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Improving Snap Bean Yield and Quality Through Organic Fertilizer additives and Citric Acid Spraying under Newly Reclaimed Land Conditions

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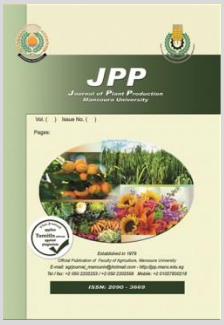

ABSTRACT

Snap bean (*Phaseolus vulgaris* L.) plants are sensitive to water and nutrient shortages, especially during flowering and pod setting stages. Hence, The present study aimed to investigate the benefits of citric acid foliar spray(CA) at 1.5g/l alone and combined with different levels of farmyard manure (FYM); control (100% mineral fertilizers) and 25%, 50% 75% and 100% of the recommended rate of FYM on snap bean cv. Bronco grown in sandy soil conditions. The study was conducted in Qalabshu, Dakahlia Governorate, Egypt during two seasons of 2015 and 2016 in a complete randomized block design (CRBD). The results showed that CA + 50% FYM treatment increases almost studied parameters either vegetative growth or pod yield over the control and other treatments. Although the treatment of CA + 100% FYM gave the highest values of pod qualities i.e., chlorophyll content (2.13 and 2.27), protein% (15.8 and 17.1) and TSS% (7.9 and 8.6) in both season, respectively, it had the lowest values of fresh pod yield (around 17.5% relative to control). Overall, the results indicated that organic fertilization is very important procedure in enhancing water and minerals status of new reclaimed soils. Moreover, citric acid as an antioxidant is effective in minimizing the negative impacts of water and mineral shortages of sandy soils. Accordingly, it can be recommended to fertilize snap bean plant grown in sandy soil by 50% FYM + 50% mineral fertilizers and spraying the plants by citric acid (1.5g/L) to obtain the highest fresh pod yield with best quality.

Keywords: *Phaseolus vulgaris* L., farmyard manure, citric acid, pod yield, pod quality.

INTRODUCTION

Snap bean (*Phaseolus vulgaris* L.) as one of pulses is an excellent source of cheap protein, minerals e.g., calcium, iron and zinc and folates for man consumption in developing country (Broughton *et al*., 2003 and Hefni *et. al*., 2010), in addition to its importance in exportation. Bronco cv. is considered as one of the promising cultivars for producing fine pods for exportation because it matches the consumer demands in EU market. In addition, the legume plants e.g., bean plant fix atmospheric N2 into $NH4^+$ in the soil which maintain soil fertility (Peter and Stephen, 2013). According to the statistic of Egyptian Agriculture Ministry during season of 2017, the area devoted for snap bean was 27,255 hectares produced about 283,520 ton. There are many factors affecting snap bean productivity such as environmental stresses. Poor soil such as sandy soil that lacks water and minerals is one of the most important environmental stresses, since more than 90% of Egyptian soils are classified as sandy soil.

Finding relatively safe tools to overcome the adverse effects of drought and mineral deficiency stresses or improve drought tolerance of sensitive plants could be of great value, particularly under arid and semi-arid regions where lack of water becomes a limiting factor for growth and productivity of plants. Ertek (2014) pointed that controlled fertilization to increase plant yield is of vital importance. Large scale conversion to organic fertilization has been debated for its effectiveness in meeting production goals. Organic manures improve soil fertility by stimulating soil microbial biomass (Ayuso *et. al*., 1996), supply provenances of whole indispensable macro- and micro nutrients in ready-made various forms and increasing holding water capacity due to enhanced soil aggregation (Pagliai *et. al*., 2004; Liang *et al*., 2011 and Fouda *et. al*., 2017) which finally enhance the chemical, physical and biological properties of the soil. Evidently, farmyard manure (FYM) has been used as a common organic fertilizer for improving soil physical and chemical properties. Farmyard manure added to the soil increases its organic matter, which in turn increases the proportion of chelating of minerals e.g., Mn, Zn and Cu in the soil to 50 %, 88 % and 98 %, respectively (Mc-Grath *et. al*., 1988). Plant dry weight, N and K contents in roots, P content in shoots, number of fruits per plant, average fruit weight, yield per plant and total yield per feddan of many vegetables plants were increased when plants were fertilized by farmyard manure under sandy soil conditions (Mostovoi, 1986 on pea; El-Mansi et. al., 1999 on garlic and Nour, 2004 on pea) and even under drought stress condition (El-Tohamy *et. al*., 2013 on bean). Evidently, combined application of mineral and organic fertilizer had a higher positive effect on microbial biomass and hence soil health, absorption of N, P and K by plants which maintain the soil and sustaining the productivity of bean crop (Hussein *et. al*., 2016 and Fouda *et. al*., 2017).

Moreover, foliar application of ameliorative and anti-stress substances such as citric acid is a method that may decrease the oxidative effects resulted from water and nutrients deficiencies in sandy soil. El-Tohamy *et. al*., (2013)

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found that using citric acid as foliar spraying at 1.5g/l during or before an expected drought period to improve drought tolerance of bean plants. Furthermore, the importance of exogenous application of citric acid in increasing its internal accumulation and improving fruits quality is evident under mild water stress (Kang *et al.*, 2009 and Iwasaki *et al.*, 2011) and salinity stress (Sun and Hong, 2011)

Considering the above facts, the present study was undertaken for further understanding the response of snap bean, in terms of vegetative growth and yield as well as chemical and physical qualities to citric acid as foliar spray alone and in combination with different levels of organic manure under sandy soil conditions and the role of that on enhancing fruit yield and its quality as well as increasing tolerance to the environmental stresses.

MATERIALS AND METHODS

Two field experiments were carried out in a private vegetable farm at Qalabshu, Bilqas district, Dakahlia Governorate, Egypt (36 Km apart of Mansoura) during seasons of 2015 and 2016 to study the effect of different levels of organic manure and foliar application by citric acid on snap bean (*Phaseolus vulgaris* L.) plants cv. Bronco towards improving quality and productivity under poor sandy soil as shown in Table (1).

Table 1. Soil characterization of the experimental site

Season	Texture	$CaCO_3$ %	pH	O.M %	Available nutrients in soil (ppm)		
					N	P	K
2015	Sandy	7.55	8.1	0.66	16	28	130
2016	Sandy	7.52	7.9	0.71	18	25	122

Fertilization rates using in this experiments:

Mineral fertilizers i.e., ammonium sulphate (20.6%N), calcium super phosphate (16% P_2O_5) and potassium sulphate (48% K_2O) were applied at rates of (70-80-50, NPK). P-fertilizer was added in one dose during soil preparation. N and K fertilizers were divided into two equal doses; the first part was added during soil preparation and the second was before the first irrigation. However, farmyard manure (FYM) was used in organic fertilization and the chemical composition of it was presented in Table (2). Four different levels of farmyard manure, i.e., without FYM, 25%, 50%, 75% and 100% of the recommended dose(35ton / feddan) ,determined based on N% in FYM, were amended after land preparation in ditches (20 cm width) and then covered by sand.

Table 2. Chemical properties of farmyard manure used in the experiment during 2015 and 2016 seasons.

Properties	N %	P %	K %	C %	C:N ratio	pH (1:2.5)	F.C. %	OM %
FYM	0.50	0.25	1.15	12.54	20.6:1	7.8	16.97	22.01

Every plot consisted 5 dripper lines 0.7m in width and 3m in length. In the first week of September, seeds were sown in hills 10 cm apart and 5cm deep on one side of dripper lines and two seeds per hill. The plot area was 10.5m^2. Agricultural practices other than the experimental treatments were carried out as recommended by the Ministry of Agriculture in Egypt.

Foliar spray treatment of citric acid:

At the 4th leaf stage; plants were sprayed with citric acid (1.5g/l) and every two weeks (three times), while control treatment received only tap water. The experimental design was randomized complete block with three replicates.

The experiment included 6 treatments as follows:

1. 100% mineral fertilizers + tap water foliar spraying (control).
2. 100% mineral fertilizers + citric acid foliar spraying (1.5g/L).
3. 75%mineral fertilizers + 25%FYM (8.75ton/fed) + citric acid foliar spraying.
4. 50% mineral fertilizers + 50%FYM (17.5ton/fed) + citric acid foliar spraying.
5. 25%mineral fertilizers + 75%FYM (26.5ton/fed) + citric acid foliar spraying.
6. 100%FYM (35ton/fed) + citric acid foliar spraying.

Measurements and data recorded:

1- Vegetative growth characters:

At 55 days after sowing and at the beginning of pods setting, 3 plants were randomly chosen from each plot to determine the vegetative growth characters, i.e., plant height, number of branches and leaves/plant, leaf area/plant and fresh weight/plant. Dry weight% was also calculated according to the following formula:

$$\textbf{Dry weight\%} = [\textbf{Dry weight of plant (g)} / \textbf{fresh weight of plant (g)}] \times 100$$

2- Flower set% and fresh pod yield and its attributes:

At flowering time, fruit set% was calculated as follows:

$$\textbf{Fruit set\%} = (\textbf{Number of setting fruits} / \textbf{total number of flowers}) \times 100$$

Pickings were carried out twice a week to harvest green pods that reached its marketing stage specified for Bronco variety (medium fine). At the second picking, random samples of pods from each plot were used to record the following traits:

- Average number of pods/plant (10 plants).
- Fresh pod weight/ plant (100 plants)
- Average pod diameter (100 pods).
- Average pod length (100 pods).

In addition, sum of all pickings were calculated to determine total yield of fresh pod as ton/fed. Also, relative response% was calculated according to the following formula:

$$\textbf{Relative fresh pod yield\%} = \frac{\textbf{Treatment pod yield (ton/fed)} - \textbf{control Pod yield (ton/fed)}}{\textbf{Treatment pod yield (ton/fed)} - \textbf{control Pod yield (ton/fed)}} \times 100$$

3- Leaf chlorophyll and pod quality:

- Pigments of total chlorophyll of leaves and pods were determined according to Lichtenthaler and Wellburn (1983).
- Total protein% of fresh pod was determined by multiplying nitrogen content by 6.25 according to A.O.A.C. (2000).
- Total Soluble solid (TSS) was determined by using Zeiss Laboratory Refractometer.

Statistical analysis of data:

Statistical analysis was accomplished to obtain the analysis of variance (ANOVA) according to Gomez and

Gomez (1984). The mean performance was compared by least significant value (LSD) method at 5%. All statistical analyses were performed using analysis of variance technique by means of CoSTATE Computer Software. Duncan Multiple Range Test at 5% was used to test the significant differences between treatment means.

RESULTS AND DISCUSSION

1.Vegetative growth characters:

The inability of sandy soil to retain water and mineral nutrients caused an observed adverse action on vegetative growth characters i.e., plant height, number of leaves and branches, fresh and dry weight of plant and leaves area (Table 3 and Fig. 1) in both seasons. However, these parameters were improved by foliar spraying of citric acid and soil amendment by farmyard manure (FYM). The highest values were obtained with exogenous application of citric acid combined with equal quantities of both mineral and organic fertilizers (50%mineral fertilizers+ 50%FYM) followed by that of citric acid and 75%FYM. These increments may be due to the increase in water retention of sandy soil and absorption and uptake of macro and micro- elements induced by organic matter in addition to the anti-stress impact of citric acid. On contrary, the decrease in the control characters may be due to the reduction in growth and development in different plant organs, since the low water retention and poor soil stresses restricted plant growth.

The notability in the vegetative growth by the level of 50% FYM combined with 50% mineral NPK might be refer to its simulative effect on the physical properties of the soil (Marculescu *et. al.*, 2002 and Ozores Hampton *et. al.*, 2011). Moreover, FYM guaranty higher levels of nutritional elements, particularly N, which is basically the most important structural element for plant growth (Amanullah *et. al.*, 2007). Many studies have found advantageous impacts of organic manure on soil properties expressed as water-holding capability and magnitude intensity (Fawole *et. al.*, 2010). The acquired results are in pretty endorsement with Dada and Fayinminnu (2010), Abul-Soud *et. al.*, (2010) and Shafeek *et. al.*, (2017). However, 100% organic manure was less effective due to the slow emission of nutrients (Eissa, 1996).

Table 3. Some vegetative characters of snap bean plants as affected by different levels of FYM and foliar spray by citric acid in 2015 and 2016 seasons

Characters	Plant height (cm)		No. of branches/ plant		No. of leaves/ plant		Leaf area (cm^2/plant)		Fresh weight (g/plant)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	19.3	20.1	8.0	6.7	9.0	8.7	271.5	263.0	50.5	53.0
100% MF + CA	21.3	21.0	7.3	7.7	9.7	9.3	287.5	286.6	54.7	54.5
25%FYM + CA	23.2	23.1	8.3	8.0	10.0	10.7	301.4	298.6	55.3	55.8
50%FYM + CA	24.9	25.4	10.0	9.7	11.7	11.7	317.4	331.8	61.9	63.5
75%FYM + CA	20.8	21.6	8.7	9.3	10.0	11.0	307.6	314.0	54.0	53.8
100%FYM + CA	20.8	19.6	8.0	8.3	10.0	9.3	282.3	286.4	50.3	50.4
LSD5%	2.09	1.9	1.1	1.3	1.6	1.7	18.6	15.0	4.7	5.1

MF: mineral fertilizers; FYM: farmyard manure; CA: citric acid

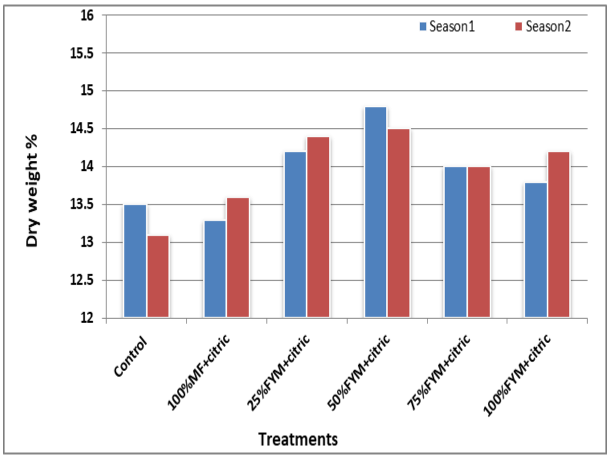

Fig 1. Effect of different levels of FYM amendment and foliar spray of citric acid on dry weight% of snap bean plant in seasons of 2015 and 2016.

On the other hand, Sun and Hong (2011) and El-Tohamy *et. al.*, (2013) found that exogenously applied with citric acid significantly improved the plant growth under stress conditions and induced defense mechanisms by increasing the activities of antioxidant enzymes. Also, exogenous citric acid improved internal citric acid and helped stress tolerance improvement of plants during saline stress conditions (Sun and Hong, 2011) and water stress conditions (Kang et al., 2009 and Iwasaki *et al.*, 2011). This is may be attributed to the contribution of citric acid in enhancing water status due to its role in osmotic adjustment under drought conditions. Williamson and Milburn (1995) also, found that citric acid treatment resulted in the highest relative water content (RWC) which indicated the involvement of citric acid in increasing hydraulic conductance.

2. Number of flowers and pods/plant, pods set%, pods yield and physical quality of pod:

Obtained data of Table (4) and Figures (2 and 3) indicate that pods set percentage, number of flowers and pods/plant, weight of pods/plant and pods yield per feddan as well as pod physical quality expressed as length and diameter were negatively affected under sandy soil conditions, while the mentioned parameters showed significant values under the treatments of 50%mineral NPK + 50% FYM+ foliar spray by CA.

Fresh weight of pod/ plant and pod yield/fed. were significantly increased by foliar spray of 1.5g/l citric acid, but the increment in the other mentioned parameters did not reach to the significance at 5% level. The exogenous foliar spray of citric acid combined with FYM amendments significantly improved all studied parameters, except the fresh weight of pods/plant and pod yield/fed which were decreased significantly with 100% FYM compared with the control and other treatments in both seasons. From the previous data, it can be generally said that the highest values were obtained with citric acid and 50%FYM +50% mineral fertilizers.

Table 4. Number of flowers and pods/plant, fresh weight of pod/ plant and pod characteristics as affected by different levels of FYM and foliar spray by citric acid in 2015 and 2016 seasons

Characters	No. of flowers/ plant		No. of pods / plant		Weight of fresh pod (g/plant)		Total yield of fresh pod (ton/ feddan)		Pod characters diameter (cm)		Pod characters length (cm)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	21.0	21.3	15.1	15.6	80.43	81.87	3.1	3.17	0.95	0.94	10.07	10.13
100%MF+CA	21.3	21.3	16.2	15.8	87.03	85.37	3.38	3.28	0.96	0.94	10.53	10.43
25%FYM + CA	25.7	24.0	19.6	18.0	92.4	88.23	3.62	3.57	1.05	0.97	11.3	11.0
50%FYM + CA	26.7	27.0	22.1	21.8	96. 5	97.43	4.03	3.97	1.08	1.1	11.8	11.82
75%FYM + CA	27.3	26.7	19.3	20.1	82.77	83.37	2.99	3.21	0.95	0.96	10.17	10.57
100%FYM + CA	22.7	25.0	16.5	14.5	74.13	72.17	2.51	2.66	0.93	0.90	10.33	10.47
LSD5%	1.3	2.2	1.8	1.9	3.22	3.14	0.11	0.20	0.05	0.07	0.78	0.56

MF: mineral fertilizers; FYM: farmyard manure; CA: citric acid

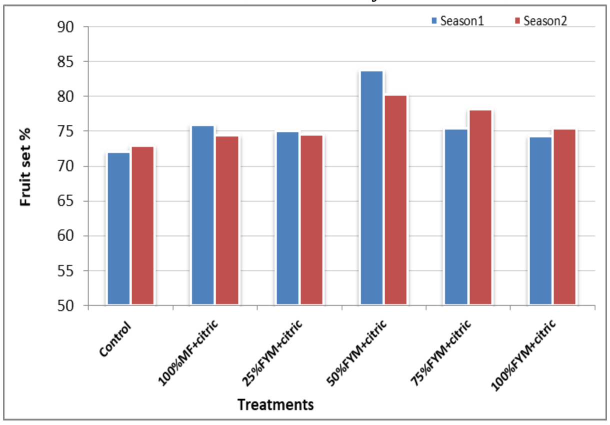

Fig 2. Effect of different levels of FYM amendment and foliar spray of citric acid on fruit set% of snap bean plant grown under sandy soil conditions in seasons of 2015 and 2016.

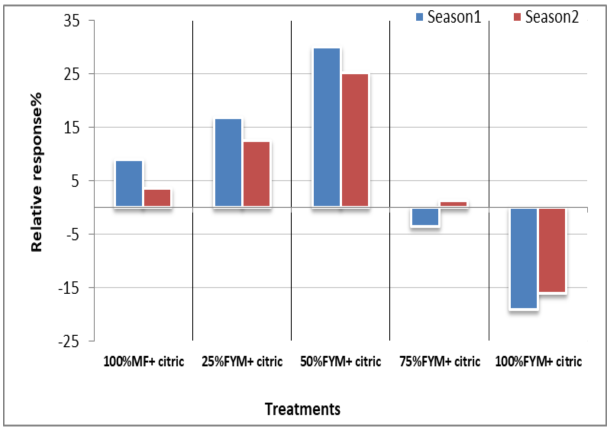

Fig. 3. Relative response% of fresh pod yield of feddan in snap bean grown under sandy soil conditions in seasons of 2015 and 2016.

The increase in the flowers and pods number/plant, total pods yield and pod characteristics may be due to convenient effect of FYM on the vegetative growth (Table 3 and Fig.1) and to adequate proportions of nutrition elements in available form by the presence of FYM as the slow-release fertilizers (Kolbe *et. al*,. 1995 and Marschner, 1995) in addition to, increment in performance of the activation of beneficial microorganisms in the soil (El-Gizy, 1994; Suresh *et. al*., 2004 and Remesh, 2008) and this helps in the transform of organic forms to mineral forms, which are the available forms to plants. Some examiner came to comparable results of snap bean plants (Gabr, 2000; El-Bassiony *et. al*., 2010 and Shafeek *et. al*., 2017). However, positive effects of assigned treatments on vegetative growth traits, as shown previously, may reflected on flowering, setting and yield and its attributes. El- Tohamy *et. al*., (2013) found that citric acid as foliar spray at 1.5g/l significantly increased snap bean yield and pod length and diameter under drought stress. This is may be attributed to the significant role of citric acid in the adjustment of metabolism and physiology of the plants under stress conditions (Silvente *et. al*., 2012).

3.Leaf chlorophyll and nutritional value of fresh pod:

The positive effect of citric acid and different levels of FYM on total chlorophyll content of leaf and pod, TSS% and protein% of pod in snap bean grown under adverse condition of sandy soil are shown in Table 5.

The highest chlorophyll content of leaf was obtained with citric acid foliar spray combined with 50%FYM, whereas, the highest records of chemical quality of pod were obtained with citric acid +100% FYM followed by citric acid combined with either 75% or 50% FYM.

These results agree with those of Awad *et. al*., (2007) and Al-Said and Kamal (2008) who found that nitrogen helps to increase chlorophyll content in the plant. In addition, Uchida (2000) pointed that adequate nitrogen level improved the quality and quantity of legumes protein and dry weight. However, citric acid, as antioxidant, has an important role before and during stresses exposure by mean of depressing oxidation action in the plant which helps healthy growth and development and eventually pod nutrition quality (Rakha, 2017).

Table 5. Chlorophyll contents of leaf and pod and crude protein and TSS percentages of pod as affected by different levels of FYM and foliar spray by citric acid in 2015 and 2016 seasons

Characters	Total leaf chlorophyll (mg/g fw)		Total pod chlorophyll (mg/g fw)		Total protein%		Pod TSS%	
Treatments	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	3.70	3.80	1.80	1.80	13.43	13.8	6.7	5.9
100%MF+CA	3.97	3.67	2.03	2.07	13.42	13.5	7.3	6.0
25%FYM + CA	3.93	4.00	2.00	2.23	13.7	13.7	7.0	6.0
50%FYM + CA	4.54	4.51	2.30	2.23	15.1	16.6	7.3	7.9
75%FYM + CA	4.13	4.20	2.10	2.23	15.1	17.0	7.9	7.8
100%FYM + CA	4.20	4.20	2.13	2.27	15.8	17.1	7.9	8.6
LSD5%	0.15	0.058	0.06	0.11	0.18	0.09	0.06	0.09

MF: mineral fertilizers; FYM: farmyard manure; CA: citric acid

RECOMMENDATION

On the light of the obtained results through the study, it is recommended to amend sandy soil with 50% farmyard manure + 50% of recommended mineral NPK to improve chemical, physical and microbial properties of sandy soil in order to provide sufficient amounts of water and nutritional elements for sensitive plants e.g., snap bean, in addition to foliar spray three times with 1.5g/l citric acid to overcome the oxidative stress and secure good yield and quality of fresh pods.

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تحسين إنتاجية وجودة الفاصوليا من خلال إضافة السماد العضوي و الرش الورقى بحمض الستريك تحت ظروف الأراضي المستصلحة حديثًا

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تعتبر الفاصوليا الخضراء من النباتات الحساسة لنقص الماء والعناصر الغذائية. لذلك فإن الدراسة الحالية تهدف الى الإستفادة من فوائد حمض الستريك (1.5جم/لتر) بمفرده او بالاضافة الى مستويات مختلفة من السماد العضوى [(بدون سماد عضوى (الكنترول) ، 25% ، 50% ، 75% و 100% من المعدل الموصى به] على النمو، والتزهير ، المحصول و الجودة فى الفاصوليا الخضراء صنف برونكو. وتمت الزراعة فى منطقة قلابشو التابعة لمحافظة الدقهلية – مصر خلال العروة الخريفية للعامين 2015 و2016. وأستخدم لذلك تصميم قطاعات كاملة العشوائية فى ثلاث مكررات. ولقد أعطت معاملة الرش الورقى بحمض الستريك مع معدل 50% من السماد العضوى أفضل النتائج لمعظم الصفات المدروسة مقارنة بمعاملة الكنترول (التسميد المعدنى الموصى به فقط) وباقى المعاملات. وعلى الرغم من أن معاملة الرش الورقى بحمض الستريك مع معدل 100% السماد العضوى قد تفوقت فى صفات الجودة للقرون متمثلة فى محتوى الكلوروفيل (2.13 و2.27 ملجم/ جم وزن غض) ، نسبة البروتين (15.8 و17.1 %) و نسبة المواد الصلبة الكلية (7.9 و 8.6%) لكلا الموسمين على التوالى، إلا أنها أعطت أعلى نسبة نقص لمحصول الفدان (حوالى 17.5%). بصفة عامة، أشارت النتائج الى الأهمية الكبيرة لإستخدام التسميد العضوى من أجل تحسين الحالة المائية والغذائية للتربة . بالإضافة الى أهمية المركبات المضادة للأكسدة مثل حمض الستريك للحد من التأثيرات الضارة لنقص الماء والعناصر فى التربة الرملية حديثة الاستصلاح.