

EFFECT OF APPLICATION TIME AND RATES OF FOLIAR FERTILIZATION ON THE VEGETATIVE GROWTH, FLOWERING AND SOME MINERAL CONTENTS OF *Brassica nigra* L. Koch

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ABSTRACT

This study was carried out during two successive seasons of 2005/2006 and 2006/2007 to study the effect of application time and rate of foliar fertilization with complete fertilizer solution containing 20%, 20%, 20% of N, P and K at the rates of 2, 4 and 6 g L⁻¹ on vegetative growth, flowering and some chemical constituents of *Brassica nigra* [L.] Koch. All foliar fertilization treatments exhibited remarkable significant effects on plant height, number of branches, number of leaves, number of inflorescences, herbage fresh and dry weights, inflorescence fresh and dry weights and seed yield dry weight when compared with untreated plants.

Chemical analysis showed that the highest content of N, P, K were obtained, in general, from plants sprayed with 4 g L⁻¹ of the complete fertilizer solution sprayed either every 10 or 20 days.

Concerning the micronutrient contents (Fe, Mn, and Zn) in leaves of *B. nigra* [L.] Koch, foliar fertilization resulted in significant effect on Fe, Mn and Zn in leaves when compared with untreated plants. The highest content of chlorophyll a and b in leaves was found in plants sprayed with complete fertilizer solution at the rate of 4 g L⁻¹.

Generally, the maximum increase in the studied parameters resulted from spraying plants with 4 g L⁻¹ of complete fertilizer every either 10 or 20 days. So, economically the results recommend spraying mustard plants with 4g L⁻¹ complete fertilizer 20-20-20 every 20 days.

Keywords: *Brassica nigra* [L.] Koch – foliar fertilization – N P K fertilization – Mustard.

INTRODUCTION

Brassica nigra (black mustard) is an annual plant cultivated for its seeds, which are commonly used as a spice. The plant is believed to be native to the southern Mediterranean region of Europe, and has been cultivated for thousands of years. The spice is generally made from ground seeds of the plant, with the seed coats removed. The small (1 mm) seeds are hard and vary in color from dark brown to black. They are flavorful, although they have almost no aroma. The seeds are commonly used in Indian cuisine, for example in curry. The seeds have a significant amount of fatty oil. This oil is used often as cooking oil in India (Anonymous, 2009).

Brassica nigra [L.] Koch "black mustard" is a member of Brassicaceae family. It is an annual herbaceous plant, widely cultivated in China and India. Mustard is a cool weather crop and grows up to 3 meter. It likes a moist and a sunny location. Seed pods harvested in late summer before they become dry, and allow the seeds to ripen in the pods at shade (Brickell and Zuk. 1996)

Black mustard is a common spice used in the entire world. All parts of the mustard plant are edible, including leaves, flowers and seeds. Mustard works well with all types of meats, poultry and seafood. Seeds and leaves used as salad greens (James, 2002).

Nowadays, soil alkalinity and pollution are considered as the most important problems in Benghazi Libya. Moreover, using of mineral fertilizers in agriculture production have resulted in serious problem in the soil and contaminate the underground water.

Foliar fertilization is frequently applied in horticultural practice. This fertilization is recommended in an integrated plant production because it is environmental friendly and gives the possibility to achieve high productivity and good quality yields. This application is successful for all crops, since soil surface application of most fertilizers has little effect on rapid improvement of plant nutrition (Weinbaum et al., 2002). Foliar fertilization should be applied under conditions of decreased nutrient availability in soil (pH), dry topsoil, and decreased root activity (Wójcik 2004).

MATERIALS AND METHODS

This study was conducted during two successive seasons of 2005/2006 and 2006/2007 at the Experimental Farm, Faculty of Agriculture, University of Benghazi Libya. The soil of the experimental field was clay in texture, the physical and chemical analysis of the soil are shown in Table 1.

Table (1): physical and chemical properties of the experimental soil

	Characters	Value	
		Season 2005	Season 2006
Physical properties	Sand %	18.57	18.42
	Silt %	39.36	32.50
	Clay %	42.07	49.07
	Texture grade	Clay	Clay
Chemical properties	pH	8.30	8.40
	Ec (dsm ⁻¹ at 25° C)	0.66	0.71
	Total soluble N(ppm)	15.2	16.00
	Available P (ppm)	11	19.00
	Available K (ppm)	37.5	39.10

Seeds of *Brassica nigra* [L.] Koch were obtained from Ministry of Agriculture, Egypt and sown at 50 x 50 cm apart in plots on 16th and 20th of November in both seasons, respectively. Treatments were arranged in a complete randomized block design (CRBD) with four replicates, each replicate contained 20 plants.

A formula of nitrogen, phosphorus and potassium was prepared from ammonium sulphate, urea, potassium nitrate, potassium dihydrogen phosphate and potassium sulphate. Calcium and magnesium of the Glenhazel basic formula no. 2 as 180 and 50 ppm from calcium sulphate and magnesium sulphate, respectively, were used for all the treatments. Besides trace basic elements solution A at the rates of 4.0, 0.5, 0.5, 0.5 and 0.05 ppm from Fe, B, Mn, Zn and Cu were used from ferrous sulphate, boric acid,

manganese sulphate, zinc sulphate and copper sulphate, respectively (Bentley, 1982). The final formula was 20% N: 20% P_2O_5 : 20% K_2O . Plants were sprayed with aqueous solution of 2%, 4% and 6% for every plant until the solution was run-off every either 10 or 20 days beginning from 20th of December during both seasons.

The experiments included 7 treatments:

- 1- control plants which sprayed with water
- 2- plants sprayed three times with 2% aqueous solution of fertilizers every 10 days
- 3- plants sprayed three times with 4% aqueous solution of fertilizers every 10 days
- 4- plants sprayed three times with 6% aqueous solution of fertilizers every 10 days
- 5- plants sprayed three times with 2% aqueous solution of fertilizers every 20 days
- 6- plants sprayed three times with 4% aqueous solution of fertilizers every 20 days
- 7- plants sprayed three times with 6% aqueous solution of fertilizers every 20 days

All normal cultural practices were done. Data for vegetative growth and chemical analyses were recorded at the end of both seasons in 15th April. The treatments were repeated in both seasons. Data were recorded for the following parameters:

1- Growth parameters:

- Plant height (cms).
- Number of branches / plant
- Number of leaves / plant
- Number of inflorescence / plant
- Herbage fresh weight / plant (g)
- Herbage dry weight / plant (g).
- Inflorescence fresh weight / plant (g).
- Inflorescence dry weight / plant (g).
- Seed yield dry weight / plant (g).

2- Chemical analysis:

- Plant Nitrogen, phosphorus, potassium, Mg, Fe and Zn content were determined according to the methods described by Sadasivam and Manickan (1991).
- Leaf Chlorophyll a and b content were determined according to Sadasivam and Manickan (1991).

Data were statistically analyzed

All data were subjected to the statistical analysis using ANOVA, Tukey's test with the SPSS program and the means were separated according to the methods mentioned by Gomez and Gomez (1984).

Results and Discussion

1- Vegetative growth

Generally, results presented in Table 2 show that the effect of spraying *Brassica nigra* (black mustard) plants with any concentration at any

interval of application showed significant increase of the studied vegetative characters.

It is obvious from Table (2) that spraying black mustard plants with aqueous solution of 4g L⁻¹ three times every 10 days significantly increased plant height as compared to other treatments.

The results presented in Table (2) clearly show that spraying plants with aqueous solution containing 2g L⁻¹ three times every 20 days significantly increased number of branches and leaves per plant compared to other application treatments in the first and second seasons. However, spraying plants with aqueous solution containing 6 g L⁻¹ three times every 10 days significantly increased number of inflorescences produced by plant.

Generally, similar increases in vegetative or flowering characters as a result of foliar fertilization treatments have been reported by Kolota and Osinska (2001) on cabbage and cucumber, Shaaban et al. (2004) on tomato plants and Salem and Awad (2005) on *Coriandrum sativum* L.

Agina et al. (2005) on some ornamental plants and El-Sallami and Gad (2005) on *Aster novi belgii* found that foliar fertilization increased number of branches and leaves/plant.

Table (2) effect of foliar nutrition and time of application on vegetative growth of *Brassica nigra* during 2005 and 2006 seasons

Treatment	Growth of Brassica nigra during 2005 and 2006 seasons							
	plant height (cm)		Number of branches		Number of leaves/plant		No. of florescence/plant	
	Seasons							
	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd
Control	189 c	205 c	8.00 c	8.50 c	74.0 d	77.33 d	13.00 c	15.33 c
2 g/L/10 days	275 a	285 a	12.50 b	11.20 b	18.66 bc	125.0 c	36.66 b	42.33 b
4 g/L/10 days	284 a	305 a	15.25 a	16.85 a	126.00 bc	135.33 b	45.66 a	49.33 b
6 g/L/10 days	259 b	255 b	15.25 a	15.45 a	116.10 bc	122.66 bc	75.00 a	83.66 a
2 g/L/20 days	245 b	230 b	17.00 a	17.35 a	175.33 a	181.66 a	50.66 b	60.00 ab
4 g/L/20 days	265 ab	240 b	15.00 a	15.25 a	148.33 b	170.00 a	59.66 b	63.33 ab
6 g/L/20 days	254 b	230 b	13.50 a	13.40 a	166.33 ab	153.33 b	54.00 b	57.66 b

From data in Table (3), it was noticed that spraying plants with 2 g L⁻¹ three times every 20 days had a pronounced effects on herb fresh and dry weights of *Brassica nigra* plants during both seasons. Meanwhile, plants subjected to spraying with the medium concentration of 4 g L⁻¹ for three times at the intervals of 20 days produced the heaviest fresh and dry weights of inflorescences during the first and second seasons. Besides, production of dry seeds per plant by this treatment was higher.

On the other hand, control plants which sprayed with water resulted in the lowest values for herb fresh and dry weights, fresh and dry weights of inflorescences per plant as well as dry seeds produced from every plant.

The increase in vegetative growth as affected by the application of fertilizers may be due to that nitrogen led to synthesis or formation of amino acids which considered a basics for protein formation, which participates in cell enlargement and cell division (Taiz and Zeiger 2008). The previous results are in conformity with those of El-Gendy et al., (2001) on *Ocimum basilicum* and Moghazy and Abd El-Fattah (2005) on *Hibiscus sabdiffera* L.

Trejo-Téllez et al., (2007) concluded that foliar fertilizers containing N, P, K and micronutrients are commonly recommended as the most efficient method of increasing yield and improve quality of crop products.

Table (3) Effect of time application and foliar nutrition on herbage and inflorescence of *Brassica nigra* during 2005 and 2006 seasons

Treatment	Herb fresh weight (g)		Herb dry weight (g)		Inflorescence fresh weight		Inflorescence dry weight		seed yield dry weight /plant	
	Seasons									
	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd
Control	803.28 d	621.10 d	81.32 d	94.80 c	109.80 c	119.10 c	22.30 d	30.90 c	10.15 c	11.44 c
2g/L/10 days	715.52 b	730.25 a	158.57 a	158.30 a	193.52 b	203.30 b	44.24 c	48.40 b	19.42 b	24.58 a
4g/L/10 days	629.96 c	638.25 c	199.92 b	119.92 b	279.29 a	295.28 a	61.56 a	66.75 b	21.75 a	27.58 a
6g/L/10 days	621.75 c	632.50 c	97.61 bc	110.40 b	231.85 b	244.33 b	55.17 b	62.35 b	19.15 a	22.70 a
2g/L/20 days	725.06 a	740.28 a	138.70 a	144.50 a	206.75 b	218.10 b	62.36 ab	74.70 b	17.67 a	19.15 b
4g/L/20 days	700.79 b	712.65 ab	129.06 ab	139.90 a	302.87 a	320.50 a	75.45 a	106.80 a	24.42 a	28.15 a
6g/L/20 days	633.61 c	641.86 c	92.20 c	99.30 b	179.55 b	184.88 b	50.25 bc	49.25 b	15.62 a	18.10 b

2- Mineral contents of leaves

Nitrogen and potassium percentages of *Brassica nigra* leaves significantly increased with foliar nutrition rates, compared with those of the control in both growing season (Table 4). The highest value of leaves N, P and K were obtained from the application of 4 g L⁻¹ three times every 10 days and 4 g L⁻¹ three times every 20 days. The difference between these two application rates was not significant. Meanwhile, the leaves content of N, P and K were increased by increasing concentrations of foliar application up to 4 g L⁻¹. Data presented in (Table 5) reveal that micronutrients (Fe, Mn and Zn) content of the leaves of *Brassica* were significant with the different concentrations of fertilization treatment compared to control during both season.

Table (4) Macronutrients and Micronutrients concentration in leaves of *Brassica nigra* as affected by foliar nutrition during the winter seasons of 2005/2006 and 2006/2007 under clay soils condition

Treatment	N %		P %		K %	
	Seasons					
	1 st	2 nd	1 st	2 nd	1 st	2 nd
Control	2.01 c	2.11 c	0.40 c	0.49 c	0.81 c	0.89 c
2 g/L/10 days	2.40 b	2.49 b	0.57 b	0.67 b	1.15 b	1.06 c
4 g/L/10 days	3.15 a	3.00 a	0.77 a	0.61 b	1.28 a	1.41 a
6 g/L/10 days	2.55 b	2.70 b	0.62 b	0.70 b	1.07 b	1.16 b
2 g/L/20 days	2.50 b	2.68 b	0.70 b	0.85 a	1.25 a	1.12 b
4 g/L/20 days	3.15 a	3.37 a	0.83 a	0.96 a	1.33 a	1.44 a
6 g/L/20 days	2.47 b	2.55 b	0.69 b	0.77b	1.28 a	1.19 b

The most favorable concentration of Fe, Mn and Zn spraying in this respect were obtained by 6 g L⁻¹ three times every 20 days in the first season, but in the second season it was respect was 4 g L⁻¹ three times every 10 days. Foliar application is particularly useful under conditions when nutrient uptake from the soil is unavailable. This is often the case for the micronutrients such

as Fe, Zn and Mn. These nutrients are frequently retained or fixed by soil particles and for this reason are scarcely available to plant roots. Foliar application in the form of either inorganic salts or chelates is a valuable tool in combating nutrient deficiencies. As micronutrients are only required in small quantities, foliar spray applied once or twice and correctly timed, is adequate to meet the demand of the crop.

Results of Kolota and Osinska (2001) showed that the optimum foliar fertilization in concentrations of 1.5% and 3.0% four times during the intensive period of plant growth at two week intervals increased the marketable yield in cabbage and cucumber.

Fritz (1978) added that repeated application of small units of foliar fertilizers are stimulating plant metabolism and increased nutrient uptake. Total production as well as its quality is improved by foliar fertilization. The stimulating effect of foliar fertilization depends on sound basic fertilizer rates including the supply of trace elements either via root or via the foliage.

Shaaban et al. (2004) found that when tomato plants received NPK as foliar fertilization, concentrations of K, Ca and Mg in leaves as well as in the fruits were increased.

Bowman and Paul (1992) showed comparable N absorption rates by *Lolium* leaves as a result of foliar applications of urea, ammonium and nitrate. On the other hand, Wojcik (2004) reviewed that a higher absorption rate of N by the leaves treated with urea than those treated with nitrate or ammonium. Also Furuya and Umemiya (2002) reported that peach (*Prunus persica* Batsch) leaf treatment with urea appeared to be more effective in increasing N content than other inorganic forms of N. Studies of Reickenberg and Pritts (1996) concluded that absorption of urea by the leaves of most crops is greater and faster than that of inorganic N forms. This phenomenon is related to the fact that the cuticular membrane is 10 to 20 times more permeable to urea than to inorganic ions (Kolattukudy, 1996). It is believed that urea molecules facilitate the penetration of other leaf applied nutrients (Weinbaum, 1988). Therefore, many foliar fertilizers contain some addition of urea to improve the efficiency of absorption of mineral nutrients. Wójcik, (2004) showed that the rates of P uptake was higher with K_2HPO_4 than any source.

Knoche et al. (1994) states that there is a strong correlation between nutrient concentration on a leaf surface and the rate of its uptake by the epidermal cells. However, elevated nutrient concentrations may cause some leaf troubles leading to the reduction in nutrient absorption. According to Marschner (1995) such absorption by these leaves is limited by the destruction of ectodesmata structures. Maximum concentrations of particular mineral nutrients in a spray solution depend on plant species, plant development stage, nutritional plant status, plant healthiness, and weather conditions.

Addition of foliar fertilizers containing N, P and K to different medicinal and aromatic plants has become popular in recent years for their favorable effect on growth and flowering. Altland *et al* (2002) reported that supplying vinca, marigold and salvia plants with Osmocote NPK 14:14:14 or 17:17:17 produced the best in large and more attractive plants.

Foliar application is particularly useful under some conditions where nutrients uptake from the soil is restricted. This is often the case for the micronutrients such as Fe, Zn, Mn and Cu which plays a very important role in vital processes of plants (Mortvedt *et al.*, 1991).

Foliar application of micronutrients proved to be effective on vegetative growth parameters and flower yield of *Tagetes patula* (Omer, 1992), *Zinnia elegans* (Manoly, 2001), and *Pelargonium hortorum* (Frost *et al.*, 2003), and *Coriandrum sativum* (Salem and Awad, 2005).

The objective of this study was to investigate the effect of foliar fertilization with a complete fertilizer containing N, P and K at a formula of 20: 20: 20 at a rates of 2 or 4 or 6 g L⁻¹ every 10 or 20 days on the vegetative characters and yield of *Brassica nigra* [L.] Koch.

Table (5) Effect of treatments on Fe, Mn and Zn (ppm) in leaves of *Brassica nigra* during the two seasons of 2005 and 2006

Treatment	Fe		Mn		Zn (ppm)	
			season			
	1 st	2 nd	1 st	2 nd	1 st	2 nd
Control	0.150 c	0.161 b	0.148 c	0.155 c	25.80 c	30.14 c
2 g/L/10 days	0.174 b	0.192 a	0.173 b	0.191 b	41.35 b	38.28 c
4 g/L/10 days	0.199 a	0.211 a	0.96 a	0.230 a	54.10 a	61.20 a
6 g/L/10 days	0.169 b	0.182 a	0.195 a	0.184 b	44.95 b	46.95 b
2 g/L/20 days	0.180 ab	0.185 a	0.177 b	0.192 b	57.25 a	61.25 a
4 g/L/20 days	0.208 a	0.227 a	0.229 a	0.201 b	66.17 a	66.04 a
6 g/L/20 days	0.177 b	0.186 a	0.182 a	0.191 b	47.63 b	50.15 a

Table (6) Effect of treatments on Chlorophyll content (mg/g fresh weight) in leaves of *Brassica nigra* during the two seasons of 2005 and 2006

Treatment	Chlorophyll a (mg/g fresh weight)		Chlorophyll b (mg/g fresh weight)	
	1 st season	2 nd season	1 st season	2 nd season
Control	0.44 c	0.59 c	0.55 c	0.77 v
2 g/L/10 days	0.84 b	0.98 b	0.75 b	0.97 b
4 g/L/10 days	1.18 a	1.43 a	1.02 a	1.26a
6 g/L/10 days	0.94 a	1.10 b	0.85 b	0.99 b
2 g/L/20 days	0.81b	0.93 b	0.74 b	1.02 b
4 g/L/20 days	0.99 a	1.29 a	0.93 a	1.37 a
6 g/L/20 days	0.81b	1.05 b	0.8 b	1.11 b

Wójcik, (2004) also showed that foliar application of nutrient solutions causes salt concentrations on a leaf surface to be higher than those of soil solutions. Increased tolerance of the epidermis to high spray solution concentrations is caused by the presence of the wax layer and the cuticular membrane. Since most mineral nutrients passively diffuse into the epidermal cells, absorption depends on their concentrations on the leaf surface. Knoche *et al.* (1994) states that there is a strong correlation between nutrient concentration on a leaf surface and the rate of its uptake by the epidermal cells. However, elevated nutrient concentrations may cause some leaf troubles leading to the reduction in nutrient absorption. According to Marschner (1995) such absorption by these leaves is limited by the

destruction of ectodesmata structures. Maximum concentrations of particular mineral nutrients in a spray solution depend on plant species, plant development stage, nutritional plant status, plant healthiness, and weather conditions.

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تأثير مواعيد ومعدلات التسميد بالررش على النمو الخضري والإزهار ومحتوي العناصر في نبات الخردل

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قسم البساتين كلية الزراعة جامعة قناة السويس ١٥٢٢ ٤

أجريت هذه الدراسة في موسمي ٢٠٠٥-٢٠٠٦ و ٢٠٠٦-٢٠٠٧ لدراسة تأثير مواعيد ومعدلات التسميد بالررش بسماد كامل يحتوي على ٢٠% ن و ٢٠% فوسفات و ٢٠% بوريا مع العناصر الصغرى بمعدل ٢ و ٤ و ٦ جم ل^{-١} على النمو الخضري والزهرى والمحتوي الكيماوي لنباتات الخردل. أظهرت جميع معاملات التسميد بالررش تأثيرات معنوية على ارتفاع النبات وعدد الأفرع وعدد الأوراق وعدد النورات والوزن الطازج والجاف للشعب والوزن الطازج والجاف للنورات ومحصول البذور الجاف عن معاملة المقارنة.

أظهر التحليل الكيماوي أن أعلى محتوى لعناصر النيتروجين والفوسفور والبوتاسيوم كان، بصفة عامة، في النباتات التي تم رشها بالمحلول السمادي الكامل بتركيز ٤ جم ل^{-١} سواء كل ١٠ أو ٢٠ يوم. فيما يتعلق بمحتوي العناصر الدقيقة (الحديد والمنجنيز والزنك) في الأوراق فإن التسميد بالررش بالسماد الكامل أدى إلى زيادة معنوية في هذه العناصر عن معاملة المقارنة. كما كان أعلى محتوى للكلوروفيل أ أو ب في أوراق النباتات التي تم رشها بالسماد الكامل بمعدل ٤ جم ل^{-١}. بصفة عامة كانت أعلى القياسات في النباتات التي تم رشها بالمحلول السمادي الكامل بمعدل ٤ جم ل^{-١} سواء كل ١٠ أو ٢٠ يوم.

من الناحية الاقتصادية يوصي برش نباتات الخردل بمحلول سمادي كامل يحتوي ٢٠% ن و ٢٠% فوسفات و ٢٠% بوريا مع العناصر الصغرى بمعدل ٤ جم ل^{-١} كل ٢٠ يوم ولثلاث مرات.