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Enhancement of Cassava productivity in Egyptian new reclaimed lands by using different foliar application treatments

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Abstract: Two field experiments were carried out in new reclaimed lands at El Nobaria region (north of Egypt) during the two growing seasons of 2014 and 2015 aiming to enhance Cassava productivity by using different foliar application treatments. Six foliar spraying treatments, i.e., liquid bio-fertilizer, granular bio-fertilizer, mixed bio-fertilizers, urea, yeast and Moringa extract were compared to non-treated control. The experiments were carried out in a complete randomized blocks design in four replicates. The characters of vegetative growth (plant height, number of leaves per plant, and number of main stems and lateral branches, leaf area and the content of total chlorophyll), tuber yield and tuber characters as well as chemical contents of tuber roots were evaluated.

The results showed that, the monthly foliar spraying of all application treatments at 60, 90 and 120 days after Cassava planting increased all vegetative growth characters mentioned above and enhanced tuber roots productivity as well as improved chemical contents of Cassava tuber roots compared to non-treated control. The monthly foliar application of Moringa extract ranked the first to increase all vegetative growth characters, tuber yield and its characters, i.e., length and diameter as well as improved chemical contents of Cassava tubers, i.e., dry matter, starch, total carbohydrates, total fiber, N, P and K. Next to Moringa extract, spraying of yeast improved Cassava productivity, and then urea spraying came. The foliar application of mixed bio-fertilizers both of liquid and granular resulted in more stimulation in increasing Cassava productivity compared to single additive of liquid bio-fertilizer or granular bio-fertilizer.

Keywords: Cassava, foliar application, FZB24, Yeast, Urea, Moringa, Tuber yield and quality.

Introduction

World human population is expected to reach 8.0 billion by 2025, most of predicted population growth (97%) will be in the developing countries, including Egypt.With high severity change in global climate, developing countries are confronted with severe food-security challenges[1]. The challenge for agricultural sector in Egypt is to alleviate the negative impact of climate changes and environmental stresses. This should motivate us to introduce non-traditional crops in Egypt.

Cassava (*Manihotesculenta*Crantz) is one of the important crops in tropical regions of the world[2].It is a non-traditional vegetable root crop which considered one of the most important tropical root crops, known as "Africa's food security crop"[3]. Cassavais a major staple as it is produced both for direct consumption and industrial use. It is ranks fourth food crops in the developing countries which is a major source of low cost carbohydrates, cheapest caloric source and contains nearly the maximum concentration of starch compare to

other crops [4,5]. Cassava crop consumed as human food throughout varying degrees of processing, where, several recipes of Cassava are delicacies in the diet of the people[6]. Cassava flour is now added as a component for baking bread and biscuits. Sometimes, leaves are consumed as a vegetable, which are containing high levels of protein.

Cassava is considers as a new non-traditional vegetable crop in Egypt. Introduction and cultivation of Cassava in the newly reclaimed lands in Egypt showed very succeed and promising, since it can be mixed with wheat flour at a ratio about 15% for bread making[5,7,8].Further, for animal feed root flour can substitute maize with a ratio of 20 -30 %. In addition, it can depend on rich starch of Cassava roots as a cheapest alternative raw material source for several industrial purposes[5,7,9,10]. Thus,Cassava crop has a tremendous future in Egypt.

Considerably, as a new non-traditional crop, research work on Cassava is still rather limited in Egypt. Hence, more scientific and applied agronomical information is urgently needed to establish crop production knowledge and procedures to spread and enhance its cultivation under Egyptian conditions, especially in the newly reclaimed sandy soils, which suffering from nutrients limitation. The foliar application of different nutrient sources may improve plant growth and enhance the sustainable production of Cassave even under newly reclaimed lands. The rhizobacterium *Bacillus* strain FZB24, showed useful value and effective uses as bio-fertilizer and plant-strengthening agent for several vegetable crops even under different stress conditions such as salinity and water deficit, leading to reduce the impact effects of stresses [11,12,13,14,15,16]. Also, yeast is a natural bio-substance proven to be of useful stimulatory, nutritional and protective functions for several vegetable crops. The foliar spraying of yeast increased growth, yield and quality of many vegetable crops [14,17,18,19,20]. The beneficial effect of urea as an available and fast source for nitrogen, which isrequired in the largest amount by vegetable crops and essential for plant growth and its productivity are recognized[21,22,23,24].Also, the application of Moringa extract has been assumed to provide enhancement effects as plant-strengthening and natural nutrients source for several plant production[25,26,27].Therefore,the present study is aiming to evaluate different foliar applications of different nutrients sourceson the productivity of Cassava plants cultivated in newly reclaimed lands(sandy soils).

Materials and Methods

Two field experiments were conducted in newly reclaimed lands during the successive seasons of2014 and 2015 at theExperimental Station of the National Research Centre in El Nobaria region, Behira Governorate, north of Egypt to investigate the effect of different foliar application treatments of nutrients sources on growth, yield and chemical contents of Cassava plants.The soil texture is sandy with 78.6% sand, 13.9% silt and 7.5% clay. The pH was 7.5 and EC was 2.2dS/m. Sixfoliar spraying treatments were compared to non-treated control as follows:

1. Non-treated control.
2. Liquid bio-fertilizer and bio-control agent (FZB24®L, from ABiTEP GmbH, Berlin), contains natural plant growth-promoting rhizobacteria. After 60, 90 and 120 days from planting, plants were foliar sprayed (500ml product/200 L water/hectar).
3. Granular bio-fertilizer and bio-control agent (FZB24® WG, from ABiTEP GmbH, Berlin), contains spores of *Bacillus amyloliquefaciens*, a non-pathogen microorganism. For application, 0.2 ggranularproduct was dissolved into 1.0L water, androot zone was watered with bacterial spore-suspension (1.0 L/m^2) directly after planting. After 60, 90 and 120 days from planting, plants were foliar sprayed (250 g granular product/200 L water/hectar).
4. Mixed of bio-fertilizers, mixed of the above liquid and granular products.
5. Urea, plants were foliar sprayed (800 g urea/200 L water/hectar)after 60, 90 and 120 days from planting.
6. Yeast, dry yeast was foliar sprayed (800 g dry yeast/200 L water/hectar) three times after 60, 90 and 120 after planting.
7. Moringa extract,the powder dried leaves of *Moringaoleifera* were obtained from the Egyptian Scientific Association for Moringaas a natural stimulant product for plant growth. Moring extract was foliar applied (1000 g powder of dried leaves/200 L water/hectar)after 60, 90 and 120 days from planting.

Cassava was planted on 22nd April during the two growing seasons of 2014 and 2015. Cassava stalks of similar thickness of approximately 2.5 - 3.0 cm in diameter were cut into stalk cuttings of 25 - 30 cm in length and planted vertically by burring two-thirds of the cuttings into the soil and keeping one third of them over

ground, then irrigated directly after planting. The standard agricultural practices were carried out uniformly in all treatment plots as recommended, wherever they were necessary.20 m^3 organic manure and 500 kg Calcium super phosphate (15.5% P_2O_5)/feddan (4200m^2) were added during land preparationthrough the ditches before planting and ditches were covered by soil. Drip irrigation lines were used and spread over the ditches. Also, 250 kg Ammonium sulphate (20.5% N) as a source of Nitrogen and 200 kg Potassium sulphate (48% K_2O) as a source of potassium asrecommended doses for Cassava were added for all experimental plots. The total amounts of nitrogen and potassium fertilizers were divided into 4 equal doses. Fertilization program started at the fourth week after planting, and thenother doses were monthly applied. Cassava variety used in this experiment was Indonesian cultivar.

The experimental designwas a complete randomized blocks with four replications for each treatment.

Data recorded:

Vegetative growth parameters: Representative random samples of 8 plants were labeled in each replicate for every treatment at 180 days after planting and the following characters were recorded: Plant height, leaves number per plant, number of mainstemsand number of lateral branches,leaf area and total chlorophyll content.

Tuber yield and yield components: The following data were recorded, i.e., number of tubers per plant and tuber fresh weight, and root/shoot ratio was calculated according the following equation: Weight of tubers (g/plant) / Weight of shoot (g/plant).

Tuber characters: The following data were recorded, i.e., length of tuber and diameter of tuber, dry matter percentage of tubers.

Chemical composition of tubers: Starch percentage was determined as described by [28]. Total carbohydrates percentage was determined colorimetrically as gram of glucose /100 g dry weight of tubers according to the method of [29]. Total fibers percentage of root tubers was determined as described by[30].Nitrogen was determined in Cassava tubers according to method of [31]. Phosphorus was determined colorimetrically according to the method described by [32].Potassium was determined using Flame Photometer according to the method of[33].

Statistical analysis: The treatment effects were evaluated by analysis of variance. The differences among treatments mean values were compared using Duncans's multiple range test at P<5% as reported by [34].

Results

Vegetative growth characters:

The effect of different nutrients sources as foliar application treatments on vegetative growth characters of Cassava plants during two growing seasons of 2014 and 2015 is presented in Table (1).

The results showed that, themonthly foliar spraying of all application treatments,i.e., liquid bio-fertilizer, granular bio-fertilizer, mixed bio-fertilizers, urea, yeast and Moringa extract at 60, 90 and 120 days after Cassava planting increased all vegetative growth characters, i.e., plant height, number of leaves per plant and number of main stems and lateral branches, leaf area and chlorophyll contentcompared to non-treated control. The obtained datashowed that, thefoliar application of Moringa extract ranked the first inincreasing all vegetative growthcharacters of Cassava which mentioned above, followed by theyeast, urea, mixed bio-fertilizers(both granular bio-fertilizer with liquid bio-fertilizer)and lastlycoming individual application of granular bio-fertilizeror liquid bio-fertilizer.These findings were completely similar in both growing seasons.

Tuber yield and tuber characters:

The results presented in Table (2)exhibit the effect of differentfoliar application treatmentsof nutrients sources on Cassava yield and tuber characters during the growing seasons of 2014 and 2015.

The productivity of Cassava plants and tuber characters were foliar sprayed by all nutrients sourceswere much higher comparing with those non-treated control plants.The obtained datashowed that, Cassava yield as represented by number of tubers per plant, tuber fresh weight (g) and calculated tuber/shoot ratio wasimprovedand reached its maximum by foliar addition of Moringa extract during the two growing seasons.

Also, foliar spraying of Moringa extract recorded great enhancements in tuber characters, i.e., length and diameter as well as its dry matter percentage in both growing seasons. The same attitude on Cassava yield and tuber characters were found by foliar application of yeast, urea, mixed bio-fertilizers, granular bio-fertilizer and liquid bio-fertilizer, respectively, in descending order during the two growing seasons compared to non-treated control.

Table (1): Effect of different foliar application treatments on vegetative growth characters of Cassava plants at 180 days after planting in 2014 and 2015 seasons.

Foliar application treatments	First season (2014)						Second season (2015)					
	Plant height (cm)	Leaves number/ plant	Number of main stems	Lateral branches/ plant	Leaf area (cm^2)	Chlorophyll content	Plant height (cm)	Leaves number/ plant	Number of main stems	Lateral branches/ plant	Leaf area (cm^2)	Chlorophyll content
Non-treated control	127 D	126.3 D	2.3 C	3.2 C	122.3 C	39.8 C	129 D	117.0 D	2.7 C	2.8 C	122.0 C	41.3 C
Liquid bio-fertilizer	133 D	132.3 D	2.6 C	3.6 C	132.9 C	41.1 C	133 D	124.5 D	2.9 C	3.6 C	128.9 C	42.7 C
Granular bio-fertilizer	145 C	143.2 C	3.3 B	4.8 B	145.9 B	44.8 B	148 C	139.3 C	3.6 B	4.8 B	148.9 B	45.0 B
Mixed bio-fertilizers	152 C	151.2 B	3.7 B	4.9 B	159.5 B	45.1 B	158 C	151.9 B	3.9 B	4.9 B	159.5 B	46.5 B
Urea	172 B	172.5 A	4.9 A	6.0 B	160.9 A	49.9 A	179 B	174.9 A	5.4 A	5.8 B	160.9 A	50.9 A
Yeast	182 A	174.2 A	5.7 A	6.3 A	164.2 A	51.6 A	182 A	175.9 A	5.7 A	6.9 A	164.8 A	52.0 A
Moringa extract	187 A	178.2 A	5.8 A	6.4 A	166.9 A	52.2 A	186 A	177.4 A	5.9 A	7.1 A	165.9 A	53.6 A

The values in the column having the same letter are not significantly different at P= 0.05.

Table (2): Effect of different foliar application treatments on tuber yield and tuber characters of Cassava plants at 180 days after planting in 2014 and 2015 seasons.

Foliar application treatments	First season (2014)						Second season (2015)					
	Tubers number/ plant	Tuber weight (g)	Tuber/ shoot ratio	Tuber length (cm)	Tuber diameter (cm)	Dry matter (%)	Tubers number/ plant	Tuber weight (g)	Tuber/ shoot ratio	Tuber length (cm)	Tuber diameter (cm)	Dry matter (%)
Non-treated control	9.4E	289.8 D	1.27 B	29.8 C	3.79 B	32.13 D	8.5 E	286.7 D	1.26 B	30.2 C	3.61C	31.98 D
Liquid bio-fertilizer	10.1 D	290.8 D	1.26 B	34.9 B	4.02 B	32.39 D	10.1 D	289.8 D	1.29 B	34.9 B	3.89 B	33.49 C
Granular bio-fertilizer	12.4 C	296.7 C	1.25 B	35.2 B	3.97 B	34.63 C	11.8 C	298.7 C	1.25 B	36.2 B	3.92 B	33.63 C
Mixed bio-fertilizers	13.6B	314.3 B	1.29 B	37.9A	4.58 A	34.62 C	12.4 B	309.9 B	1.28 B	37.1 B	4.49 A	34.19 C
Urea	13.5 B	313.2 B	1.38 B	35.3 B	4.74 A	37.02 B	12.8 B	311.0 B	1.41 B	36.9 B	4.54 A	37.84 B
Yeast	13.6B	325.7 A	1.78 A	38.2 A	4.81A	36.23 B	13.3 A	325.9 A	1.76 A	40.5 A	4.65 A	36.93 B
Moringa extract	14.1 A	334.4 A	1.75 A	39.5 A	4.82 A	39.57 A	13.5 A	329.2 A	1.79 A	40.9 A	4.71 A	40.12 A

The values in the column having the same letter are not significantly different at P= 0.05.

Chemical composition:

Data presentedin Table (3)show the response of chemical constituents, i.e., starch, total carbohydrates, total fiber, Nitrogen (N), Phosphorus (P) and Potassium (K) in tuber tissuesof Cassava plantsto different foliar application treatments during the growing seasons of 2014 and 2015.

The chemical contents of Cassava tubers were improved in all foliar sprayed plants, at 60, 90 and 120 days after planting, compared to non-treated control plants. The obtained results indicated that Cassava plants which were foliar sprayed by Moringa extract contained the highest values of starch, total carbohydrates, N, P and K as well as less content of fiber in tubers tissues during the two growing seasons. The other foliar application treatments, i.e., yeast, urea, mixed bio-fertilizers, granular bio-fertilizer and liquid bio-fertilizer, respectively, in descending order,increased chemical quality composition of Cassava tubers by increasing the values of starch, total carbohydrates, N, P and Kand decreasing fiber contents in tuber tissuesduring the two growing seasons. The non-treated control plants resulted in Cassava tubers contained the lowest values of starch, total carbohydrates, N, P and K as well as muchfiber contents in tuber tissues. These findings were completely similar during the two growing seasons.

Table (3): Effect of different foliar application treatments on chemical contents of tuber roots of Cassava plants at 180 days after planting in 2014 and 2015 seasons.

Foliar application treatments	First season (2014)						Second season (2015)					
	Starch (%)	Total carbohydrates (%)	Total fibers (%)	N (%)	P (%)	K (%)	Starch (%)	Total carbohydrates (%)	Total fibers (%)	N (%)	P (%)	K (%)
Non-treated control	51.01 B	59.56 C	2.83 A	0.73 C	0.22 C	0.86 C	48.49 B	53.83 E	2.34 A	0.71 C	0.25 C	0.85 C
Liquid bio-fertilizer	50.18 B	61.98 B	2.76 A	0.81 B	0.23 C	0.83 C	48.77 B	56.23 D	2.31 A	0.79 B	0.24 C	0.84 C
Granular bio-fertilizer	53.56 A	60.17 C	2.51 B	0.85 B	0.26 B	0.82 C	48.51 B	61.87 C	2.16 B	0.86 B	0.26 C	0.86 C
Mixed bio-fertilizers	53.85 A	62.90 B	2.33 C	0.84 B	0.28 B	0.89 C	49.94 B	66.43 B	2.07 C	0.85 B	0.30 B	0.89 C
Urea	51.69 A	62.77 B	2.56 B	0.97 A	0.27 B	1.00 B	50.98 B	65.31 B	2.19 B	0.97 A	0.26 C	1.05 B
Yeast	53.95 A	64.94 A	2.58 B	0.94 A	0.31 A	1.07 A	51.18 B	66.19 B	2.14 B	0.95 A	0.32 B	1.08 A
Moringa extract	54.84 A	65.43 A	2.25 C	0.98 A	0.32 A	1.12 A	55.84 A	69.31 A	2.05 C	0.99 A	0.37 A	1.10 A

The values in the column having the same letter are not significantly different at P= 0.05.

Discussion

The aim of presented experiment is to enhance Cassava productivity under Egyptian conditions in new reclaimed lands, which suffering from limitation of nutrients and water resources. The foliar application of different nutrients sources may be the direct, cheap and effective way to avoid any problem in nutrients uptake by root system[12,14,17,18,19,20,22,24,35].Indeed, the obtained results of the presented study reported positive effects for all foliar sprayed treatments on growth, yield and tuberqualityofCassaveplants compared to non-treated control.The maximum increments in growth, productivity and quality were associated with monthly foliar application of Moringa extract. All growth parameters in terms of plant height, number of leaves per plant and number of main stems and lateral branches, leaf area and chlorophyll content of Cassava plants as well as tuber yield and its quality were observed to be maximum by monthly foliar application of Moringa extract. The positive effect for Moringa extract may be due to its high contents of nutrients and vitamins (Table 4), which may be attributed to more availability of nutrients for photosynthetic process and the assimilation rates, which leading to increase the vegetative growth and tubers yield of Cassava.

Table (4):Analysis of Moringa leaves.

Carbohydrate, %	38.2
Protein, %	27.1
P, mg/kg	2040
K, mg/kg	13240
Mg, mg/kg	3681
S, mg/kg	8700
Ca, mg/kg	20030
Zn, mg/kg	46
Mn, mg/kg	10.5
Fe, mg/kg	282
B, mg/kg	4.1
Cu, mg/kg	5.9
Vitamin A (Beta Carotene), mg/kg	163
Vitamin B1(Thiamin), mg/kg	26.4
Vitamin B2 (Riboflavin), mg/kg	206
Vitamin B3 (Niacin), mg/kg	82
Vitamin B6 (Pyridoxine), mg/kg	33
Vitamin C (Ascorbic Acid), mg/kg	163.5
Vitamin E (Tocopherol), mg/kg	92.3

The obtained results are in conformity and accordance with the findings ofmany authors such as [12,14,17,18,19,20, 22, 24,35,36,37].

Conclusion

Cassava productivity was enhanced by using foliar spraying of several additives of nutrients sources. Where, the monthly foliar applications of Moringa extract ranked the first to increase all vegetative growth characters, tuber yield and tuber characters as well as improved chemical contents of Cassava tubers.

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