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Influence of Cobalt, Water Quantities, and Crop Sequence on Growth and Yield of Common Bean in Nematode-Infested Soil

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ABSTRACT

Egyptian agriculture faces a number of accelerating concerns to satisfy food security for over-population increase, avoid lack in the available water resources, challenge expected climatic changes, and manage crop pests and diseases. Hence, horizontal and vertical expansion in Egyptian agriculture is desperately needed. The present study assessed the effect of three components of such an expansion on growth parameters and yield of common bean (*Phaseolus vulgaris*) planted in reclaimed land. Bean plants irrigated once with cobalt sulphate at concentrations 0, 8, 12, 16, and 20 ppm promoted plant growth parameters and pod yield. Nevertheless, the highest cobalt concentration, 20 ppm, indicated inferior growth parameters ($P \leq 0.05$) relative to one or more of its other applied concentrations. The standard amount of water usually required to irrigate common bean planted in reclaimed land mostly showed better ($P \leq 0.05$) plant growth parameters and yield than low amounts; *i.e.* 80 and 60% of the standard water supply. Cobalt supplement under different moister levels (100%, 80%, and 60%) gave better yield than untreated check. As cobalt concentration increased and/or water supply decreased, abscisic acid contents in plants were enhanced. Plant-parasitic nematode levels were not detectable before bean cultivation probably due to fallowing and sanitation practices which preceded bean cultivation. Also, the levels of the root-knot nematode, RKN (*Meloidogyne arenaria*), as devastating pathogen of common bean worldwide, were low or non-detectable at harvest but reached a damaging level on broad bean in adjacent field. Given the country's ambition to dramatically expand agriculture horizontally via such reclaimed lands which favor RKNs, an example of crop rotation system with possible modifications and guidelines to manage the nematodes was presented.

Key words: agricultural expansion, cobalt sulphate, common bean, water deficit, nematodes, Egypt.

INTRODUCTION

Green bean or common bean (*Phaseolus vulgaris* L.) is an important legume worldwide. It is the highly relished pulse grain in Egypt where its dry seeds or green pods (unripe fruits) are cooked. Its seeds are considered a good supply of dietary protein which represent 22% of the total seed weight (Sharf et al., 2014). In addition to local consumption of common bean, it may provide a significant source of foreign currency. With the current intention in increasing our exports to face over-population challenge, Egypt's agricultural sector exports rose 3% to US$ 2.2 billion in 2017 from US$ 2.1 billion in 2016 according to the monthly report by Export Council of Agricultural Crops in Egypt. Yet, serious problems are facing such crop production increase; mainly limited water resources and arable land, expected unfavorable climatic changes, and harmful crop pests and diseases. Therefore, horizontal and vertical expansion in Egyptian agriculture via integrated approaches is imperative. In this respect, recent reports (e.g., Nadia Gad and Kandil, 2008; Nadia Gad, 2010; Emam et al., 2018) pointed out that cobalt is a promising element for improving plant growth and production. Cobalt had a significant effect on enhancing olive production in terms of trees growth, fruit quality and quantity, mineral content, endogenous hormones and oil percentage especially with organic fertilization under drip irrigation system (Nadia Gad, 2010). Organic matter decreases soil pH and increases the availability of cobalt and cobalt in turn increases the tree efficiency to tolerate drought and salinity. Biabak (1995) found that winter wheat plants grown in a sandy loam soil supplied with nitrogen can uptake more cobalt. Helmy and Nadia Gad (2002) showed that cobalt at 25 mg/kg soil had a positive effect on parsley plant growth and yield as well as chlorophyll content, total soluble solids, and L-Ascorbic acid. Cobalt is required in low levels for maintaining high yields of tomato (Runner et al, 2003), squash (Atta El-Aly, 1998), groundnut (Basu et al, 2006) sweet potato (Nadia Gad and Kandil, 2008) and potato (El-Bordiny and Nadia Gad, 2008). El-Howeity and Asfour (2012) reported that cobalt has a bright future to improve crop production in Egypt. In another aspect, Egypt confronts main restrictions concerning its water supply; a limited water resources, rapid population increase, obstacles in the convenient sharing of Nile water with its basin states, and expected negative consequences of climate change (Gad, 2017). Such factors require wise and careful use of water and impose concerns about its future availability for various activities and development programs. Admittedly, there is a growing deficiency in the irrigation water in Egypt. The government's trend to save water is apparent especially with harbingers of additional water deficit after the construction of the Renaissance Dam in Ethiopia. Hence, rationalization of water use has become a necessity. For example, Abouziena et al. (2013) tested the possibility of using wastewater for canola irrigation. Abd-Elgawad et al. (2017) stressed the need to replace crops that consume large quantities of water with their counterparts of less need for water (*e.g.* sugar beet instead of sugar cane).

Green bean is also susceptible to damage caused by plant-parasitic nematodes (PPNs), especially the root-knot nematodes, RKNs (*Meloidogyne* spp.) which are endoparasitic forms capable of damaging on many economically important crops in Egypt and elsewhere (Perry et al., 2009). Abd-Elgawad (2014) estimated annual yield losses of green bean and dry bean due to damage by plant parasitic nematodes in Egypt as 7%. This accounted for actual annual yield losses of 18913.44 and 5230.13 metric tons of green and dry beans, respectively. While current land reclamation efforts are directed to turn proximate or marginal deserts into agricultural production, RKNs favor such reclaimed light soils. So, reclamation entails the risk of growing susceptible crops where serious nematode species are likely to be a hazard to crop production. Among agricultural practices, crop rotation proved useful in reducing nematode damage to susceptible crops worldwide where RKNs have been frequent targets of management by crop sequence. Traditional crops in addition to fallow have been useful in rotation sequences for suppressing certain species and races of root-knot nematodes (McSorley et al., 1994; Xie et al., 2017). Because many interacting factors influence common bean yield, we tested herein three practices; *i.e.* water quantities, crop rotations, and cobalt concentrations. We studied the effect of cobalt on common bean growth parameters and yield under different water quantities. Because of the serious RKN damage in newly reclaimed lands, we examined their population levels under such practices and emphasized the importance of sanitation. A crop rotation scheme was presented and discussed to face nematode problems in current and expected reclaimed areas.

MATERIALS AND METHODS

The field with reclaimed soil located at The Research and Production Station, National Research Centre (NRC), Noubaria district, El-Behera Governorate, Egypt, is known to be infested with PPNs especially *M. arenaria* (Hammam et al., 2017). The delimited experimental site had been planted with sunflower (*Helianthus annuus* L.) on 10 May and harvested at the beginning of August, 2016. Then, it was left fallow until March, 2017 during which the previous crop residues and weeds in soil were eliminated to clear the soil of pests and pathogens. Seeds of common bean (*Phaseolus vulgaris* L.) cv. Nebraska were sown (8,000 plants/feddan) on 16 March, 2017. Just before seeding, soil was sampled to determine its characteristics and contents by Plant Nutrition Department, Agricultural and Biological Research Division, NRC. Thus, soil texture, moisture, pH, EC, cations and anions, organic matter, CaCOs, total nitrogen and available P, K, Fe, Mn, Zn and Cu were determined (Blakemore et al., 1981; Black et al., 1982; Cottanie et al., 1982; Rebecca, 2004). Soil preparation for common bean cultivation included good plowing and adding 20 m^3 buffalo manure + 200 kg superphosphate + 100 kg agricultural sulfur + 50 kg potassium phosphate + 50 kg ammonium sulphate per feddan. These fertilizers were added initially at the bottom of the lines, and then the layout was adjusted so that the manure is in the middle of the lines based at the rate of 12 lines per 7.10 meter. The irrigation pipes were extended above the middle of the line directly above the fertilizers.

The experimental lay out was completely randomized block design with three replicates/plots (5 X 3 m each) per treatment. Each plot contained 3 50-meter rows (100 plants/ row). Each block had three different water quantities (treatments) for irrigation as split design. These three treatments were the standard amount of water usually required to irrigate common bean planted in reclaimed land, 80%, and 60% of the standard amount. Components of the irrigation system included automatic control unit, a water pump, timers, filter units and control valves. The PVC pipes had main lines (6 inch diameter), submain lines (63 mm diameter), and lateral lines (16 mm diameters) with GR drippers. The automation controller system consisted of moisture sensors, temperature sensors, signal conditioning circuit, digital to analog converter, LCD Module, relay driver, and solenoid control valves. The important parameters to be measured for automation of irrigation system are quantity of soil moisture and temperature. The entire field is first divided into small sections such that each section contained one moisture sensor and a temperature sensor. A resistance temperature detector (RTD) was used as a temperature sensor while tensiometers could continuously monitor soil water status, and schedule the desired irrigation. Once the soil has reached desired moisture level, the sensors send a signal to the micro controller to turn off the relays, which control the valves of drip irrigation systems (Shinghal et al., 2010). Irrigation treatments were controlled by flow meter that was installed at the head of each irrigation treatment. Each of these treatments got different cobalt sulphate concentrations as sub-split design; the concentrations were 0, 8, 12, 16, and 20 parts per million (ppm). The seedlings, at the third true leaf, were irrigated with each concentration of cobalt sulphate once. So, there were fifteen treatments; three moisture levels for irrigation X five cobalt concentrations. Total cobalt was determined in Aqua regia solution according to Cottanie et al. (1982). Using leaf water meter, leaf water potential was measured in plant fresh leaves. All other agricultural practices were carried out as recommended (Derhab, 2003). Fifty five days after seeding, plant growth parameters in terms of plant height, number of leaves, root length, and shoot fresh and dry weight were measured. Ninety days after sowing, pods were harvested and their weight was recorded. Fresh samples of shoot were taken for analysis of endogenous abscisic acid according to Shindy and Smith (1975). For pre-plant PPN sampling, on 15 March, fifteen composite soil samples, each sample from three plants representing the three replicates of a treatment, were randomly taken and processed for nematode extraction. Likewise, at harvest, soil and whole plant root systems were collected and examined for nematodes. Each sample was kept in polyethylene bags and sent directly to the laboratory for nematode extraction. Nematodes in soil were extracted in an aliquot of 250 g soil by sieving and decanting method (Byrd et al., 1996). The extracted PPNs were counted using Hawksly slide and identified according to Siddiqi (2000) under light microscope. Data were subjected to analysis of variance and averages of plant growth parameters, and pod yield were compared using Least Significant Difference (LSD) at 5% statistical probability level.

RESULTS AND DISCUSSION

Soil analysis indicated that the field consisted of 69.8% sand, 26.7% silt, and 3.5% clay, with 0.19% organic matter and a pH of 8. Other physical and chemical analysis of this sandy loam soil (Table 1) revealed also that it belongs to newly reclaimed land in Egypt.

Table 1. Physical and chemical analysis of the experimental soil at Noubaria district, Egypt.

Physical	Soil texture distribution (%)			Soil texture class	Water Saturation	Field capacity	Wilting point	Available water			
	Sand	Silt	Clay	Sandy loam	%						
	69.8	26.7	3.5		20.0	14.4	3.9	10.5			
Chemic	pH (1:2.5)	EC	Soluble cations (meq/l)				Soluble anions (meq/l)				
			Ca	Mg	K	Na	HCO_3	CO_2	Cl	SO_4	
	8.0	1.0	9.0	1.4	5.4	3.26	-	1.18	6.6	2.4	
Total	Available		Available micronutrients				Cobalt (ppm)			CaC %	O %
(ppm)			(ppm)				Soluble	Available	Total		
N	P	K	Fe	Mn	Zn	Cu	0.39	1.78	9.68	3.17	0.19
25.2	15.3	10.2	23	10.5	3.62	5.22					

EC: Electric conductivity was measured as dSm^{-1} in soil paste determined according to Rebecca (2004). OM: Organic matter.

Thus, such reclaimed soil can contribute to alleviate the problem of the decreased arable lands due to considerable urban encroachment (Tate, 2016).

Plant growth parameters in terms of plant height, number of leaves, root length, and shoot fresh and dry weights were greatly influenced by both cobalt treatments and irrigation regime treatments (Table 2). Clearly, such growth parameters were better, either with significant or non-significant values, in all cobalt treatments than in the untreated check. Nevertheless, the highest cobalt concentration, 20 ppm, indicated inferior growth parameters ($P \leq 0.05$) relative to one or more of its other applied concentrations. It is noteworthy that shoot fresh and dry weights were significantly higher at 16 than 20 ppm of cobalt within the standard water regime. This is possibly due to toxicity at the highest cobalt level applied.

On the other hand, the standard amount of irrigation water mostly showed better ($P \leq 0.05$) plant growth parameters than those affected by lower water supply; 80 and 60% of the standard amount of irrigation water. Four exceptions had non-significant differences (Table 2). Such results may block the chance to lessen the standard water supply in order to save water. Yet, this precaution should not be on the expense of exploiting the advantage of adding cobalt especially at lower concentrations; *i.e.* less than 20 ppm cobalt. Fortunately, unlike other heavy metals, cobalt is a server for human consumption and up to 8 ppm can be consumed on a daily basis without health hazard (Young, 1983). Cobalt is an essential element for the synthesis of vitamin B12, which is required for human and animal nutrition (Young, 1983).

Effects of cobalt on some physiological contents of common bean plants under different water supply were presented (Table 3). Water consumption per plant measured in mm/season showed significant ($P \leq 0.05$) difference among the three water quantities for each cobalt level applied. The highest plant consumption was always attained at the standard amount of water supply for a fixed cobalt level. Likewise, leaf water potential (measured in bar) was generally lower at the standard amount of water supply than the other two water amounts; *i.e.* 80 and 60% of the standard amount of irrigation water, for each cobalt level. Table (3) showed that the values of leaf water potential significantly increased with all cobalt levels compared with untreated plants. These findings are strongly supported by Egrove (2000) who reported that soil application of cobalt at 3 mg per kg dry soil increased leaf water content and decreased water deficit during daytime in tomato and potato leaves. Cobalt treatment also increased water absorption capacity and the content of strongly bound water in the leaves. Cobalt increased cytoplasmic pressure and leaf resistance to dehydration and decreased the wilting coefficient of the plants, increasing thereby their drought resistance (Zhu, 2002).

Strikingly, abscisic acid had always higher levels in plants irrigated with lower amounts of water than those irrigated with the standard water supply (Table 3). Even plants with the lowest water supply had higher abscisic acid level than those with medium water supply. Abscisic acid conducts numerous plant developmental processes such as controlling organ size and stomatal closure. So, it is especially important for plant response to negative environmental factors such as heat and drought stresses (Zhu, 2002). Consequently, it is likely that low water supply had induced such high abscisic acid levels to enable plant adaptation to stressed conditions.

Table 2. Effect of cobalt on growth parameters of common bean (*Phaseolus vulgaris*) plants under different water quantities at Noubaria district, Egypt.

Growth parameters	Plant height (cm)			Leaves no./ plant			Root length (cm)			Shoot fresh weight (g)			Shoot dry weight (g)		
Available water / Cobalt Conc. (ppm)	100	80	60	100	80	60	100	80	60	100	80	60	100	80	60
Control (0)	16.5	13.5	10.60	12	11	9	7.2	6.0	4.5	65.5	61.2	52.0	12.17	12.14	10.1
8	20.5	18.5	16.23	16	15	13	8.2	7.9	6.4	76.0	74.1	65.0	15.25	14.84	12.42
12	24.8	22.9	21.03	18	16	14	10.1	8.8	7.6	79.7	77.5	68.3	16.04	15.49	12.96
16	24.2	21.9	20.60	18	16	14	9.8	8.5	7.0	78.6	76.4	67.2	15.70	15.22	12.68
20	22.9	20.7	19.45	17	15	13	9.3	8.0	6.91	76.1	74.0	65.1	15.20	14.78	12.16
LSD at 5%	1.6			1.0			0.47			1.84			0.32		

Table 3. Effect of cobalt on physiological contents of common bean (*Phaseolus vulgaris*) plants under different water quantities at Noubaria district, Egypt.

Yield parameters	Water consumption per plant (mm/season)			Leaf water potential (-bar)			Abscisic acid (µg per g fresh tissue)		
Available water (%) / Cobalt Conc.(ppm)	100	80	60	100	80	60	100	80	60
Control (0)	510	408	306	-12.6	-12.2	-12.0	0.0	0.690	0.875
8	460	364	256	-9.8	-9.5	-9.2		0.918	1.946
12	439	346	241	-8.3	-8.0	-7.8		1.225	2.490
16	422	339	234	-8.0	-7.3	-7.0		1.905	3.130
20	394	317	219	-7.2	-6.8	-6.5		2.124	3.476
LSD at 5%	0.4			0.2			1.15		

On the contrary, as cobalt rates in plant media increased abscisic acid contents in plants significantly increased. Increasing abscisic acid levels stimulate stomata closure. Thus, it is likely that cobalt application reduced plant water loss and could be used to reduce water consumption under the condition of limited water supply or desertification. These results are in harmony with those obtained by Auge and Duan (1991). Root-knot nematode, RKN (*Meloidogyne arenaria*) was not detected at pre-plant sampling. Moreover, only *M. arenaria* was found though with non-detectable level in most treatments at harvest (Table 4). Out of the 15 treatments, each of *M. arenaria*-second stage juveniles (J2) or egg masss were detected in only five treatments but nematode-root galls were found on plant roots of seven treatments. Interestingly, such low population densities of RKN may be due to nematode suppressive soil and/or agriculture practices opposing RKN reproduction. Such practices include cultural practices, chemical control and biological control. The apparent nematode control presented herein (Table 4) was likely due to sanitation and fallowing. Fallowing reported herein was exploited to exclude PPNs by root-tilling and destruction of the previous crop residues as well as weed roots. On the contrary, RKNs reached a damaging level in a field without fallowing adjacent to this experiment where the mean numbers of RKN galls/plant, egg masses/plant, and J2/ 250 g soil were 50.28, 17.75, and 260.83, respectively at the beginning of May, 2017 (Hammam et al., 2017). It is well known that soil textures of such reclaimed lands favor RKNs reproduction with consequent crop damage. RKNs are likely to be a hazard to crop production when transported via organic fertilizers, irrigation water, plant materials and machinery. Nematodes may also spread by wind, animals, and soil erosion. The root knot nematodes have potential to cause severe (90%) quality and yield losses to dry and green bean (Shree and Schwartz, 2011). Also, *M. incognita* causes 63% yield losses in common bean in Colombia (Mullin et al., 1991). Significant increase in pod yields was apparent in cobalt-treated plots (Table 5). The highest increase in pod yields was 7.89 tons/feddan achieved by cobalt concentrations at 12 and 16 ppm. Apparently, sub-optimal amounts of irrigating water have negatively and progressively affected pod yields

Table 4. Effect of cobalt on numbers of root-knot nematode galls, egg masses, and second stage juveniles (J2) associated with common bean (*Phaseolus vulgaris*) plants under different water quantities at Noubaria district, Egypt.

Nematode parameters	Root galls			Egg masses			J2 in 250 g soil		
Available water (%) / Cobalt Conc.(ppm)	100	80	60	100	80	60	100	80	60
Control (0)	2	8	18	ND	ND	9	ND	ND	65
8	ND	ND	ND	ND	ND	ND	ND	ND	ND
12	73	ND	19	51	ND	11	405	246	194
16	96	15	ND	61	5	ND	912	ND	ND
20	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = Nematodes not detected.

Nevertheless, pod yields at the applied cobalt concentrations were generally better than the untreated check for a specific water regime (Table 5). Further studies to document and exploit the assumption that all cobalt concentrations promoted bean yield under different water quantities (100%, 80% and 60%) compared with untreated plants are guaranteed. For example, fresh pod yield of bean plants grown using 80% of the standard water amount was not significantly different from those grown using the standard water amount. Thus, cobalt saved 20% from irrigation water and helped plants to resist water deficit as well as increase pods yield. These results agree with those obtained by Sarada and Polasa (1992) who found that cobalt was an essential element for growth of the *Rhizobium* species; an endosymbiotic bacteria responsible for nitrogen-fixation during association with roots of legumes such as common bean. It is assumed that the safest practices to manage PPNs are preventive methods, including sanitation and employing resistant cultivars.

Table 5. Effect of cobalt on pod yield of common bean (*Phaseolus vulgaris*) plants under different water quantities at Noubaria district, Egypt.

Yield parameters	Pod yields (ton/fed)		
Available water (%) / Cobalt Conc.(ppm)	100	80	60
Control (0)	5.12	3.90	2.88
8	7.84	5.97	4.371
12	7.89	6.00	4.31
16	7.89	5.811	4.11
20	7.32	5.52	3.891
LSD at 5%	0.971		

In the present study, fallowing before bean cultivation was apparently responsible for nematode control. No PPN species were detected at pre-planting of the bean though they were detectable at nearby area (Hammam et al., 2017). Thus, it is preferable in such reclaimed soil to manage PPNs *via* fallowing, crop rotation, and/or soil solarization. Since future plans of the Egyptian Government have not clarified the exact crops that they expect 1.5 million feddans of newly reclaimed lands to produce, an example of crop rotation is suggested herein (Table 6). Yet, this rotation may be adjusted according to available production means, soil health and fertility, and economic conditions. For instance, peanut may replace corn if the soil is free from peanut race of RKNs. Also, Egyptian clover mayreplace fallowing if its production means are available to raise cattle and livestock.

Table 6. Example of a rotation plan for a root-knot nematode-infested reclaimed land.

Year / Land section	1	2	3
A	Corn then wheat	Legume then sesame	Fallow then vegetables (e.g. tomato)
B	Fallow then vegetables (e.g. tomato)	Corn then wheat	Legume then sesame
C	Legume then sesame	Fallow then vegetables (e.g. tomato)	Corn then wheat

On the other hand, a fallow, a period of crop rotation in which the land is designedly not cultivated, may be used to allow the soil to recover its production potential (Bello et al., 2004). It also decreases levels of pathogen and pest populations. Fallowing alleviates Egyptian concern for water supply in increasingly reclaimed land and enables us to better manage the crop. This management may include better timing of sowing and harvesting,selecting proper cultivar, and/or modifying plant density. Moreover, other crop rotations can be successfully employed for 2-, 3-, or 4-field rotation systems where rotation guidelines should be considered. In this respect, the longer the cycle, the better will be the nematode management results. Both rotation system and crops must be changed from time to time if the method is to succeed. Admittedly, the level and species of nematodes in the soil and plant roots should be regularly assessed and managed accordingly with suitable crops/cultivars. Soil fertility should also be maintained *via* organic and chemical fertilization to cope with the selected crop sequences. The required amount of available water, economic value and reasonable marketing should support selection of the rotated crop. Strict sanitation practices should be followed to avoid the above-mentioned sources of PPN contamination

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الملخص العربى

تأثير الكوبالت وكمية مياه الري وتتابع المحاصيل على نمو ومحصول الفاصوليا في التربة الموبوءة بالنيماتودا

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تواجه الزراعة المصرية عدداً من المخاوف المتزايدة من أجل تحقيق الأمن الغذائي بمواجهة زيادة عدد السكان ، وتجنب نقص الموارد المائية المتاحة، وتحدي التغيرات المناخية المتوقعة، ومكافحة آفات وأمراض المحاصيل، وبالتالي هناك حاجة ماسة للتوسع الأفقي والرأسي في الزراعة المصرية . قيمت الدراسة الحالية تأثير ثلاثة مكونات لمثل هذا التوسع على مؤشرات نمو ومحصول الفاصوليا المنزرعة في الأراضي المستصلحة. أعطت نباتات الفاصوليا المروية مرة واحدة بكبريتات الكوبالت بتركيزات 0 و 8 و 12 و 16 و 20 جزءًا في المليون أفضل مؤشرات لنمو ومحصول الفاصوليا، ومع ذلك فإن أعلى تركيز للكوبالت (20 جزء في المليون) أعطت مؤشرات نمو أدنى – بصورة معنوية – من واحد أو أكثر من تركيزات الكوبالت الأخرى. أعطت الكمية النموذجية من المياه المطلوبة عادة لري الفاصوليا المنزرعة في الأراضي المستصلحة مؤشرات نمو نباتية أفضل – بصورة معنوية – من تلك المعطاة بكميات مياه أقل (80٪ و 60٪ من إمدادات المياه القياسية). أعطت تركيزات الكوبالت – مع مستويات مختلفة من مياه الري (أي 100٪ و 80٪ و 60٪ من الكمية النموذجية من المياه المطلوبة عادة لري الفاصوليا) عائداً محصوليا أفضل من تلك غير المعاملة بالكوبالت. مع زيادة تركيز الكوبالت و/أو نقص إمدادات المياه ، زاد مستوي حمض الأبسيسيك في النباتات. لم تكن مستويات النيماتودا المتطفلة نباتياً قابلة للاكتشاف قبل زراعة الفاصوليا بسبب نرك الارض بور وممارسات تطهير الارض التي سبقت زراعة الفاصوليا. كانت مستويات نيماتودا تعقد الجذور (*Meloidogyne arenaria*) والتي تسبب اضراراً للفاصوليا في الكثير من أنحاء العالم، منخفضة أو غير قابلة للاكتشاف عند حصاد الفاصوليا في حين وصلت إلى مستوى ضار على محصول الفول البلدي المنزرع في حقل مجاور. نظراً لطموح البلد في التوسيع الزراعي بصورة أفقية بشكل كبير عن طريق مثل هذه الأراضي المستصلحة التي تعتبر مرتعاً خصباً لنيماتودا تعقد الجذور، فقد قمنا بتقديم مثال على نظام دورة زراعية في الأراضي المستصلحة مع مناقشة تحويرات محتملة وإرشادات لإدارة النيماتودا في مثل هذا النظام.

الكلمات المفتاحية: التوسع الزراعي، كبريتات الكوبالت، الفاصوليا، عجز المياه، النيماتودا، مصر.