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Enhancing Onion Yield, Quality, Storability and Profitability by Using FYM, Copper and Bio-fertilizer

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THIS INVESTIGATION explored the effect of copper application under organic and bio-fertilization on onion growth, yield and yield components, chemical contents and bulb storability as well as economic efficiency during 2018/2019 and 2019/2020. In this research, the design of the experiments was split-split design in complete randomized blocks in four replications. The factors were: A. farmyard manure (0.0, 12 and 24 t ha^{-1}) where arranged in the main plots, B. copper (0.0 and foliar spray of copper sulphate at rate of 0.1% twice, about 600 L ha^{-1}) where randomly allocated in sub plots, and C. biofertilizer (0.0 and inoculation with *Azotobacter chroococcum* inoculant) where randomly applied in sub- sub plots. The results indicated that increasing FYM levels, foliar spraying of Cu and bio-fertilization improved all studied onion quality and quantity, except copper concentration in onion leaves at 75 days age which affected only by copper application. From the results of this research, it could be recommended to fertilize onion plants with 12 t ha^{-1} of FYM instead of 24 t ha^{-1} with Cu spraying and biofertilizer inoculation to maximize the quality, quantity, storability and net return of onion grown in alluvial soil at Middle Egypt conditions.

Key Words: Onion yield, Storability, Profitability, Economic analysis, FYM, Copper, Bio-fertilizer

Introduction

Onion (*Allium cepa* L.) is considered to be an economically important vegetable grown worldwide and used year-round, fresh, and processed. Onion contains carbohydrates, vitamins, minerals, antioxidants, and essential oils (Roldan et al., 2008 and Sekara et al. 2017). Bulb onion originated in the Mediterranean region and south west Asia. The ancient of Egypt, China and India have been used onion since over 4000 years. Onion not only used as cooking to provide flavor, but also it contains vitamin C and K, meanwhile its content of Na is very low (Hamasaki et al., 1999). About 3, 295, 143 hectares are cultivated all over the word produced about 74, 250, 809 tones, while Egypt cultivated about 77857 hectares in 2018 season, which produced about 1875740 tones (Adam and Fangary, 2020). It is a plant of very high culinary value, e.g., chopped or minced as well as medicinal value.

Copper is an essential nutrient for plant which induce the activation of various enzymes. It helps in the formation of protein, in term causes a synthesis of soluble nitrogen compounds. The healthy plants contain about 8-20 $\mu g g^{-1}$ copper, while the deficient plants contain less than 6 $\mu g g^{-1}$. Allam et al. (2013) and Rahman et al. (2015) reported that treated onion plants with copper as foliar spraying enhanced its growth parameters, yield components and yield. Also, Ballabh et al. (2013) stated that supplied onion plants with copper led to highest quality content and yield increases.However, an adequate nutrient supply requires a good knowledge of different guidelines including the rate of supply, the timing supply, the chemical forms, and the downward movement in the soil. Copper sulfate ($CuSO_4.5H_2O$) is commonly used by farmers regarding its solubility and its low cost (Souza et al., 2015).

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The use of inorganic fertilizers without supplementation with organic manure led to micronutrient deficiencies, imbalance of chemical and physical properties, consequently unsustainable crop production (Yohannes et al., 2017). Organic manure decomposition provides more nutrients to plants and resulted to higher nutrient uptake, in turn higher yield (Shaheen et al., 2007). Aisha et al (2007) reported that chemical fertilizers caused many harmful effects to human health and the environmental conditions. N, P and K are lost by leach down into soil. Organic manure holds nutrients in available form, which enhance enzymes and hormones as well as nutrients needed for soil fertility and production (Bhuma, 2001). Shaheen et al (2007) reported that organic and biofertilizers increased onion yield by suppling it by essential nutrients and improve soil biological, physical and chemical properties. In this concern, Kumar et al (2019) reported that organic fertilizers provide several benefits such as improve soil structure and enhances microorganism's activity, consequently good human health.Overall, excessive amounts of inorganic fertilizers are applied to onion in order to achieve a higher bulb yield (Shedeed, et al., 2014).

The biofertilizer is the micro-organisms inoculant, which used as seed inoculation. It is able to convert the unavailable nutrients to available ones through several biological processes (Aswani et al., 2005 and Fawy et al., 2016). It is considered as inexpensive source of nutrients than other fertilizers which don't need non-renewable source of energy for their production. The bio-fertilizer is biologically active strains micro-organisms which helpful to plant growth by improving soil fertility (Somani et al., 1990). Nobu (1993) and Yadav (2006) stated that integrated chemical fertilizers, organic manure such as FYM, compost…. etc. and biofertilizers led to reduce in nutrient losses and environmental pollution as well as increasing onion production. Moreover, Wu et al (2005) cleared that biofertilizer improved the growth substances such as indole acetic acid, gibberellins, as well as cytokinin materials. Many workers stated the beneficial effect of biofertilizers on onion quality and quantity such as Shaheen et al (2007), Abou El-Salehein et al (2014), Kumar et al (2019) and Rafique et al (2019).In general, biofertilizers can be successfully applied to onion plants under conditions which are favorable for the effective action of a particular kind of fertilizer, but the expectations of their potential should be reasonable (Petrovic et al. 2020).

This investigation explored effects of copper application under organic and bio-fertilization on onion growth, yield and yield components, chemical contents and bulb storability as well as economic efficiency.

Materials and Methods

Plant materials and soil analysis

Two field experiments were conducted in the experimental Farm of Sids Agricultural Research Station, ARC, Beni-Suef Governorate, Egypt (Lat. 29° 04⁻ N, long. 31° 06⁻ E and 30.40 m above the mean sea level) at 2018-2019 and 2019-2020 seasons to assess the response of quality, quantity and storability of onion plants (*Allium cipa* L.) to copper, farmyard manure and biofertilizer application. Some physical and chemical properties of the experimental sites were determined according to Klute (1986) and Page et al. (1982), respectively and listed in Table 1.

TABLE 1. Some physical and chemical properties of the experimental soil before planting

Soil properties	2018/2019	2019/2020
Physical properties		
Particle size distribution:		
Clay (%)	55.64	56.07
Silt (%)	28.81	26.61
Sand (%)	16.55	17.32
Texture grade	Clay	Clay
Chemical properties		
pH (1:2.5 soil-water suspension)	7.9	8.0
EC, soil paste (dS m^{-1})	1.05	1.20
Organic matter (g kg^{-1})	18.1	17.2
Available N (mg kg^{-1})	22.0	19.0
Available P (mg kg^{-1})	12.0	14.0
Available K (mg kg^{-1})	181.0	176.0
Available Cu (mg kg^{-1})	0.5	0.4

Treatments and experimental design

The design of the experiments was split-split design in complete randomized blocks in four replications. The factors were: A. farmyard manure (0.0, 12 and 24 t ha^{-1}) where arranged in the main plots (some chemical properties of used farmyard manure are listed in Table 2, according to A.O.A.C, 1990), B. copper [0.0 and foliar spray of copper sulphate ($CuSO_4.5H_2O$, MW.159.609, El Nasr Pharm. Chem. Co. Production, Egypt)at rate of 0.1% twice, about 600 L ha^{-1}] where randomly allocated in sub plots, and C. biofertilizer (0.0 and inoculation with *Azotobacter chroococcum* in inoculant) where randomly applied in sub- sub plots. The farmyard manure was added before planting during land preparation, while bio-fertilizer only treated onion transplantswas performed by soaking onion transplants in *Azotobacter chroococcum* inoculant for 20 minutes before transplanting, where the *Azotobacter chroococcum* in inoculant contain active microorganisms that responsible for fixed atmospheric nitrogen [*Azotobacter chroococcum* DSM 2286 was grown in King's medium (Atlas, 1995). Cultures were incubated at 28 ºC for three days on a rotary shaker until the early log phase to ensure a population density of 109 cfu/ml culture. This strain (*Azotobacter chroococcum* DSM 2286), was obtained from bank strains of Laboratory Soil Microbiology, Department of Microbiology Section, Soil, Water and Environment Institute, ARC. The strain was previously defined by genotypic identification which performed by amplification and partial nucleotide sequencing of the 16s ribosomal DNA (16s rDNA) (El Zemrany et al., 2015)]. However, foliar spraying of copper sulphate $CuSO_4.5H_2O$ 0.1% (1 gram/Litter water) was added twice after one month and one month later from transplanting by using sob solution.

The field planting

The plot area was 3×3.5 m (10.5 m^2 = 1/1000 ha^{-1}). The seedling (Giza 20 variety) was transplanted on 15 and 20 November, respectively at spacing of 10 cm between plants and 60 cm between rows.75 kg P_2O_5 ha^{-1} as superphosphate (15.5 % P_2O_5) was added before transplanting during land preparation. Also, 290 and 115 kg N and K_2O ha^{-1} as ammonium nitrate (33.5 % N) and potassium sulphate (48 % K_2O) were added in two equal doses, the first before the first irrigation and the other at one month later. The recommended culture practices for onion plants were done as in district, where weeds and pests were controlled manually or biologically to avoid copper interaction.

The recorded data

Growth parameter and nutrient status

Five onion plants were randomly taken from each plot after 75 days from transplanting to measure some growth parameters such as plant height, number of leaves $plant^{-1}$ and fresh weight $plant^{-1}$ as well as some nutritional status, e. g. and N, P and K content. NPK content were determined in inner mature leaves according to A.O.A.C. (1990).

Yield and quality characters

At harvesting (about 120 days from transplanting), total bulb yield was determined from each plot. Also, five plants from each plot were randomly taken to measure bulb diameter and bulb weight. Moreover, total soluble solids were measured by using Digital Refractometer.

Storability characters

A representative 50 onion bulbs were randomly taken to store under natural atmosphere for two, four and six months from 15 April to 15 October. The percentage of dry matter and total soluble solids were monthly determined during the period of storage. The weight loss (%) was calculated according to following equation:

weight loss(%)= (weight at start period of storage-weight of the end storage period)/(weight at start period of storage) x100

TABLE2. Some chemical properties of used farmyard manure.

Chemical properties	2018/2019	2019/2020
pH	7.79	7.82
EC, dS m^{-1}	4.53	4.71
Total nitrogen (g kg^{-1})	14.7	14.4
Total phosphorus (g kg^{-1})	2.7	2.9
Total potassium (g kg^{-1})	11.3	10.6
Organic carbon (g kg^{-1})	274.1	268.5
Organic matter (g kg^{-1})	472.6	462.9
C/N ratio	1:19	1.19

Economic study

The economic study include: 1- estimate the net return and benefit cost ratio of the treatments. The cultivation cost was determined as the sum of land rent, land preparation, seedling fertilizers, irrigation, pest control, labor and others. 2- Gross return, estimated by multiplying the bulb yield by local price at harvest. 3- Net return, was calculated by subtracting the total cultivation cost from gross return. 4- Benefit cost ratio, was calculated as the following equation:

Benifit cost ratio= (Gross return) / (Cost of cultivation)

Statistical analysis

The obtained data were statistically analyzed by analysis of variance according to method described by Snedecor and Cochran (1980). Duncan's multiple range for comparing the differences between treatment means was used at the probability level of 0.05.

Results and Discussion

Growth parameters

The data of the effect of FYM, copper and biofertilizer on onion growth parameters, namely, plant height; number of leaves/plant and fresh weight/plant were presented in Table 3. Results show that the studied growth parameters were significantly affected by FYM application. Added 12 t FYM ha^{-1} increased the abovementioned parameters 22.7, 14.3 and 16.5 % over without manuring in both seasons, respectively the same trends were obtained in the second season. The promotive effect of FYM on onion growth is mainly due to FYM contain different nutrients, which enhancing the cell division, elongation and vegetative growth (Mahmoud et al., 2017 and Gererufael et al., 2020), beside its direct effect on soil properties.Moreover, Marschener (2012) indicated that the positive effect of FYM may be attributed to its role in improving the soil physical and chemical properties, including aggregation, permeability, water holding capacity and soil pH, consequently improved root absorption. These results are in line with those obtained by Bashir et al. (2015) and Kumar et al. (2019).

Concerning the copper effect, the obtained results reveal that foliar spraying of 0.1% Cu led to increase growth parameters of onion. Comparing with no copper, supplied onion plants with copper resulted in 4.6, 2.3 and 2.6 % increasing in plant height, number of leaves /plant and fresh weight /plant in the first season, respectively in the first season. The corresponding increasing in the second season were 4.4, 3.0 and 3.3 % in the same respect. The positive effect of copper on the vegetative growth of onion may be due to copper is essential micronutrients for plants which play as important role for activation of many enzymes (El-Hadidi et al., 2016). These results agree with those obtained by Allam et al. (2013), Ur Rahman et al. (2015) and El-Zemrany et al. (2016).

As for bio-fertilizer, the data clearly show that using biofertilizer led to significant increasing in the studied growth parameters of onion plants. Using biofertilizer gave values of onion plant height, number of leaves /plant and fresh weight / plant higher than no bio-fertilizer by about 4.6, 2.3 and 2.6 % in the first season, and 4.4, 2.6 and 2.3 % in the second one. In this connection, Subbo-Rao (1988) mentioned that bio-fertilizer led to improve the availability of nutrients, hence increasing onion growth parameters. He added that bio-fertilizer decreased the amount of chemical nitrogen fertilizer by about 25% also enhances the plant growth and bulb yield due to release of hormones, vitamins and nutrients. Similar findings were also reported byVachan and Tripathi (2017), Shah et al. (2019) and El zemrany and Faiyad (2021).

As for the effect of the interaction between treatments, results show that the studied onion growth parameters were significantly affected by the interaction between FYM and copper (A×B), FYM and bio-fertilizer (A×C) and among the three factors (A×B×C), where both copper or bio-fertilizer did not affect growth parameters under the high organic manure level (24 t ha^{-1}). Also, it is obvious to notice that the effect of 12 t ha^{-1} FYM + copper + bio-fertilizer is in part to treatment of 24 t ha^{-1} FYM with or without copper or bio-fertilizer. In general, the highest values of onion growth parameters were obtained under the treatment of 12 or 24 t ha^{-1} FYM + CU + bio-fertilizer. On the other, the treatment of without FYM, Cu and bio-fertilizer exhibited the lowest ones.

Nutrient status

The nutrient status in onion leaves at 75 days age as expressed as N, P, K and Cu concentration are presented in Table 4. The data show that N, P, K and Cu content in onion leaves were positively affected by FYM application. Increasing FYM levels up to 24 t/ha increased N, P, K and Cu concentration by about 38.8, 25.7, 14.8 and 67.6 % over without manuring treatment, respectively in the first season. Same trends were obtained in the second season. The positive effect of FYM on nutrient status of onion leaves may be due to FYM addition increased organic matter in soil, in turn enhance soil water holding capacity and nutrient solubility (Reddy and Aruna, 2008). Also, cook (1982) indicated that FYM decomposition resulted in produces humate salts, which helps to adsorb nutrients for plants. Similar results were obtained by Abou-El-Salehein et al (2014) and Doklega (2017).

Regarding copper application, the data show that foliar spraying of copper resulted in significant increasing only on copper content in onion leaves, while N, P and K unaffected. The relative increment in copper content due to copper application reached to 13.8 and 12.1 % over without copper in both seasons respectively. The foliar application with CuSO4 might be due to their critical role in crop growth, implicated in photosynthesis processes, respiration and other biochemical and physiological activates. The positive effect of copper application on copper content in onion leaves were reported by many workers, such as Ur Rahman et al (2015) and El-Hadidi et al (2016).

As for bio-fertilizer, the data revealed that, using Azotobacter in as bio-fertilizer gave highest N, P, K and Cu concentration in onion leaves than without bio-fertilizer treatment. The promotive effect of bio-fertilizer in nutrient status may be attributed to bio-fertilizer increased N-fixing activities and inducing growth substance, consequently improved the nutrient adsorption by plant roots (Wu et al., 2005). These results are in harmony with those obtained by Tadav et al (2005) and Shaheen et al (2007) who reported that N, P, K and Cu content in onion leaves increased by using bio-fertilizer.

The data of the interaction indicated that nutrient composition of onion leaves unrespond to the interaction between treatments. This means that the highest N, P and K content was recorded for plants supplied with 24 t ha^{-1} FYM and treated with bio-fertilizer. However, the plants fertilized with 24 t ha^{-1} FYM + bio-fertilizer + foliar spraying of copper exhibited the highest values of copper content. Many workers stated the promotive effect of combined organic manure with bio-fertilizer on nutrient content such as Mondal et al (2004) and Abou-El-Salehien et al (2014).

TABLE 3. Growth parameters at 75 days age as affected by FYM, Cu and biofertilization

Treatments			1st season			2nd season		
FYM (t/ha)	Copper (CU)	Bio-fertilization	Plant height (cm)	No. of leaves/plant	Fresh weight/plant	Plant height (cm)	No. of leaves/plant	Fresh weight/plant
0.0	Without	Without	42.72e	10.52c	11.82 c	45.67 e	10.86 c	11.97 c
		With	47.15d	10.93c	12.41 c	50.07 d	11.20 c	12.73 c
	With	Without	46.51d	11.01c	12.50 c	48.63 d	11.29 c	12.78 c
		With	50.33c	11.54 b	12.83 b	54.02 c	11.86 b	13.03 b
12	Without	Without	52.76c	11.35 b	12.84 b	55.67 c	11.61 b	13.06 b
		With	56.03 b	11.86 b	13.25 b	58.91 b	11.99 b	13.62 b
	With	Without	55.05 b	11.93 b	13.53 b	58.26 b	12.18 b	13.76 b
		With	59.17 a	12.36 a	14.04 a	60.36 a	12.65 a	14.29 a
24	Without	Without	59.72 a	12.64 a	14.37 a	60.72 a	12.93 a	14.70 a
		With	59.14 a	12.72 a	14.36 a	60.91 a	12.90 a	14.72 a
	With	Without	59.81 a	12.73 a	14.42 a	60.88 a	12.94 a	14.73 a
		With	59.56 a	12.65 a	14.39 a	60.80 a	12.92 a	14.71 a
Mean of FYM (t/ha):								
0.0			49.60 c	11.31 c	12.63 c	46.68 c	11.01 c	12.40 c
12			58.30 b	12.11 b	13.69 b	55.78 b	11.88 b	13.42 b
24			60.83 a	12.93 a	14.72 a	59.69 a	12.69 a	14.39 a
Mean of Copper (cu):								
without			55.33 b	11.92 b	13.47 b	55.92 b	11.67 b	13.18 b
with			57.16 a	12.31 a	13.89 a	55.23 a	12.02 a	13.62 a
Mean of Biofertilization:								
without			54.97 b	11.97 a	13.50 b	52.76 b	11.70 a	13.25 b
with			57.52 a	12.25 a	13.85 a	55.07 a	12.01 a	13.55 a

TABLE 4. leaf chemical content at 75 days ages as affected by FYM, Cu and biofertilization

Treatments			1st season				2nd season			
FYM (t/ ha)	Copper (CU)	Bio-fertilization	N%	P%	K%	Cu µgg-1	N%	P%	K%	Cu µgg-1
0.0	Without	Without	3.13a	0.32 a	2.91 a	15.11 a	3.05 a	0.35 a	2.94 a	13.52 a
		With	3.35 a	0.37 a	3.02 a	15.31 a	3.21 a	0.39 a	3.07 a	13.71 a
	With	Without	3.16 a	0.31 a	2.92 a	18.16 a	3.08 a	0.37 a	2.95 a	16.08 a
		With	3.34 a	0.37 a	3.03 a	18.29 a	3.14 a	0.40 a	3.06 a	16.15 a
12	Without	Without	3.65 a	0.38 a	3.15 a	22.76 a	3.49 a	0.40 a	3.18 a	19.96 a
		With	3.82 a	0.41 a	3.37 a	22.53 a	3.71 a	0.45 a	3.40 a	19.73 a
	With	Without	3.68 a	0.37 a	3.16 a	25.19 a	3.51 a	0.41 a	3.18 a	21.68 a
		With	3.87 a	0.40 a	3.37 a	25.23 a	3.72 a	0.45 a	3.41 a	21.76 a
24	Without	Without	4.34 a	0.41 a	3.30 a	26.39 a	4.11 a	0.47 a	3.35 a	24.06 a
		With	4.67 a	0.45 a	3.52 a	26.40 a	4.42 a	0.51 a	3.67 a	24.15 a
	With	Without	4.40 a	0.42 a	3.31 a	29.63 a	4.13 a	0.46 a	3.36 a	26.65 a
		With	4.61 a	0.45 a	3.54 a	29.69 a	4.40 a	0.50 a	3.65 a	26.71 a
Mean of FYM (t/ha):										
0.0			3.25 c	0.35 c	2.98 a	16.72 c	3.12 c	0.38 b	3.01 a	14.87 c
12			3.76 b	0.40 b	3.27 a	23.93 b	3.61 b	0.44 a	3.30 a	20.79 b
24			4.51 a	0.44 a	3.42 a	28.03 a	4.27 a	0.48 a	3.51 a	25.40 a
Mean of Copper (cu):										
without			3.83 a	0.39 a	3.21 a	21.42 b	3.67 a	0.43 a	3.27 a	19.19 b
with			3.85 a	0.39 a	3.22 a	24.37 a	3.67 a	0.43 a	3.27 a	21.51 a
Mean of Biofertilization:										
without			3.73 b	0.37 b	3.13 b	22.87 a	3.56 b	0.41 b	3.16 b	20.33 a
with			3.94 a	0.41 a	3.31 a	22.91 a	3.77 a	0.45 a	3.38 a	20.37 a

Average bulb weight and total bulb yield

The data in Fig. 1 and 2 show the effect of FYM, Cu and bio-fertilizer on average bulb weight and total bulb yield. The data clearly indicate that increasing FYM levels up to 24 t ha^{-1} were gradually increased bulb weight and yield in both seasons. Comparing with control, added 24 t FYM ha^{-1} increased bulb weight and total bulb yield by about 40.1 and 41.2 % in the first season, respectively. Same trends were obtained in the second season. The promotive effect of FYM on onion yield is mainly due to its positive effect on growth parameters as discussed before (Table 3). These results are in accordance with those obtained by Doklega (2017) and Kumar et al (2019) who stated that applied FYM at high level led to highest average bulb weight and total bulb yield.

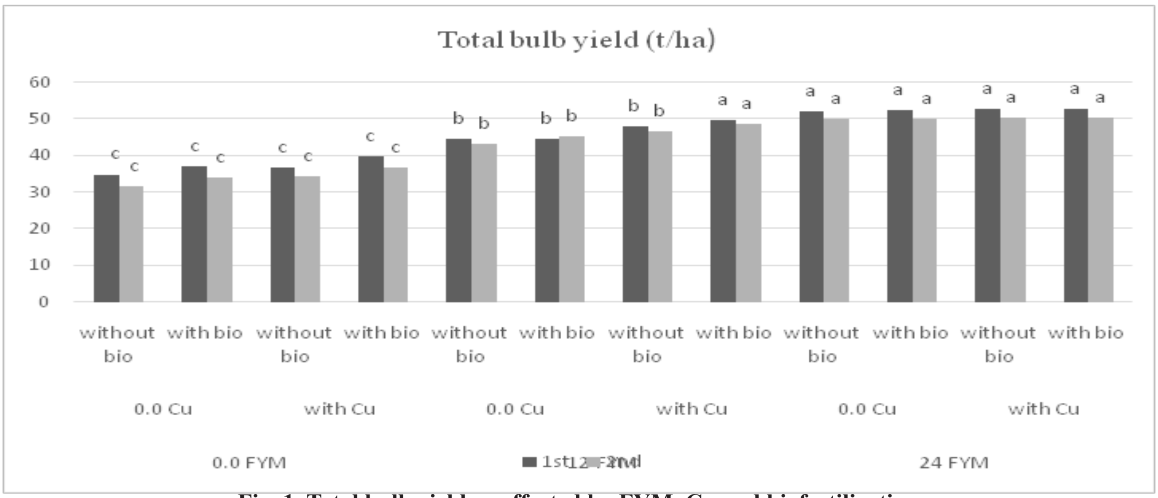

Fig. 1. Total bulb yield as affected by FYM, Cu and biofertilization

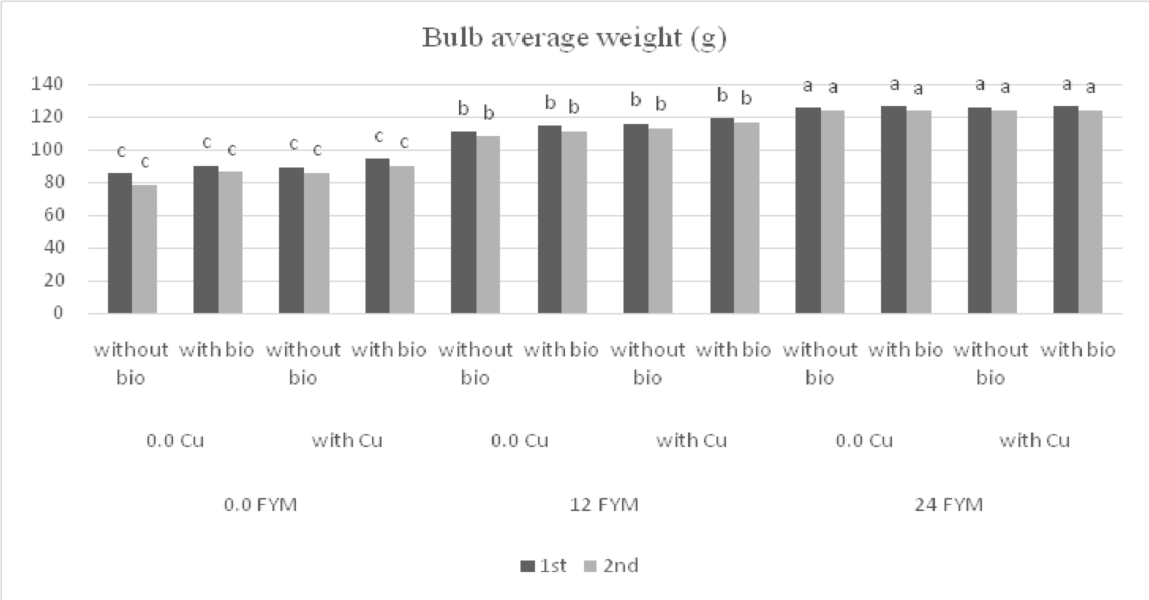

Fig. 2. Bulb average weight as affected by FYM, Cu and biofertilization

As for foliar application of copper, the results reveal that supplied onion plants with copper yielded higher bulb weight and bulb yield than without copper application. Added copper gave average bulb weight (111.65 g) and total bulb yield (46.67 t ha^{-1}) surpassed that without copper (108.67 g and 44.79 t ha^{-1}) by about 2.7 and 4.2 %, respectively in the first season. Similar trends were obtained in the second season. The beneficial effect of copper on increasing onion yield may be due to the role of copper as essential micronutrients on activation many enzymes, consequently on plant growth (El-Hadidi et al., 2016). These results are similar to those obtained by Alan et al (2013) and Ballabh et al (2013).

With regard to the effect of bio-fertilizer, data indicated that fertilized onion plants with bio-fertilizer resulted in significant increasing in both average bulb weight and total bulb yield. Treated onion plants with Azotobacter as bio-fertilizer exhibited greater average bulb weight (111.69 and 108.79 g) and total bulb yield (46.62 and 44.23 t ha-1) that without bio-fertilization treatment (108.63 and 105.36 g) and (44.83 and 42.78 t ha-1) respectively in both seasons. The positive effect of bio-fertilizer on bulb weight and yield could be explained by its effect on growth parameters as mentioned before (Table 3). These results are in harmony with those obtained by Kumar et al (2019) and Shah et al (2019) who stated that bio-fertilization had positive effect on both average weight and total bulb yield.

The data of the interaction indicated that average bulb weight and total bulb yield were affected by the interaction between FYM and Cu (A×B), the interaction between FYM and bio-fertilizer (A×C) and the interaction among the three studied factors (A×B×C), where copper or bio-fertilizer unaffected average bulb weight or total bulb yield under the high FYM level (24 t ha^{-1}). In general, the treatment of 12 t FYM ha^{-1} + foliar spraying of copper + bio-fertilizer gave bulb weight or total bulb yield at par with the treatment of 24 t FYM ha^{-1} with or without both copper and bio-fertilizer. This means that it could save about 12 t FYM ha^{-1} by using copper + bio-fertilizer. On the other hand, the plants without each of FYM, Cu and bio-fertilizer recorded the lower values of average weight and total bulb yield.

Bulb quality

Bulb quality expressed as bulb diameter, dry weight (%) and T.S.S (%) is one of the most important characters of onion crop which increases their market return rends were obtained. It is evident from the data in Table 5 that the three studied onion quality were significantly improved due to FYM application. Increasing organic manure level up to 24 t ha^{-1} resulted in increasing bulb diameter, dry matter % and total soluble soiled (%) by about 26.7, 3.7 and 13.3 % over without manuring in the first season, respectively. Similar trends were obtained in the second season. The positive effect of FYM on bulb diameter may be attributed to farmyard manure as organic fertilizer contain higher levels of nutrients. These nutrients, whether macro or micro nutrients are released during its decomposition by the microorganisms. Also, FYM improved physical properties of soil and its fertility, consequently increased the vegetative including bulb diameter (Yadav, 2006). Moreover, Doklega (2017) mentioned that FYM has a positive effect on growth parameters, hance increased chlorophyll formation, which improved photosynthesis efficiency, which reflected in high formation of carbohydrates, total soluble salts and results are similar to those obtained by Kumar et al. (2019) and Shah et al (2019) who pointed out that FYM application improved onion quality.

With regard to copper effect, the data reveal that feuded onion plant copper resulted in significant increasing in dry weight (%) and total soluble solid (%), while bulb diameter unaffected by copper application. The beneficial effect of copper on onion quality is mainly to copper as an important micronutrient which interferes with protein formation, resulted in formation soluble nitrogen compounds (El-Hadidi et al., 2016). These results are confirmed with those obtained by Allam et al. (2013) and Ur Rahman et al (2015).

As for the response of onion quality to bio-fertilizer, data indicated that treated onion plants with bio-fertilizer has improved bulb diameter, dry weight (%) and T.S.S. (%). The relative increasing in the three quality parameters due to bio-fertilization were 5.1, 0.7 and 0.8 % when compared with no bio-fertilizer, respectively in the first season. The corresponding increasing in the second were 4.9, 0.8 and 0.7 %. In this concern, Aswani et al (2005) mentioned that bio-fertilizes improved onion yield and quality by provided the plants with nutrients through biological processes, which converted the nutrients from unavailable to available form, such as fixed atmospheric nitrogen to available source to plants. Also, it supplied the plants with hormones and growth regulators (Dibute et al 1993). These results are in line with those obtained by (Yadav, 2006), (Shah, 2019) and Baddour and Sakara (2020).

TABLE 5. Blub quality as affected by FYM, Cu and biofertilization

Treatments			1st season			2nd season		
FYM (t/ha)	Copper (CU)	Bio-fertilization	Blub diameter (cm)	Dry matter (%)	T.S.S. (%)	Blub diameter (cm)	Dry matter (%)	T.S.S. (%)
0.0	Without	Without	5.32 a	15.43 c	14.12 d	5.16 a	15.27 c	14.01 d
		With	5.81 a	15.61 b	14.37 d	5.66 a	15.51 b	14.13 d
	With	Without	5.33 a	15.62 b	14.75 c	5.24 a	15.49 b	14.56 c
		With	5.80 a	15.79 b	14.82 c	5.63 a	15.60 b	14.68 c
12	Without	Without	6.47 a	16.01 b	15.10 c	6.39 a	15.87 b	14.94 c
		With	6.96 a	16.24 a	15.28 b	6.85 a	16.18 a	15.19 b
	With	Without	6.49 a	16.23 a	15.29 b	6.41 a	16.08 a	15.17 b
		With	6.97 a	16.49 a	15.52 b	6.84 a	16.23 a	15.40 b
24	Without	Without	7.03 a	16.60 a	16.44 a	6.95 a	16.42 a	16.28 a
		With	7.04 a	16.61 a	16.43 a	6.95 a	16.43 a	16.29 a
	With	Without	7.02 a	16.62 a	16.46 a	6.93 a	16.44 a	16.27 a
		With	7.03 a	16.61 a	16.46 a	6.94 a	16.42 a	16.28 a
Mean of FYM (t/ha):								
	0.0		5.57 b	15.62 c	14.52 c	5.43 b	15.47 b	14.35 c
	12		6.73 a	16.25 b	15.30 b	6.63 a	16.16 b	15.29 b
	24		7.04 a	16.61 a	16.46 a	6.95 a	16.43 a	16.29 a
Mean of Copper (cu):								
	without		6.44 a	16.09 b	15.29 b	6.33 a	15.95 b	15.14 b
	with		6.44 a	16.23 a	15.55 a	6.34 a	16.05 a	15.40 a
Mean of Biofertilization:								
	without		6.28 b	16.09 b	15.36 b	6.18 b	15.93 b	15.21 b
	with		6.60 a	16.21 a	15.48 a	6.48 a	16.06 a	15.32 a

The data of the interaction indicate that seed quality was responded to the interactions between FYM and Cu (A×B), FYM and bio-fertilizer (A×C) and the interaction among the three factors (A×B×C), except bulb diameter, which affected only by the interaction between FYM and bio-fertilizer (A×C). in general, Cu and bio-fertilizer unaffected onion quality under the high FYM level. Moreover, combined 12 t ha^{-1} FYM with foliar spraying of copper and bio-fertilization resulted in onion quality at par with 24 t ha^{-1} FYM. On the other hand, the onion plants without each of FYM, Cu and bio-fertilizer exhibited the lowest onion quality. Many authors pointed out that, using bio-fertilizer accelerate the positive effect of organic manure on onion quality such as Saad Abou-El-Hassan (2018) and Kumar et al (2019). Also, Pramanik et al. (2018) stated that combined copper as foliar spraying with FYM improved onion quality.

Onion Storability

Onion storability is the most essential character for onion production due to two seasons. The first, the possibility of present onion bulb overall the year and the second, onion is a biennial plant, thus, bulbs must be stored until the next season for seed production. In this study, the percent of bulb weight loss after 2,4 and 6 weeks were used to express the potentiality of onion storability. Data in Table 6 show that FYM had a significant effect on weight loss percentage of onion during the studied period. The total weight loss (%) at 6 months after harvest were 40.46, 34.22 and 31.33 % due to treated onion plants with 0.0, 12.0 and 24.0 t ha^{-1} FYM, respectively. It is unequivocal that increasing organic manure level resulted in reducing bulb weight loss, which means improved onion storability. The decrement in weight loss caused by FYM application may be due to its effect on increasing total soluble solids (Doklega, 2017). These results are in line with those obtained by Singh et al (2010) and Saad Abou-El-Hassan (2018).

As for copper, the data show that foliar spraying of copper resulted in minimum weight loss than without copper application during the storage period. The relative reduction in weight loss due to supplied onion plants with copper at the end of storage period reached to 6.8 and 6.1 % over without copper in both seasons, respectively. These results are in line with those obtained by El-Mansi and Sharaf El-Dien (2005) and Obiadallu et al (2016) who stated that foliar spraying of copper at rote of 50 ppm led to minimum weight loss percentage of onion bulbs during the period of storage. Regarding the effect of bio-fertilizer, the data revealed that treated onion plant with bio-fertilizer increased its storability potential. Comparing with no bio-fertilization. The bio-fertilization, decreased the weight loss percentages at 2, 4 and 6 months by about 7.6, 7.4 and 5.9 % over without bio-fertilization treatment, respectively in the first season. Similar trends were obtained the second season. The positive effects of bio-fertilizer on onion storability may be due to its effect on improving total soluble solids of onion (Banjare et al., 2015) and Kumar et al. (2019).

The data of the interaction indicated that onion storability was affected by the interaction between FYM and Cu (A×B), FYM and bio-fertilizer (A×C) and the interaction among the three factors (A×B×C). in general, combined 12 t ha^{-1} FYM with both copper and bio-fertilizer gave the best storability potential in par with the effect of 24 t ha^{-1} FYM. On the other hand, the onion plants without each of FYM, copper and bio-fertilizer recorded the lowest storability character of onion. These results are similar to those obtained by Singh et al (2015) and Saad Abou- El-Hassan et al. (2018) who found that combined bio-fertilizer with organic manure resulted in improving onion storability.

Economic measurements

The economic measurements were performed to calculate the net return and the benefit cost ratio of the three studied treatments. The cultivation cost and variables cost (Table 7) were calculated as sum of land rent, land preparation, the seedlings price, and the cost of irrigation; NPK fertilizers; weeds and insects' control; and harvesting. The partial budget analysis due to the different treatments were listed in Table 8.

The data reveal that increasing FYM levels up to 24 t ha^{-1}, foliar application of 0.1 % copper sulphate or using bio-fertilizer individually recorded the highest total gross return, total net return and benefit cost ratio in both seasons (94541, 52145 and 2.24, respectively in the first season 110682, 49044 and 1.8 in the second one). On the other hand, combined 24 t ha^{-1} FYM with or without copper application and bio-fertilizer exhibited the greatest net return and benefit cost ratio. The positive effect of FYM on the economic analysis of onion plant may be due to its effect on total onion yield. Similar results were obtained by Vachan and Tripathi (2017), Saad Abou- El- Hassan et al (2018) and Gererufael et al (2020) who stated that using organic fertilizer increased both net return and benefit cost ratio of onion.

TABLE 6. Weight loss % after 2, 4 and 6 months as affected by FYM, Cu and biofertilization

Treatments			1st season			2nd season		
FYM (t/ha)	Copper (CU)	Bio-fertilization	Two months	Four months	Six months	Two months	Four months	Six months
0.0	Without	Without	8.26 a	16.35 a	44.25 a	7.79 a	15.16 a	41.25 a
		With	7.43 b	14.91 b	41.13 b	6.61 b	13.27 b	38.65 b
	With	Without	7.10 b	14.36 b	40.25 b	6.10 b	13.08 b	38.12 b
		With	6.27 c	12.17 c	36.19 c	5.66 c	11.34 c	34.25 c
12	Without	Without	6.15 c	12.25 c	37.01 c	5.52 c	11.19 c	35.52 c
		With	5.63 d	11.02 c	34.25 d	4.79 d	10.25 c	32.41 d
	With	Without	5.82 d	11.04 c	34.31 d	4.46 d	10.16 c	32.62 d
		With	5.04 e	10.12 d	31.30 e	3.71 e	9.33 d	30.18 e
24	Without	Without	5.03 e	10.10 d	31.32 e	3.76 e	9.34 d	30.22 e
		With	5.04 e	10.13 d	31.35 e	3.70 e	9.32 d	30.19 e
	With	Without	5.01 e	10.14 d	31.31 e	3.75 e	9.36 d	30.21 e
		With	5.06 e	10.13 d	31.31 e	3.74 e	9.35 d	30.24 e
Mean of FYM (t/ha):								
0.0			7.27 a	14.45 a	40.46 a	6.54 a	13.22 a	38.07 a
12			5.66 b	11.11 b	34.22 b	4.63 b	10.24 b	32.69 b
24			5.04 c	10.13 c	31.33 c	3.74 c	9.36 c	30.22 c
Mean of Copper (cu):								
without			6.26 a	12.46 a	36.55 a	5.36 a	11.42 a	34.71 a
with			5.72 b	11.33 b	34.11 b	4.57 b	10.44 b	32.61 b
Mean of Biofertilization:								
without			6.22 a	12.37 a	36.41 a	5.23 a	11.38 a	34.66 a
with			5.75 b	11.41 b	34.26 b	4.70 b	10.48 b	32.65 b

TABLE 7. Total cultivation cost L.E./ha (Egyptian pound L.E. = about 0.064 US dollars)

	1st season	2nd season
Common costs		
Land rent	11900	11900
Land preparation	1428	1428
Seedling's price	7474	20944
Planting	2677.5	2677.5
Irrigation	560	560
Fertilization	8806	8806
Weed control	660	660
Insect's control	6400	6400
Harvesting	5175.5	5175.5
Total	39321	58551
Variable cost		
FYM		
12 t/ha	1500	1500
24 t/ha	3000	3000
Copper		
Without	0.0	0.0
With (0.1% copper sulphate twice)	140	140
Biofertilizer		
Without	0.0	0.0
With	100	100

TABLE 8. Economic analysis of onion production as affected by FYM, Cu and biofertilization

Treatments			1st season			2nd season		
FYM (t/ha)	Copper (CU)	Bio-fertilization	Gross return (L.E.)	Net return (L.E.)	Benefit cost ratio	Gross return (L.E.)	Net return (L.E.)	Benefit cost ratio
0.0	Without	Without	62496 j	23175j	1.59 c	69542 j	10991 j	1.19 c
		With	67068 h	27647h	1.70 c	74932i	16331i	1.28 c
	With	Without	66456i	27085i	1.69 c	75570 h	16919 h	1.29 c
		With	71838 g	32367g	1.82 b	81092 g	22341 j	1.38 b
12	Without	Without	80154 f	39333f	1.96 b	95370 f	35319 f	1.59 b
		With	85878 e	44957e	2.10 a	99550 e	39449 e	1.66 a
	With	Without	86310 d	45439d	2.11 a	102542 d	42391 d	1.70 a
		With	89334 c	48363c	2.18 a	107184 c	46933 c	1.79 a
24	Without	Without	93906 b	51585b	2.22 a	110374 b	48823 b	1.79 a
		With	94230 b	51809 b	2.22 a	110484 b	48883 b	1.79 a
	With	Without	94878 a	52507 a	2.24 a	111232a	49581 a	1.80 a
		With	95148 a	52677 a	2.24 a	111638a	49887 a	1.79 a
Mean of FYM (t/ha):								
0.0			66965 c	27569 c	1.71 c	75284 c	16646 c	1.29 c
12			85419 b	44523 b	2.09 b	101162 b	41023 b	1.69 b
24			94541 a	52145 a	2.23 a	110682 a	49044 a	1.80 a
Mean of Copper (cu):								
without			80622 b	39751b	1.97b	93375b	33299b	1.55b
with			83994 a	43073a	2.05a	98043a	37842a	1.63a
Mean of Biofertilization:								
without			80700b	39854b	1.97b	94105b	34004b	1.56b
with			83916a	42970a	2.04a	97313a	37137a	1.62a

Conclusion

It could be concluded that whether fertilization of onion plant with 24 t ha^{-1} FYM or 12 t ha^{-1} FYM + foliar spraying of copper + bio-fertilizer gave similar improvements to all onion quality, quantity and its storability as well as net return and benefit cost ratio. In general, the treatment of 12 t FYM ha^{-1} + foliar spraying of copper + bio-fertilizer gave onion yield, quality, storability and profitability at par with the treatment of 24 t FYM ha^{-1} with or without both copper and bio-fertilizer. This means that it could save about 12 t FYM ha^{-1} by using copper + bio-fertilizer.

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