Response of Some Faba Bean to Fertilizers Manufactured by Nanotechnology

Gomaa[1], M. A., E. E. Kandil[1], A. A. Abuo Zeid[2] and Bilkess M. A. Salim[1]
1- Plant production Department, The Faculty of Agriculture (Saba Basha), Alexandria University, Egypt.
2- Legumes Crops Department, Field Crops Institute, Agric. Res. Center (ARC), Egypt.

ABSTRACT: Two field experiments were conducted at the Nubaria Region, Egypt, during 2014/2015 and 2015/2016 growing seasons, in split plot design with three replications to investigate the response of some faba bean (*Vicia faba* L.) cultivars to mineral and nano-fertilizer applications and their interaction. The main plots were designated for foliar fertilizer with Nano fertilizer (NPK + micronutrients at vegetative stage, flowering stage, and seed filling stage, (vegetative + flowering, (vegetative + filling), (flowering + filling), (vegetative + flowing + filling) stages and Mineral fertilizer(NPK + Micronutrients), while subplot were allocated for three faba bean cultivars (Nubaria 1, Nubaria 2 and Nubaria 3).Significant increase was recorded on plant height (cm), pod length (cm), number of pods/plant, number of seeds/pod, 100- seed weight (g), grain, straw, and biological yield (tons/fed.) as well as harvest index % with fertilizing "Nubaria 2" cultivar by foliar nano- fertilizer at two or three stages (vegetative, flowering or filling) in both growing seasons. Nubaria 2 cultivar recorded the highest mean values for most characters studied.
Key words: Faba bean, nanofertilizer, cultivars, Nubaria, Region

INTRODUCTION

Faba bean (*Vicia faba*) is a winter growing food legume crop. There are three main reasons for growing this crop, 1. Cash crop through marketing dry seeds, 2. As a component of a rotation based on winter or summer cereals or cotton, and 3. Green manure where soils have been degraded in organic and physical fertility.

Nanotechnology can present solutions for increasing the value of agricultural products and reducing environmental problems. With using Nano-particles and Nano-powders, we can produce controlled or delayed releasing fertilizers. Nano-particles have high reactivity because of more specific surface area, more density of reactive areas, or increased reactivity of these areas on the particle surfaces. These features simplify the absorption of fertilizers and pesticides that produced in Nano scale (Anonymous, 2009). The use of nanofertilizers causes an increase in their efficiency, reduces soil toxicity, minimizes the potential negative effects associated with over dosage and reduces the frequency of application. Nanofertilizers mainly delay the release of the nutrients and extend the fertilizer effect period. Obviously, there is an opportunity for nanotechnology to have a significant influence on energy, the economy and the environment, by improving fertilizers. Hence, nanotechnology has a high potential for achieving sustainable agriculture, especially in developing countries (Naderi and Danesh-Shahraki, 2013). Furthermore, it is known that under nutrient limitation, crops secrete carbonaceous compounds into rhizosphere to enable biotic mineralization of N and/or P from soil organic matter and of P associated with soil inorganic colloids. Since, these root exudates can be considered as environmental

signals and be selected to prepare nanobiosensors that will be incorporated into novel Nano fertilizers (Al-Amin Sadek and Jayasuriya, 2007, Sultan *et al*., 2009).

Synthesized nanoparticle size ranged between 15 and 25 nm caused a significant improvement in shoot length (15.1 %), root length (4.2 %), root area (24.2 %), chlorophyll content (24.4 %), total soluble leaf protein (38.7 %), plant dry biomass (12.5 %), and enzyme activities of acid phosphatase (76.9 %), alkaline phosphatase (61.7 %), phytase (322.2 %), and dehydrogenase (21 %) were observed over control in 6 weeks old plants. The grain yield at crop maturity was improved by 37.7 % due to application of zinc nanofertilizer (Tarafdar *et al*., 2014).Maximum production of maize was recorded for normal irrigation as 7 day irrigation period and application of nano-Zn nutrient and nanobiofertilizer nutrient, while severe water stress without application of nano- Zn nutrient and nano-biofertilizer produced minimum production (Farnia and Omidi, 2015). Synthesized nano-practices SNPs, significantly, enhanced most of the growth and yield attributes NPK uptake and nutrient use efficiency of wheat. Silver nanoparticles in 25 mg/L concentration showed significant improvement in maximum leaf area and highest grain yield of wheat (Jhanzab *et al.,* 2015). The maximum plant height, Leaf fresh and dry weights, number of leaves per plant, and Chlorophyll content were gained with nano Zn chelated fertilizer treatment at rate of 100 mg on 600 liters water. Minimum plant height, leaf fresh and dry weight, number of leaves per plant, and chlorophyll content were obtained with control treatment (without fertilizer) (Vafa *et al.,* 2015).

The main objective of this study was to investigate the response of some faba bean (*Vicia faba* L.) cultivars to mineral and nano-fertilizer and their interaction.

MATERIALS AND METHODS

Two filed experiments were conducted at Nubaria Agriculture Research Station, Alexandria, Egypt, during the growing seasons of 2014/2015 and 2015/2016 to study the effect of foliar mineral and Nano fertilizers on growth and yield of three faba bean cultivars under Nubaria conditions.

Treatments were arranged in a split plot design with three replications during both growing seasons of study. Whereas, the main plots were designated for foliar fertilizer (Nano fertilizer at vegetative stage, Nano fertilizer at flowering stage, Nano fertilizer at seeds filling stage. Nano fertilizer at (vegetative + flowering) stages, Nano fertilizer at (vegetative + filling), Nano fertilizer at (flowering + seeds filling) stages, Nano fertilizer at (vegetative + flowing + seeds filling) stages, and Mineral (NPK + Micronutrients), while subplot was alocated for three faba bean cultivars (Nubaria 1, Nubaria 2 and Nubaria 3)

Nano-fertilizer (8% Total N, 5 % total P, 3% total K, 10% micronutrients, 5% Amino acids and 5% Seaweed extract) at rate of 1 cm^3/fed., and Mineral fertilizer (10 % N, 8% P, 5% K and 10% micronutrients) at rate of 0.5 litter/fed. used as foliar application.

A representative soil sample (0-30 cm) was taken before planting to determine some physical and nutritional properties of the experimental site **(Page** *et al.,* **1982)** and are presented in Table (1).

Table (1). Some soil properties of the experimental sites at Nubaria in 2014/2015 and 2015/2016 seasons

Mechanical analysis					
Season	**Clay (%)**	**Silt (%)**	**Sand (%)**	**Organic matter (%)**	**Texture class**
2014/2015	23.35	21.17	52.20	0.78	Sandy clay loam
2015/2016	22.63	23.61	53.38	0.81	

Chemical analysis												
	pH	**EC (dS/m)**	**HCO_3^- (%)**	**Ca CO_3 (%)**	**Available element (mg/kg)**							
					N	**P**	**K**	**Fe**	**B**	**Zn**	**Cu**	**Mn**
2014/2015	8.05	1.96	12.21	24.78	28.2	7.39	199.1	5.3	1.0	0.75	1.2	4.5
2015/2016	8.15	1.88	11.65	24.43	25.7	6.45	186.9	4.2	0.8	0.96	2.5	5.6

The preceeding crop in the experimental site was Egyptian clover (*Trifolium alexandrinum*, L.) in the first season and wheat (*Triticum aestivum*, L.) in the second season. Each sub plot consisted of 6 ridges, 3 meters in length, 60 cm width and 20 cm between hills.

The field experiment was ploughed twice then it was fertilized by phosphorus fertilizer before planting as single Calcium- Super Phosphate (15.5 % P_2O_5) at the rate of 200 kg/fed., and potassium sulphate (48 % K_2O), was added at rate of 50 kg/fed., before planting with soil preparation. Other agricultural practices for growing faba bean plants were applied as recommendation by Ministry of Agriculture.

Plant height (cm), total chlorophyll content (µg/cm^2), pod length (cm), number of pods/plant, number of seeds/pod, 100- seed weight (g), seed yield (kg/fed.), straw yield (kg/fed.), biological yield (kg/fed.), and harvest index (HI) were recorded in both seasons.

The chlorophyll pigments were measured by using digital reading of chlorophyll meter SPAD-502, where the value measured by the chlorophyll present in the plant leaf. The values are calculated based on the amount of light transmitted by the leaf in two wave lengths in which the absorbance of chlorophyll is different. Total chlorophyll was determined by digital apparatus (SPAD-502) according to Murillo-Amador *et al*. (2004) who suggested the following equation to transfer SPAD units to µg cm^{-2}.

$$Y = -2.79 + 0.88 * X \text{ ; Where, } X = \text{SPAD units}$$

All data collected were subjected to analysis of variance according to Gomez and Gomez (1984). All statistical analysis was performed using analysis of variance

technique by means of CoStat computer software package (CoStat, Ver. 6.311., 2005).

RESULTS AND DISCUSSION

Data in Tables (2, 3, 4, 5 and 6) indicates the effect of foliar application of Nano and mineral fertilization on some growth attributes such as plant height (cm) and chlorophyll content (µg/cm^2), yield and its component i.e. number of pods/plant, pod length (cm), number of seeds/pod, 100- seed weight (g), seed, straw, biological yields as well as harvest index (HI %) of three faba bean cultivars (Nubaria1, Nubaria 2, and Nubaria3) at different growth stages (vegetative, flowering and filling) and their interaction during 2014/2015 and 2015/2016 seasons.

The presented data in above mentioned Tables (2 to 6) show that foliar application of nano and mineral fertilization, significantly, affected these characters in both cropping seasons.

Table (2) reveal that, the highest mean values of plant height (cm) were recorded with foliar application of nanofertilization in both growth stages (vegetative and filling) followed by foliar nanofertilization at the three growth stages (vegetative, flowering and seeds filling) and at the two stages (vegetative and flowering) of faba bean as compared with other treatments but the highest concentration of chlorophyll (µg/cm^2) was achieved by nanofertilizer spraying at stages (flowering and seeds filling) as compared with other treatments. Meanwhile, the lowest ones were recorded with foliar nano- fertilization in vegetative stage of faba bean during two cropping seasons. These results are in agreement with who that obtained by Karimia *et al*. (2014), Tarafdar *et al*. (2014) and Vafa *et al.* (2015) stated maximum plant height and chlorophyll content gained from Nano fertilizer treatment and lowest value of plant height was related to the treatment without nanofertilizer (check treatment). Also, data in Table (2) indicate that, the faba bean cultivar “Nubaria 2” recorded the tallest plants height and highest value of chlorophyll concentration (µg/cm^2), while "Nubaria 1” cultivar gave the lowest ones in both growing seasons. On the other hand, there was no significant difference between “Nubaria1” and “Nubaria 3” cultivar on plant height in the first season and on chlorophyll content during the two seasons. These differences between field bean are mainly due to genetical differences make up between the three cultivars. These results are in harmony with those obtained by Nosser (2011), Hendawey and Younes (2013), and Kandil *et al.* (2015). In Table (2) foliar application of nanofertilization in both stages (vegetative and filling) with “Nubaria 2” cultivar gave the tallest plants in the first season and it recorded the highest concentration of chlorophyll (µg/cm^2) in both seasons. Meanwhile the lowest ones were achieved by foliar nano fertilization at vegetative stage of “Nubaria 1” cultivar.

Table (3) indicate that, the highest mean values of number of pods/plant and pod length (cm) were recorded with foliar application of nanofertilization in both stages (vegetative and seeds filling) followed by foliar nanofertilization at the three

stages (vegetative, flowering and filling) and at the two stages vegetative and flowering of faba bean as compared with other treatments. Meanwhile, the lowest ones were recorded with foliar nano- fertilization in vegetative stage of faba bean during the two cropping seasons. These results are in agreement with those obtained by Nosser (2011), and Nazanin *et al.* (2013). Again Table (3) clarify that the faba bean “Nubaria 2” cultivar gave the highest values for number of pods/plant and pod length (cm), on the other hand, "Nubaria 1” cultivar recorded the lowest ones in the two growing seasons. On the other side, there was no significant difference between “Nubaria1” and “Nubaria 3” cultivar on pod length in the first and second season. These results are in harmony with those obtained by Turk and Tawaha (2001), Khafaga *et al.* (2009), Osman *et al*. (2010). At last Table (3) reveal that, interact of foliar application of nanofertilization in both stages (vegetative and seeds filling) with “Nubaria 2” cultivar achieved the highest number of pods/plant and pod length (cm). Meanwhile the lowest ones were achieved by foliar nano fertilization at vegetative stage “Nubaria 1” cultivar.

Table (4) shows that, the highest mean values for number of seeds/pod (5.00 and 4.44 seeds) and 100- seed weight (95.82 and 98.33 g), respectively, were recorded with nanofertilization in stages (vegetative and seeds filling) as compared with other treatments. Meanwhile, the lowest ones were recorded for nano-fertilization in vegetative stage of faba bean during the two cropping seasons. These results are in agreement with those obtained by Nosser (2011), Nazanin *et al.* (2013). On the other hand, Table (4) reported that the faba bean “Nubaria 2” cultivar gave the highest values for number of seeds/pod (4.67 and 5.41 pods) and 100- seed weight (97.47 and 98.92 g), respectively, while, the lowest ones were achieved by planting "Nubaria 1” cultivar in the two growing seasons. On the other side, there was no significant difference between “Nubaria1” and “Nubaria 3” cultivar for seeds number/pod in the first and second seasons, and only in the second season for 100-seed weight (g). These results are in harmony with those obtained by Khafaga *et al.* (2009), and Osman *et al*. (2010). Interaction effect as shown in Table (4) show that, fertilizing “Nubaria 2” by nano- fertilizer as foliar spraying in (vegetative and filling) stages gave the highest number of seeds/pod but the heaviest 100- seed weight were recorded by fertilizing “Nubaria 2” by nano- fertilizer at (flowering and seeds filling) stages. Meanwhile fertilizing “Nubaria 1” by nano- fertilizer at (vegetative) stage achieved the lowest ones.

Table (5) show that, the highest mean values for seed yield (1693.93 and 1679.67 kg/fed) were recorded for nanofertilization in (vegetative and seeds filling) stages as compared with the other treatments but the heaviest straw yield (2479.82 and 2477.18 kg/fed.) were achieved by fertilizing faba bean plants by nano- fertilizer as foliar application at vegetative, flowering and seeds filling stages in both seasons. Meanwhile, the lowest seed yield (1000.78 and 992.55 kg/fed.) were recorded with nano- fertilization in vegetative stage of faba bean during the two cropping seasons, while the lowest straw yield was achieved by nano- fertilizer application at flowering stage. These findings are in agreement with those obtained by Nosser (2011), and Nazanin *et al.* (2013). Table (5) again, referred that the faba bean “Nubaria 2” cultivar

gave the highest values for number of seeds/pod (4.67 and 5.41 pods) and 100- seed weight (97.47 and 98.92 g), respectively, while, the lowest ones achieved by planting "Nubaria 1" cultivar in the two growing seasons. On the other side, there was no significant difference between "Nubaria1" and "Nubaria 3" cultivar on straw yield/fed., in the first and second seasons. These results are in harmony with those obtained by Khafaga *et al.* (2009), and Osman *et al*. (2010). Interaction effect as shown in Table (5) indicate that, fertilizing "Nubaria 2" by nano- fertilizer as foliar spray in (vegetative and seeds filling) stages gave the highest seed yield/fed., and straw yield/fed. Meanwhile fertilizing "Nubaria 1" by nano- fertilizer at (vegetative) stage achieved the lowest ones.

Table (6) reveal that, the highest mean values for biological yield (3807.59 and 3792.62 kg/fed) were recorded for nanofertilization in (vegetative, flowering and seeds filling) stages as compared with other treatments but the highest HI % (46.08 and 45.75) were achieved by fertilizing faba bean plants by nano- fertilizer as foliar application at vegetative, and seeds filling stages in both seasons, respectively. Meanwhile, the lowest biological yield (2613.79 and 2619.76 kg/fed.) and HI (37.82 and 37.20 %) were recorded for nano- fertilization in vegetative stage or mineral fertilizer of faba bean during the two cropping seasons, respectively. These findings are in agreement with those obtained by Nosser (2011), and Nazanin *et al.* (2013). Table (6) again, indicated that the faba bean "Nubaria 2" cultivar gave the highest values for biological yield (3650.83 and 3678.65 kg/fed.) respectively, in respect of HI %, there was significant difference among the three cultivars only in the second season. Meanwhile, the lowest ones were achieved by planting "Nubaria 1" cultivar in the two growing seasons. On the other side, there was no significant difference between "Nubaria1" and "Nubaria 3" cultivar on straw yield/fed., in the first and second seasons. These results are in agreement with those obtained by Khafaga *et al.* (2009), and Osman *et al*. (2010). Interaction effect between the two was significant, whereas fertilizing "Nubaria 2" cultivar by nano- fertilizer as foliar spray in (vegetative and filling) stages gave the highest biological yield/fed., and HI %. Meanwhile fertilizing "Nubaria 1" by nano- fertilizer at vegetative stage achieved the lowest ones (Table 6).

Table (2). Plant height (cm) and chlorophyll (µg/cm^2) of three faba bean cultivars as influenced by foliar mineral and nanofertilizer and their interaction during 2014/2015 and 2015/2016 seasons.

Treatments	Plant height (cm)				Chlorophyll			
	Season 2014/2015			Average (A)	Season 2014/2015			Average (A)
	B). Faba bean cultivars				B). Faba bean cultivars			
A). Foliar fertilizer	Nubaria 1	Nubaria 2	Nubaria 3		Nubaria 1	Nubaria 2	Nubaria 3	
Nano at vegetative	94.83	108.40	103.33	102.19d	24.67	39.57	26.31	30.18bc
Nano at flowering	103.57	112.00	101.83	105.80cd	23.76	34.32	25.22	27.77d
Nano at filling	108.60	103.73	103.33	105.22cd	27.66	37.10	29.92	31.56b
Nano at Veg. + Flow.	114.40	118.33	117.57	116.77ab	25.84	38.72	27.60	30.72bc
Nano at Veg. + Fill.	105.33	130.47	123.67	119.82a	28.74	44.03	22.73	31.83b
Nano at Flow. + filling	117.33	119.50	107.40	114.74	31.53	47.08	36.08	38.23a
Nano (Veg. + Flow. + filling.).	117.50	127.23	112.73	119.15ab	25.84	42.68	21.41	29.98bc
Mineral at Veg. + Flow. + filling.	101.33	118.53	105.33	108.40c	23.02	40.62	24.20	29.28cd
Average (B)	107.86b	117.27a	109.40b		26.38b	40.52a	26.68b	
$LSD_{0.05}$ "A"		4.680				2.110		
$LSD_{0.05}$ "B"		2.560				1.460		
$LSD_{0.05}$ "A x B"		7.510				4.120		
	Season 2015/2016				Season 2015/2016			
Nano at vegetative	99.50	118.67	103.67	107.28d	22.76	29.92	24.26	25.65cd
Nano at flowering	103.00	114.50	106.00	107.83d	23.02	32.56	21.62	25.73cd
Nano at filling	104.67	113.00	108.33	108.67cd	24.37	29.18	21.88	25.14d
Nano at Veg. + Flow.	115.67	126.67	118.33	120.22a	25.66	34.61	26.84	29.04b
Nano at Veg. + Filling	114.00	128.83	119.50	120.78a	34.49	45.79	30.24	36.84a
Nano at Flow. +filling	115.00	125.27	111.53	117.27ab	24.99	31.76	26.90	27.88bcd
Nano at Veg. + Flow. + filling.	109.83	117.00	112.83	113.22bc	27.16	34.49	22.73	28.13bc
Mineral at Veg. + Flow. + filling.	100.97	123.83	106.53	110.44cd	24.34	33.47	25.52	27.78 bcd
Average (B)	107.83c	120.97a	110.84b		25.85b	33.97a	25.00b	
$LSD_{0.05}$ "A"		4.980				2.900		
$LSD_{0.05}$ "B"		2.410				1.100		
$LSD_{0.05}$ "A x B"		N.S.				3.120		

- Average values in the same column/row marked with the same letters are not significantly different at 0.05 level of probability.
- N.S.: not significant difference at 0.05 level of probability.

Table (3). Number of pods/plant and pod length (cm) of faba bean cultivars as influenced by foliar mineral and nanofertilizer and their interaction during 2014/2015 and 2015/2016 seasons

Treatments	Number of pods/plant				Pod length (cm)			
	Season 2014/2015			Average (A)	Season 2014/2015			Average (A)
	B). Faba bean cultivars				B). Faba bean cultivars			
A). Foliar fertilizer	Nubaria 1	Nubaria 2	Nubaria 3		Nubaria 1	Nubaria 2	Nubaria 3	
Nano at vegetative	8.00	13.33	12.00	11.11e	8.67	11.83	8.00	9.50e
Nano at flowering	10.33	13.66	11.67	11.89e	9.50	9.83	9.20	9.51e
Nano at filling	13.33	16.67	14.33	14.78d	9.33	11.67	9.80	10.27cd
Nano at Veg. + Flow.	14.67	18.33	15.67	16.22c	9.27	11.00	10.00	10.09de
Nano at Veg. + Fill.	18.00	25.00	19.67	20.89a	11.67	15.53	12.17	13.12a
Nano at Flow. + filling	17.67	22.33	19.67	19.89ab	11.10	11.33	11.83	11.42b
Nano (Veg. + Flow. + filling.).	19.33	20.33	18.67	19.44b	12.33	13.33	11.83	12.50a
Mineral at Veg. + Flow. + filling.	14.33	19.67	17.00	17.00c	10.00	11.90	10.50	10.80bc
Average (B)	14.46 c	18.67 a	16.09 b		10.23b	12.05a	10.42b	
$LSD_{0.05}$ "A"		1.160				0.7037		
$LSD_{0.05}$ "B"		0.813				0.6062		
$LSD_{0.05}$ "A x B"		N.S.				N.S.		
	Season 2015/2016				Season 2015/2016			
Nano at vegetative	7.00	13.67	11.00	10.56e	8.67	11.67	7.83	9.39e
Nano at flowering	10.33	12.67	11.67	11.56e	9.83	9.83	8.70	9.45e
Nano at filling	12.33	15.67	13.33	13.78d	9.20	11.17	9.30	9.89cd
Nano at Veg. + Flow.	14.33	17.67	16.33	16.11c	9.27	11.17	9.50	9.98de
Nano at Veg. + Filling	17.67	24.33	19.00	20.33a	12.33	15.53	12.50	13.45a
Nano at Flow. +filling	17.33	21.00	18.67	19.00b	11.63	10.83	11.33	11.26b
Nano at Veg. + Flow. + filling.	18.67	20.00	18.67	19.11b	11.83	12.83	11.33	12.00a
Mineral at Veg. + Flow. + filling.	14.33	18.67	16.67	16.56c	9.50	12.13	10.70	10.78bc
Average (B)	14.00c	17.96a	15.67b		10.28 b	11.90a	10.15b	
$LSD_{0.05}$ "A"		1.170				0.7047		
$LSD_{0.05}$ "B"		0.600				0.6052		
$LSD_{0.05}$ "A x B"		2.300				1.710		

- Average values in the same column/row marked with the same letters are not significantly different at 0.05 level of probability.
- N.S.: not significant difference at 0.05 level of probability.

Table (4). Number of seeds/pod and 100- seed weight (g) of faba bean cultivars as influenced by foliar mineral and nanofertilizer and their interaction during 2014/2015 and 2015/2016 seasons

Treatments	Number of seeds/pod				100- seed weight (g)			
	Season 2014/2015			Average (A)	Season 2014/2015			Average (A)
	B). Faba bean cultivars				B). Faba bean cultivars			
A). Foliar fertilizer	Nubaria 1	Nubaria 2	Nubaria 3		Nubaria 1	Nubaria 2	Nubaria 3	
Nano at vegetative	3.67	4.33	3.67	3.89b	68.93	93.03	86.33	82.76de
Nano at flowering	4.67	4.33	3.67	4.22 b	76.50	98.93	87.00	87.48c
Nano at filling	4.33	4.33	4.00	4.22 b	73.00	94.73	75.10	80.94e
Nano at Veg. + Flow.	4.33	4.67	3.67	4.22 b	88.17	92.17	86.47	88.94bc
Nano at Veg. + Fill.	5.00	5.33	4.67	5.00a	87.67	102.83	96.97	95.82a
Nano at Flow. + filling	4.33	4.67	3.33	4.11 b	86.57	104.17	87.67	92.80ab
Nano (Veg. + Flow. + filling.).	4.33	4.67	4.33	4.44 b	90.67	99.20	87.43	92.43ab
Mineral at Veg. + Flow. + filling.	4.33	5.00	3.00	4.11 b	85.43	94.73	75.87	85.34cd
Average (B)	4.37 b	4.67a	3.79 b		82.12c	97.47a	85.36b	
$LSD_{0.05}$ "A"	0.502				3.99			
$LSD_{0.05}$ "B"	0.367				2.25			
$LSD_{0.05}$ "A x B"	N.S.				6.36			
	Season 2015/2016				Season 2015/2016			
Nano at vegetative	2.67	5.33	2.67	3.56c	71.50	94.57	88.83	84.97c
Nano at flowering	4.33	5.67	3.00	4.33a	79.00	101.43	89.50	89.98b
Nano at filling	3.33	5.33	3.67	4.11b	75.20	97.23	77.60	83.34c
Nano at Veg. + Flow.	3.67	5.33	3.33	4.11 b	90.40	94.67	88.97	91.35b
Nano at Veg. + Filling	3.67	5.66	4.00	4.44a	90.17	105.33	99.50	98.33a
Nano at Flow. +filling	4.00	5.33	3.67	4.33a	89.07	101.67	84.53	91.76b
Nano at Veg. + Flow. + filling.	4.00	5.33	3.67	4.33 b	91.87	101.13	83.83	92.28b
Mineral at Veg. + Flow. + filling.	3.67	5.33	3.33	4.11 b	84.50	95.30	77.33	85.71c
Average (B)	3.67b	5.41a	3.42b		83.96b	98.92a	86.26b	
$LSD_{0.05}$ "A"	0.222				3.77			
$LSD_{0.05}$ "B"	0.410				2.52			
$LSD_{0.05}$ "A x B"	N.S.				7.13			

- Average values in the same column/row marked with the same letters are not significantly different at 0.05 level of probability.
- N.S.: not significant difference at 0.05 level of probability.

Table (5). Seed and straw yields (kg/fed.) of faba bean cultivars as influenced by foliar mineral, nanofertilizer and their interaction during 2014/2015 and 2015/2016 seasons

Treatments	Seed yield (kg/fed.)				Straw yield (kg/fed.)			
	Season 2014/2015			Average (A)	Season 2014/2015			Average (A)
	B). Faba bean cultivars				B). Faba bean cultivars			
A). Foliar fertilizer	Nubaria 1	Nubaria2	Nubaria 3		Nubaria 1	Nubaria 2	Nubaria 3	
Nano at vegetative	932.76	1131.20	938.39	1000.78e	1540.76	1690.29	1607.96	1613.00d
Nano at flowering	1240.14	1513.14	1148.44	1300.57c	1578.13	1986.15	1597.58	1720.62c
Nano at filling	1214.59	1448.22	1218.87	1293.89c	1671.29	1768.06	1673.23	1704.19cd
Nano at Veg.+ Flow.	1220.57	1420.57	1284.61	1308.58c	1839.66	1989.02	1516.48	1781.72c
Nano at Veg.+ Fill.	1549.56	2199.43	1332.81	1693.93a	1668.13	2459.44	1778.61	1968.73b
Nano at Flow.+ filling	1340.56	1527.04	1282.15	1383.25b	1910.56	2202.59	1762.43	1958.53b
Nano (Veg. + Flow.+ filling.).	1250.83	1373.98	1358.50	1327.77bc	2195.56	3025.93	2217.97	2479.82a
Mineral at Veg.+ Flow.+ filling.	1145.11	1381.37	1042.89	1189.79d	1939.35	2090.35	1964.56	1998.09b
Average (B)	1236.77b	1499.37a	1200.83c		1792.93b	2151.48a	1764.85b	
$LSD_{0.05}$ "A"	69.210				93.00			
$LSD_{0.05}$ "B"	35.800				52.77			
$LSD_{0.05}$ "A x B"	101.30				149.30			
	Season 2015/2016				Season 2015/2016			
Nano at vegetative	899.33	1107.31	971.00	992.55e	1588.67	1687.66	1605.32	1627.22d
Nano at flowering	1084.33	1544.81	1251.00	1293.38cd	1575.49	1983.51	1594.94	1717.98cd
Nano at filling	1191.67	1518.33	1222.00	1310.67cd	1668.66	1765.42	1670.59	1701.56cd
Nano at Veg.+ Flow.	1088.67	1472.67	1299.00	1286.78cd	1837.02	1986.38	1513.84	1779.08c
Nano at Veg.+ Filling	1326.67	2262.67	1449.67	1679.67a	1665.49	2456.81	1775.97	1966.09b
Nano at Flow.+filling	1313.13	1551.64	1308.87	1391.21b	1907.92	2199.95	1759.79	1955.89b
Nano at Veg.+Flow.+filling.	1212.30	1434.03	1300.00	1315.44c	2192.92	3023.29	2215.33	2477.18a
Mineral at Veg.+ Flow.+filling.	1166.00	1347.00	1208.67	1240.56d	2215.33	2087.71	1929.38	2077.47b
Average (B)	1160.26c	1529.81a	1251.28b		1831.44b	2148.84a	1758.15b	
$LSD_{0.05}$ "A"	72.679				93.21			
$LSD_{0.05}$ "B"	32.763				53.21			
$LSD_{0.05}$ "A x B"	2.699				151.35			

- Average values in the same column/row marked with the same letters are not significantly different at 0.05 level of probability.
- N.S.: not significant difference at 0.05 level of probability.

Table (6). Biological yield (kg/fed.) and harvest index % of faba bean cultivars as influenced by foliar mineral and nanofertilizer and their interaction during 2014/2015 and 2015/2016 seasons

Treatments	Biological yield (kg/fed.)				Harvest index %			
	Season 2014/2015			Average (A)	Season 2014/2015			Average (A)
	B). Faba bean cultivars				B). Faba bean cultivars			
A). Foliar fertilizer	Nubaria 1	Nubaria 2	Nubaria 3		Nubaria 1	Nubaria 2	Nubaria 3	
Nano at vegetative	2473.52	2821.50	2546.35	2613.79f	37.68	40.01	36.89	38.19d
Nano at flowering	2818.26	3499.29	2746.03	3021.19e	43.99	43.24	41.82	43.02bc
Nano at filling	2885.89	3216.28	2892.10	2998.09e	42.08	45.06	42.14	43.09b
Nano at Veg.+ Flow.	3060.23	3409.44	2801.09	3090.25de	39.89	41.66	45.93	42.49bc
Nano at Veg.+ Fill.	3217.69	4658.87	3111.43	3662.66b	48.16	47.22	42.86	46.08a
Nano at Flow.+ filling	3251.11	3729.63	3044.57	3341.77c	41.24	40.99	42.14	41.46c
Nano (Veg.+ Flow.+ filling.).	3446.39	4399.91	3576.47	3807.59a	36.29	31.23	37.99	35.17e
Mineral at Veg.+ Flow.+ filling.	3084.28	3471.72	3007.45	3187.82d	37.12	39.80	34.68	37.20d
Average (B)	3029.67b	3650.83a	2965.69b		40.81a	41.15a	40.56a	
$LSD_{0.05}$ "A"	122.71				1.600			
$LSD_{0.05}$ "B"	66.420				N.S.			
$LSD_{0.05}$ "A x B"	187.90				2.790			
	Season 2015/2016				Season 2015/2016			
Nano at vegetative	2488.00	2794.97	2576.32	2619.76f	36.13	39.58	37.74	37.82c
Nano at flowering	2659.82	3528.32	2845.94	3011.36e	40.74	43.80	43.98	42.84b
Nano at filling	2860.32	3283.75	2892.59	3012.22e	41.57	46.25	42.24	43.35 b
Nano at Veg. + Flow.	2925.69	3459.05	2812.84	3065.86e	37.21	42.57	46.25	42.01 b
Nano at Veg. + Filling	2992.16	4719.47	3225.64	3645.76b	44.31	47.97	44.97	45.75a
Nano at Flow. +filling	3221.04	3751.60	3068.65	3347.10c	40.78	41.42	42.68	41.63 b
Nano at Veg. + Flow. + filling.	3405.22	4457.32	3515.33	3792.62a	35.58	32.17	36.99	34.91d
Mineral at Veg. + Flow. + filling.	3102.54	3434.71	3138.05	3225.10d	37.60	39.25	38.52	38.46c
Average (B)	2956.85b	3678.65a	3009.42b		39.24 b	41.63a	41.67a	
$LSD_{0.05}$ "A"	102.21				2.111			
$LSD_{0.05}$ "B"	68.311				0.840			
$LSD_{0.05}$ "A x B"	193.21				2.376			

- Average values in the same column/row marked with the same letters are not significantly different at 0.05 level of probability.
- N.S.: not significant difference at 0.05 level of probability.

CONCLUSION

From the obtained results and from the economic point of view under the same conditions of this research, it could be recommended that using foliar nano-fertilizer with the rate of 1 cm^3/fed and at the two or three growth stages (vegetative, flowering and filling) with Nubaria 2 cultivar to obtained the highest seed yield and its components under study conditions at Nubaria Region, El-Behira governorate, Egypt.

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الملخص العربي

أستجابة بعض أصناف الفول البلدى للأسمدة المصنعة بتكنولوجيا النانو

محمود عبد العزيز جمعة[١]،عصام إسماعيل قنديل[١]،أبو زيد عبد المحسن أبو زيد[٢]، بلقيس ميلود عبدو سالم[١]

١- قسم الانتاج النباتى – كلية الزراعة سابا باشا – جامعة الاسكندرية – الاسكندرية – مصر

٢- محطة بحوث النوبارية – معهد المحاصيل الحقلية – مركز البحوث الزراعية – الجيزة – مصر

أجريت تجربتان حقليتان في المزرعة محطة بحوث النوبارية – بمنطقة النوبارية– البحيرة – خلال الموسمين ٢٠١٤/٢٠١٥ ، ٢٠١٥/٢٠١٦ على التوالي وذلك بهدف دراسة أستجابة ثلاثة أصناف من الفول البلدى للرش الورقى ببعض أسمدة النانو. أستخدم في تنفيذ التجارب تصميم القطع المنشقة مرة واحدة في ثلاث مكررات حيث أشتملت القطع الرئيسية الرش الورقى (للسماد المعدني ، سماد النانو فى طور النمو الخضرى ، سماد النانو فى طور النمو الزهرى ، سماد النانو فى طور إمتلاء البذور ، سماد النانو فى طوري (النمو الخضرى والزهرى) ، سماد النانو فى طوري (النمو الخضرى وإمتلاء البذور ، سماد النانو فى طورى (النمو الزهرى وإمتلاء البذور)، بسماد النانو فى الثلاثة أطوار (النمو الخضرى والزهرى وإمتلاء البذور). والقطع الشقية وزعت الثلاثة أصناف من الفول البلدى (نوبارية ١ ، نوبارية ٢ ، نوبارية ٣) ووزعت المعاملات عشوائياً.

استخدم سماد النانو (٨ نتروجين كلى ، ٥% فوسفور كلى ، ٣% بوتاسيوم كلى ، ١٠% عناصر صغرى ، ٥% أحماض أمينية ، ٥% مستخلص طحالب بحرية) بمعدل ١ سم^{٣}/فدان ، السماد المعدنى (١٠% نتروجين ، ٨% فوسفور ، ٥% بوتاسيوم كلي ، ١٠% عناصر صغرى) بمعدل ٠.٥ لتر/فدان رشاً على الأوراق.

وكانت أهم النتائج المتحصل عليها كما يلي:

أولاً: الصفات الفسيولوجية:

- تأثرت الصفات الفسيولوجية (أرتفاع النبات ومحتوى الأوراق من الكلوروفيل الكلى) معنوياً بالثمانية معاملات من الرش الورقى ، حيث أن رش الفول البلدى بسماد النانو فى مرحلتى التزهير والامتلاء سجل أعلى متوسطات ، فى حين أن التسميد الورقى فى مرحلة النمو الخضرى أعطى أقل قيم فى موسمى الدراسة.
- أختلفت أصناف الفول البلدى الثلاثة معنوياً فيما بينها تحت الدراسة ، حيث تفوق صنف نوبارية ٢ مقارنة بالصنفين الأخريين خلال موسمى الدراسة.
- كما أن التداخل بين عاملين الدراسة كان معنوياً ، حيث ان الرش الورقى بسماد النانو لصنف نوبارية ٢ حقق أعلى قيم لمعظم صفات النمو المدروسة مقارنة بباقى المعاملات خلال موسمى الزراعة.

ثانيا- المحصول ومكوناته:

- تأثرت صفات المحصول ومكوناته (عدد القرون/نبات – محصول البذور (كجم/فدان) – محصول القش كجم/فدان – المحصول البيولوجى (كجم/فدان) – دليل الحصاد % – وزن ١٠٠ بذرة (جم) – عدد البذور/القرن – طول القرن (سم) معنوياً بالثمانية معاملات من الرش الورقى ، حيث أن رش الفول البلدى السماد المصنع بتكنولوجيا النانو فى مرحلتى التزهير والامتلاء سجل أعلى متوسطات قيم ، فى حين أن التسميد الورقى فى مرحلة النمو الخضرى أعطى أقل قيم فى موسمى الدراسة.
- أختلفت أصناف الفول البلدى الثلاثة معنوياً فيما بينها تحت الدراسة ، حيث تفوق صنف نوبارية ٢ مقارنة بالصنفين الأخريين خلال موسمى الدراسة.
- كما أن التداخل بين عاملى الدراسة كان معنوياً ، حيث ان الرش الورقى بسماد النانو لصنف نوبارية ٢ حقق أعلى قيم لمعظم صفات النمو المدروسة مقارنة بباقى المعاملات خلال موسمى الزراعة.
- أصناف الفول البلدى الثلاثة أختلفت معنوياً فيما بينها فى محتواها من النتروجين والبروتين والبوتاسيوم والزنك والحديد والمنجنيز، حيث تفوق صنف نوبارية ٢ مقارنة بالصنفين الأخريين فى المحتوى الكيماوى من العناصر المعدنية خلال موسمى الدراسة.
- كما أن التداخل بين عاملين الدراسة كان معنوياً ، حيث ان التسميد الورقى بسماد النانو لصنف نوبارية ٢ سجل أعلى قيم لمعظم صفات النمو المدروسة مقارنة بباقى المعاملات خلال موسمى الزراعة .

التوصية:

يوصي برش صنف نوبارية ٢ ورقياً بسماد النانو تكنولوجى فى مراحل النمو الخضرى والتزهير والامتلاء. تحت ظروف التجربة في منطقة النوبارية للحصول على أعلى محصول للحبوب والقش وأفضل جودة للفول البلدى.