various rates of NPK (0, 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 g. L⁻¹) applied as foliar fertilizer on plant growth and essential oil of two purple basil cultivars.

2. Material and methods

A field experiment has been done through summer in 2019 at Al-Qadisiyah city of Al-Diwaniyah in Iraq (Al-Diwaniyah Station for Crop Cultivation and Development) to assess the application of various rates of NPK fertilizer on the production of essential oil and growth of two purple basil cultivars; Red Rubin and Dark Opal. Seeds of purple basil cultivars were purchased from USA (Johnny’s Selected Seeds company), and used in this study. Under greenhouse conditions, seeds have been planted in the plastic seedling trays, filling with peatmoss and watered with tap water. After 30 days after planting (DAP), seedlings have been moved to the field. Different rates (0, 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 g/L) of NPK foliar fertilization has been applied after 50 DAP. Samples of soil has been obtained from this experiment before growing seedling to assess some chemical and physical properties of the soil (Table 1).

Table 1. Soil chemical and physical characteristics of the study field.

| Texture of soil          | Silt clay loam |
|-------------------------|---------------|
| Organic matters (g.kg⁻¹)| 0.47          |
| EC (Electrical conductivity) (ds.m⁻¹)| 1.2          |
| pH                      | 8.1           |
| Clay (g.kg⁻¹)           | 108           |
| Silt (g.kg⁻¹)           | 512           |
| Sand (g.kg⁻¹)           | 303           |
| Availability of Nitrogen (mg.kg⁻¹)| 10           |
| Availability of Potassium (mg.kg⁻¹)| 204          |
| Availability of Phosphorus (mg.kg⁻¹)| 32           |

The field test has been designed in the completely randomized design (CRD) with 3 replicates. Each plot composed from 4 rows with 40 cm × 20 cm of plant spacing and 4 m length. Hand irrigation was applied to avoid drought stress during seedling growth, whereas the system of surface irrigation has been used until the end season. Otherwise, pesticides were applied during the growing season to control whitefly and aphids. Moreover, different weeds grown in the plot with the basil plant were controlled by hand.

At full flowers stage, various agronomic traits (height of plant, leaf number per plant, and vegetative biomass yield) have been measured, and the content of chlorophyll in the leaf has been assessed utilizing the SPAD-502 meter at 70 DAP. After harvesting plants, leaves and stalks were dried in the room for 3 days. The dry weight of vegetative biomass was measured, and plant samples have been employed to get the essential oils by the method of hydrodistillation (Clevenger). However, 50g of dried materials of leaf has been subjected to a three hours water-distillation by the apparatus of Clevenger. The extracted essential oil has been stored at 4 °C.

The inputs of field experiment were analyzed using the regression analysis, and the R software system was utilized to get the outputs of this study.

3. Results and discussion

It is clear from Figure 1 that the plant height responded significantly to NPK application in both cultivars. Plant height increased with increasing NPK rates. Plants grown under the highest NPK rate were the tallest. The increment in plant height as a result of NPK application reached 150% for red Rubin and 75% for Dark Opal from the control due to application of the highest NPK rate. This result agreed with the result of [25, 26] on sweet basil who found that enhancement of plant growth was due to the beneficial
Effect on NPK on plant growth. Also, agreed with the results of [27] and [28] on coriander and [19] on roselle. However, it should be noted that a linear relationship was observed between plant height and NPK rate for both cultivars.

![Figure 1. Effect of applying different NPK foliar fertilization rates on plant height of different purple basil cultivars.](image)

For the effect of NPK on leaves number (Figure 2), it was noted that as the rate of NPK increased, leaves number increased also in linear manner especially in Red Rubin cultivar. For Dark Opal, the relationship was different and it appears as a non-linear relation where the maximum leaves number was reached at 1.5 g L\(^{-1}\) of NPK. The increase in leaf number may be as a result of the stimulation of growth due to NPK application. This result agreed with previous ones on coriander [27,28].

![Figure 2. Effect of applying different NPK foliar fertilization rates on leaf numbers per plant of different purple basil cultivars.](image)

Leaf SPAD readings, as an indicator of chlorophyll content, increased dramatically as NPK rate increased especially in Red Rubin cultivar which shown a linear relationship. (Fig. 3). SPAD readings start from about 29 for Dark Opal cultivar and 21 for
Red Rubin cultivar for non-fertilizer treatment and reached 42 and 56 for the both cultivars, respectively at the highest rate of NPK fertilizer. Regression analysis showed positive correlation between Leaf SPAD readings and NPK rate for Red Rubin cultivar. However, the relationship between NPK rates and Leaf SPAD readings was non-linear for Dark Opal cultivar. This result agreed with results of [29] Abd El-Aziz, 2007 who stated that NPK foliar application increased chlorophyll and carotenoids especially when the spray combined with BA. Also, [25] who found that NPK foliar application increased leaf SPAD in basil plants.

![Image](image_url)

**Figure 3.** Effect of applying different NPK foliar fertilization rates on leaf SPAD of different purple basil cultivars.

The highest vegetative biomass yield was observed in treatment of 3.0 g.L⁻¹ NPK rate which were 48 (g.m⁻²) for Red Rubin and 31.5(g.m²) for Dark Opal (Fig. 4). This simulative effect of NPK on vegetative biomass may be due to that increase in plant height, and number of leaves (Fig 2, 3). These results are in harmony with previous ones mentioned by [30] which refer to the positive effect of NPK on plant growth and reflect that on total plant dry weight. It is known that NPK availability and absorption lead to improve vegetative growth and in turn increase plant biomass. [31] and [32] stated that maximum plant mass production is associated with high rates of NPK applied. Also, [33] found that Nigella sativa L showed maximum vegetative growth using mineral NPK. Therefore, it was obvious from the above results that there is a significant effect of the chemical fertilizer (NPK) on the measured parameters which represent vegetative growth. It is known that Nitrogen, phosphorus and potassium are macronutrients which are involved in many plant events. Nitrogen is considered as the main yield-limiting nutrient. It involves in many physiological and biochemical processes as a component of nucleic acids, amino acids, enzymes and proteins, in addition to chlorophyll, and its involvement in cell wall structure. Phosphorus is required by plants due to its vital roles in nucleic acids, cell membranes in addition to involvement in energy transfer. Potassium is needed as an enzyme activator and cell water balance. These all roles lead to enhance plant growth and improve its performance [34,35].
Figure 4. Effect of applying different NPK foliar fertilization rates on vegetative biomass yield of different purple basil cultivars.

Essential oil yield (%) as influenced by different of NPK rates is presented in Figure 5. Significant differences were found among the treatments of different NPK rates. Moreover, the two cultivars were also differing in their content of essential oil. The present results reveal that percent oil yield started from about 0.28% and 0.42% for Red Rubin and Dark Opal cultivar, respectively and recorded highest percent of 1.58% at 3.0 g.L-1NPK rate and 1.43% at 3.0 g.L-1NPK rate for Red Rubin and Dark Opal cultivar, respectively. The results agreed with results of [36] who found the percent 0.07-1.37% in basil. There was a relationship between oil yield and plant growth, the more the growth resulted in more oil content. According to the present results, plants treated with higher level of NPK gave more vegetative yield and hence it leads to more essential oil yield. Nitrogen, phosphorous and potassium are known to influence the growth of medicinal plants and the synthesis of essential oils [1].

This trend of increase oil as NPK increased comes in agreement with results of [37] on ginger. It is known that N have an important role in protein and carbohydrate synthesis, P enhances the translocation and proper utilization of amino acids into protein synthesis and K plays a vital role in maintenance cell turgor pressure which all lead to increase growth and in turn plant metabolism and essential oil content as stated by on Japanese mint by [38]. However, in other study [39], found clear cut evidence of the presence of correlation between the rate of nutrients and the oil content in basil herb. They attributed this correlation either to stimulation of the vegetative growth by the nutrients or changes in the leaf oil gland number and the biosynthesis of monoterpenes. Moreover, the current result comes in agreement with those mentioned by [30].

Figure 5. Effect of applying different NPK foliar fertilization rates on essential oil of different purple basil cultivars.
Conclusion

The results obtained by this experiment revealed that plant height, leaves number, chlorophyll content, plant biomass in addition oil percent were significantly affected by the application of NPK fertilizer. In general, values of these parameters increased as the NPK level increase, especially in Red Rubin cultivar which might be considered as more responsive to NPK fertilizer than dark Opal.

References

[1] Onofrei V., Amina B., Magdalena J., Sofia L., Walid O., Marian B., Andrei L., Gabriel-C. T., & Teodor R. 2018. Ecological foliar fertilization eects on essential oil composition of sweet basil (Ocimum basilicum L.) cultivated in a field system. Scientia Horticulturae 239: 104-113.
[2] Dou H., Genhua N., Mengmeng G., & Joseph G. M. 2018. Responses of Sweet Basil to Daily Light Intervals in Photosynthesis, Morphology, Yield, and Nutritional Quality. HortScience 53(4):496–503.
[3] Alhasan A., Abbas M., Al-Ameri M., & Al-Ameri. 2020. Growth and yield response of basil (Ocimum basilicum L.) to different rates of urea fertilizer under field conditions. IOP Conference Series. Earth and Environmental Science 553: 012044.
[4] Ekren S., C. Jg’dem S., Enrah Ö., Yasein S., Kukul K., Emine B., & Hatice G. 2012. The effect of different irrigation water levels on yield and quality characteristics of purple basil (Ocimum basilicum L.). Agricultural Water Management 109: 155–161.
[5] Al-Ameri D., Hamza A., Hassan B., & Alhasan A. 2020. Effect of essential oil of colocynthis, Citrullus colocynthis and spearmint, Mentha picipata against the khapra beetle, Trogoderma granarium Everts (Coleoptera: Dermentidae). IOP Conference Series. Earth and Environmental Science 553: 012045.
[6] Alhasan A. 2012. Allelopathic effects of eucalyptus (Eucalyptus spp) on germination of genotype roselle (Hibiscus sabdariffa L.). Al-Qadisiyah Journal for Agriculture Science 2(2): 30 – 42.
[7] Abbas M & Ali A. 2012. Effect of the extract of Schanginia aegyptiaca on seed germination and seedling growth of roselle (Hibiscus sabdariffa L.). Asian Journal of Agricultural Research 6(2): 83 – 90.
[8] Bufalo J., Charles, Cantrell, Tessema Astatkie, Valteho D. Zhelazakov, Archana G., Carmen S., & Fernandes B. 2015. Organic versus conventional fertilization effects on sweet basil (Ocimum basilicum L.) growth in a greenhouse system. Industrial Crops and Products 74: 249–254.
[9] Sangwan N. S., A.H.A. Farooqi, F. Shabih & R.S. Sangwan. 2001. Regulation of essential oil production in plants. Plant Growth Regulation 34: 3–21
[10] Viña A., & Elizabeth M. 2003. Essential Oil Composition from Twelve Varieties of Basil (Ocimum spp) Grown in Colombia. Journal of Brazil Chemistry Society 14(5): 744-749.
[11] Daneshian A., Gurbuz B., Cosge B., & Ipek A. 2009. Chemical components of essential Oils from Basil (Ocimum basilicum L.) Grown at Different Nitrogen Levels. International Journal of Natural and Engineering Sciences 3(3): 1 – 10.
[12] Nayak K., Gautam K., Sharma K., Mishra K., Singh S., & Jha K. 2008. Growth, oil yield and ion partitioning in basil grown on sodic soils. Communications in Soil Science and Plant Analysis 39: 833-844.
[13] McCance K., Flanigan P., Quick M., & Niemeyer E. 2016. Influence of plant maturity on anthocyanin concentrations, phenolic composition, and antioxidant properties of 3 purple basil (Ocimum basilicum L.) cultivars. Journal of Food Composition and Analysis 53: 30 – 39.
[14] Kopsell D., Kopsell D., & Curran-Celentano J. 2005. Carotenoid and chlorophyll pigments in sweet basil grown in the field and greenhouse. HortScience 40(5): 1230 – 1233.
[15] Seagel F., & David B. 2017. Salt Exclusion and Mycorrhizal Symbiosis Increase Tolerance to NaCl and CaCl2 Salinity in ‘Siam Queen’ Basil. HortScience 52(2):278–287.
[16] Ahmed H. A. Al-Jobouri. (2020). Studying Some The Functional Properties of Tamarind Tamarindus indica L. Mucilage. Al-Qadisiyah Journal For Agriculture Sciences, 10(2), 304-307.
[17] Eleiwa F., Ibrahim A., & Mohamed M. 2012. Combined effect of NPK levels and foliar nutritional compounds on growth and yield parameters of potato plants (Solanum tuberosum L.). African Journal of Microbiology Research 6(24): 5100-5109.
[18] Khalid K., & Shedeed M. 2015. Effect of NPK and foliar nutrition on growth, yield and chemical constituents in Nigella sativa L. Journal of Material and Environmental Science 6(6): 1709-1714.
[19] Abbas M. K. & Ali S. A. 2011. Effect of foliar application of NPK on some growth characters of two cultivars of roselle (Hibiscus sabdariffa L.). American Journal of Plant Physiology 6(4):220-227.
[20] Osman H. E. & Atalla A. AboHassan. 2010. Effect of NPK Fertilization on Growth and Dry Matter Accumulation in Mangrove [Avicennia marina (Forssk) vierh] Grown in Western Saudi Arabia. JKAU: Met., Env. & Arid Land Agric. Sci., 21(2): 57-70.
[21] Salman M., Elsayed O., Mohamed S. H., & Osman A. 2019. Influence of foliar fertilization on the growth and yield of chia (Salvia hispanica) plant. Egyptian Pharmaceutical Journal. 18: 263–275
[22] Anwar M., Patra D., Chand S., Kumar A., Naqvi A., & Khanuja S., 2005. Effect of organic manure sand inorganic fertilizer on growth, herb and oil yield nutrient accumulation, and oil quality of French basil. Communication of Soil Science and Plant Analysis 36: 1737–1746.
[23] Alhasan A. 2020. Effect of different NPK nano-fertilizer rates on agronomic traits, essential oil, and seed yield of basil (Ocimum basilicum L. cv Dolly) grown under field conditions. Plant Archives 20(2): 2959 – 2962.

[24] Deepak B. R, Dr. M Padma, Dr. B Neeraja Prabhakaran & Dr. D Vijaya. 2019. Effect of NPK, zinc and sulphur levels on oil yield of Japanese mint (Mentha arvensis L.) var. Kosi Journal of Pharmacognosy and Phytochemistry. 8(4): 3412-3415

[25] Alhasan A., Al-Ameri D., Al-Baldawy M., Abbas M., & Hasan H. 2020. Influence of foliar application of NPK on growth, essential oil and seed yield of basil (Ocimum basilicum L. cv Dolly). Plant Archives 20(IAAAS-2020): 288 – 291.

[26] Sanaa S. Abbas, Alaa J. Subaih and Yahya A. Saleh. (2020). The Effects of Biological and Chemical Agents on the Management of Main Pests in Tomato Plant. Al-Qadisiyah Journal For Agriculture Sciences, 10(2), 325-334.

[27] Yousuf N., Brahma S., and Kamal M. 2014. Effect of nitrogen, phosphorus, potassium and sulphur on the growth and seed yield of coriander (Coriandrum sativum L.). Bangladesh Journal of Agricultural Research 39(2): 303-304.

[28] Kamrozzman, M., Ahmed S., & Ouddus R. 2016. Effect of fertilizer on coriander seed production. Bangladesh Journal of Agricultural Research 41(2): 345-352.

[29] Abd El-Aziz G. 2007. Stimulatory effect of NPK fertilizer and benzyl adenine on growth and chemical constituents of Codiaeum variegatum L. plant. American-Eurasian Journal of Agricultural and Environmental Sciences 2:711-719.

[30] Ghatas A., & Mohamed F. 2018. Influence of mineral, micro-nutrients and Lithovit in growth, oil productivity and volatile oil constituents of Cymopogen citruts L. plants. Middle East Journal of Agriculture 7(1): 162-174.

[31] Mohammed, M.A. (2020). Structural, Optical, Electrical and Gas Sensor Properties of ZrO2 Thin Films prepared by Sol-Gel Technique. Neuroquantology, 18(3), 22-27. doi: 10.14704/nq.2020.18.3.nq20146

[32] Ahmed S., Elsayed O., Mohamed H., Eman S., Amira O. 2019. Influence of foliar fertilization on the growth and yield of chia (Salvia hispanica) plant. Egyptian Pharmaceutical Journal 18:263–275.

[33] Abdelraouf E., El-Habbasha F., Taha H., & Refae M. 2013. Effect of irrigation water requirements and fertigation levels on growth, yield and water use efficiency in wheat. Middle-East Journal Science and Research 4:441–450.

[34] Tiessen H. 2008. Phosphorus in the global environment. In: White PJ, Hammond JP, editors. The ecophysiology of plant-phosphorus interactions. USA: Springer. pp. 1–8.

[35] Fageria K. 2009. The use of nutrients in crop plants. USA: CR Press

[36] Zheljazkov, V.D., Callahan, A., & Cantrell, C.L., 2008. Yield and oil composition of 38 Basil (Ocimum basilicum L.) accessions grown in Mississippi. Journal of Agricultural and Food Chemistry. 56:241–245.

[37] Pariari A., & Bhattacharya A. 2001. Yield and quality of ginger as influenced by different doses of N and P. Journal of International for Academician. 5(1):123–126.

[38] Patra D., Aowar M., Chand S., Kiran U., Rajoput K., Kumar S. 2002. Neem and Mentha spicata oil as nitrification inhibitor for optimum yield of Japanese mint (Mentha arvensis). Communication of Soil Science and Plant Analysis 33:451-460.

[39] El-Nagar H., Hassan A., Shaban H., & Mohamed E. 2015. Effect of organic and biofertilizers on growth, oil yield and chemical composition of the essential oil of Ocimum basilicum L. plants. Alexandria Journal of agricultural Research 60: 1–16.