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Influence of Different Nitrogen Fertilizer Sources on Growth and Productivity of Williams Banana Plants

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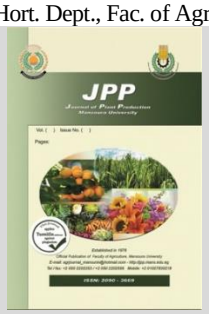

ABSTRACT

Experiments were carried out during two consecutive 2017/2018 and 2018/2019 seasons to measure the influence of various sources of nitrogen fertilizers on enhancing growth and fruiting of Williams banana plants grown under Qena Governorate, Egypt. Applying 25% of the recommended nitrogen dose along with 25 to 50% organic-N enriched with EM as a bio-form at 50 or 25% were effective in enhancing all growth aspects, production and fruit quality compared to the control. Using combination of three forms of nitrogen were more favorable than using mineral-N alone.Therefore, it could be concluded that using three forms of nitrogen fertilizers get high yield with good fruit quality of Williams bananas. In addition, it reduces the cost of production and environmental pollution, due to excess of chemical fertilizers..

Keywords: Banana, nitrogen, fertilization, organic, bio-fertilizer, yield, fruit quality, GAP.

INTRODUCTION

The main objective of Egyptian Researcher is to improve the aspects of production to meet the requirements of local and global markets. The desired increase could be achieved by following one of two ways. Firstly is applying horizontal expansion through cultivating new acreages; secondly is the vertical expansion by applying the GAP (Good Agricultural Practices).

Banana (*Musa spp.*) considered a queen of tropical fruit that cultivated by man since prehistoric times. Banana provides nutrition and well balanced diet to millions of people around the globe and also contributes to livelihood through crop production, processing and marketing (Badgujar *et al*., 2010). It has a great economic importance as one of the most popular fruits in Egypt for its high nutritive value, cheap source of energy. The total area of banana increased to 79857 feddan produced 1314177 tons with an average of 20.54 ton/feddan according to MALR(2016).

Fertilization is considered the limiting factor for improving of growth and production of banana plants because plants absorb a large amounts from the soil. Among these nutrients nitrogen (N) is the most absorbed in vegetative as well as in the reproductive periods (Al-Harthi and Al-Yahyia, 2009). In plants, N is necessary for improving growth as well as has a positive effect on protein's chemical formation, respiration and photosynthesis (Marschner, 1995). The main obstacle facing banana growers are the high costs of needed manufactured fertilizers. Besides, excessive use of chemical fertilizers leads to soil, water and air pollution (Kuttimani *et al*., 2013 and Abdel-Hafiz *et al*., 2016). The main goal of using organic cultivation is produce healthful fruits free of or with minimal chemical fertilizers, synthetic auxins, pesticides and avoid environmental pollution. Integration of mineral, organic and bio-fertilizers necessary to upgrade soil fertility, raise crop yield and reduce environmental pollution (Dahama, 1999; Abdel-Naby and Gomaa, 2000; El-Salhy, 2004; Abdel-Monem –*Eman et al*., 2008 and Baiea and El-Gioushy, 2015).

Many authors previously mentioned that adjusting the amount of N as well as using the suitable amount via mineral, organic and bio-fertilizer sources were beneficial to enhance growth and fruiting of different banana cvs as compared to use mineral-form alone (Kamel, 2002; Abdel-Monaem-Eman and Radwan, 2003; Ahmed *et al*., 2003; Hammam *et al*., 2003; Gobara, 2004; El-Sawy, 2005; Abdel-Rahman, 2005; Abdel-Monem-Eman *et al*., 2008; Bhalerao *et al*., 2009; Roshdy, 2010; Badgujar *et al*., 2010; Merwad, 2011; Kuttimani *et al*., 2013; Abdel-Rahman and Mansour, 2015; Baiea and El-Gioushy, 2015; Abdel-Hafiz *et al*., 2016; Fratoni *et al*., 2017 and El-Salhy *et al*., 2019).

Therefore, the current study was conducted to evaluate the benefits of supplementing different sources of nitrogen in terms of organic fertilizers in the presence of bio-fertilizer with the recommended dose of mineral source on growth, productivity, quality and chemical components of Williams banana cv. cultivated under Upper Egypt hot climate, in addition to reducing cost of production. Where bananas needs a large amounts of fertilizers, especially potassium and nitrogen. So, the main obstacle facing banana growers are the high costs of needed manufactured fertilizers. Besides, chemical sources negatively leads to soil, water and air polluting through their production and utilization, most notably there is high demand for producing healthful food.

MATERIALS AND METHODS

This two-year field experiment was carried out during two successive growing seasons 2017/2018 fourth ratoon and 2018/2019 fifth ratoon Williams Banana plants grown in clay loam soil under flood irrigation system. in a private banana orchard located at Nag Hammadyi, Qena

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Governorate at Upper Egypt. Soil was analyzed based on the method described by Wilde *et al*. (1985). obtained data are shown in table (1). Plant spacing was 3.5x3.5 meters a part and selecting three suckers/hole.

Table 1. Analysis of the selected orchard soil.

Characters	Values	Characters	Values
Particle size distribution:		Total N %	0.09
Sand %	22.4	Available P (mg kg^{-1})	6.8
Silt %	25.4	Available K (mg kg^{-1})	310
Clay %	53.2	Available S (mg kg^{-1})	3.11
Texture	Clay loam	Available EDTA extractable micronutrients (mg kg^{-1})	
pH (1:2.5 extract)	7.20	Zn	13.63
EC (1:2.5 extract) dSm^{-1}	0.56	Fe	10.75
OM %	1.58	Mn	11.91
$CaCO_3$ %	3.19	Cu	1.24

The experiment designed as a completely randomized block design with three replication one hole each.

The experiment contained six treatments, as it follows:

1- Application 100% of the recommended nitrogen (RDN) in mineral form as 600 g-N/plant/year (1.8 kg AN 33.5%) as mineral-N form (N_1).
2- Application of 25% mineral-N and 75% organic-N (compost) (N_2).
3- Application of 25% mineral-N and 50% organic-N plus 25% bio-N (EM) (N_3).
4- Application of 25% mineral-N and 25% organic-N plus 50% bio-N (EM) (N_4).
5- Application of 25% mineral-N and 50% organic-N plus 25% bio-N (Seaweed) (N_5).
6- Application of 25% mineral-N and 25% organic-N plus 50% bio-N (Seaweed) (N_6).

The Nitrogen source was AN (33.5% N), splitted into 14 equal batches and added two/month that started on April to October during each season. Organic fertilizer (compost, 4.9% N) was added during the second week of December in holes 15 cm depth around each plant and covered with soil. Effective microorganisms (EM) as a bio-fertilizer contains a mixed of photosynthetic and lactic acid bacteria as well as actinomyces, yeasts and fungi. EM and Seaweed extract were added as soil drench three times at one month interval starting at March. It was added in a circular hole around each plant before irrigation.Other horticulture treatments were carried out as usual.

The below parameters were measured on selected plants during the two growth seasons.

1- Vegetative characteristics:

After the emergence of the inflorescence at the 3rd week of July for both the fourth and fifth ratoon, the following parameters were studied, vegetative characteristics included pseudo stem (cm), sized leaves according to Murry (1960) and calculated as follows:

Leaf area (m^2) = length x width x 0.8,

Then, the assimilation area/plant (m^2) was measured as follows:

Leaf No. x Leaf area

Number of days taken from shooting to harvest (maturity days) was also recorded.

2- Leaf mineral contents:

Analyzed leaves were taken from the third upper leaf from the top of the plant after bunch shooting in September of each season. A sample of 10x10 cm from the middle part of the leaf blade was used as recommended by Hewitt (1955). Samples were oven dried at 70°C and digested. The clear digestion was quantitatively transferred to 100 ml volumetric flask. In this solution, the following nutrients were determined according to Wilde *et al*. (1985).

a) Total N was determined using micro-Kjeldahl method.
b) Potassium was determined in the clear digest solution by using a flame photometer.

3 – Yield and fruit quality:

Bunches of banana were picked during the common harvest data , during the period from November to January in both seasons which the bunch (or fruits) were suitable (when fingers full mature stage) for harvesting, fruits were artificially ripening, then the fruit quality was measured.

Weight of bunch and two hands were taken from the base, middle and distal end of each bunch as sample for each replicate. Weight of finger (g) and % of pulp were recorded. Percentage of total soluble solids, total acidity (malic acid/100 g pulp) and total sugars was determined based on AOAC (1990).

The data obtained were exposed to the analysis of variance (ANOVA) were according to Gomez and Gomez (1984) and Mead *et al*. (1993). Duncan's test at the 5% level was used to compare the difference between treatments means. Duncan. (1955)

RESULT AND DISCUSSION

Results

1- Influence of different nitrogen sources application on vegetative growth and percentage of leaves content of N and K:

Presented data in and Figures (1 & 2) show the influence of applying different nitrogen sources on height of pseudo stem; number of green leaves/plant and total leaves area/plant and percentage of N and K in leaves of Williams banana plants through 2017/2018 & 2018/2019 seasons. It is clear from the data that the results took a similar direction during the two seasons of study. Such data show that, application of the 25% of recommended dose of nitrogen (RND) in mineral form plus 25 or 50% in organic form enriched with effective microorganisms (EM) or seaweed as a bio-form at 50 or 25%, of the recommended N dose significantly increased such traits compared to use 100% of RDN as mineral-N fertilizers only (check treatment). The highest values of these growth traits were recorded due to enrichment with bio-form at 50% of RND (T_4 and T_6). Also, using the RDN at two forms (50% organic and 50% mineral, significantly increased these traits compared to control. Moreover, there was insignificant differences in these studied traits due to fertilization with the three forms at any dose.

The greatest values of pseudo stem height were (351..60 cm), total leaves area/plant (1.27 m^2) and leaf N% (15.35%) av. Studied seasons were recorded in plant fertilized with 25% mineral-N and 25% organic-N plus 50% EM (N_4). Lowest values for all studied growth aspects were recorded due to use 100% mineral-N (N_1).

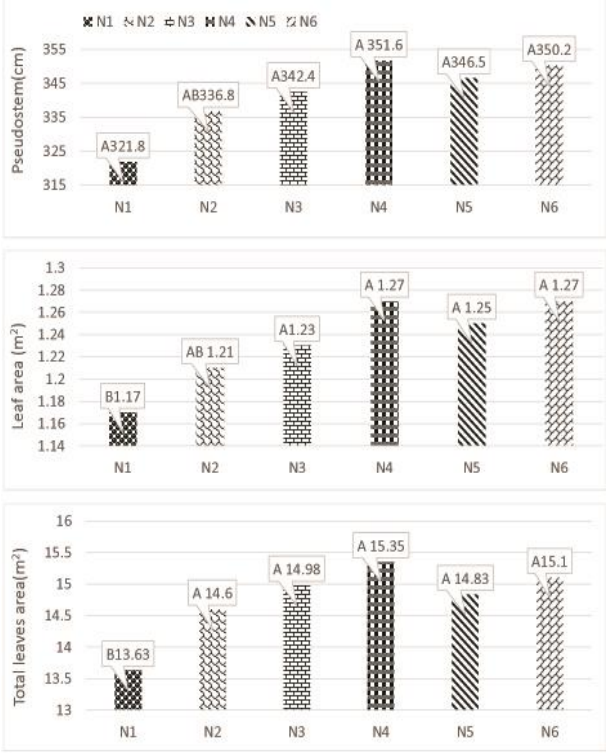

Fig. 1. Vegetative growth of Williams Banana plants affected by different nitrogen fertilizer sources as mean of 2018 and 2019 seasons

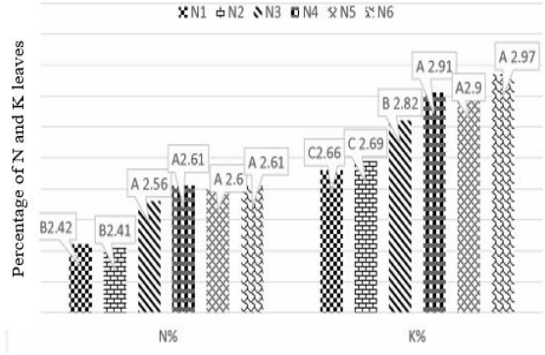

Fig 2. Concentration of N and K in Williams Banana leaves affected by different nitrogen fertilizer sources as mean of 2018 and 2019 seasons.

The recorded leaves area/plant and leaf N and K% were as follows, in a descending order: $N_4 > N_3 > N_6 > N_5 > N_2 > N_1$. Moreover, an increase in the percentage of leaves area/plant was attained 18.14, 19.49, 13.78 and 12.43% due to use N_4, N_3, N_5 and N_6 compared N_1, respectively. Fertilized with 25% mineral-N and 25% organic-N plus 50% EM (N_4) induced an increase by 7.07, 7.98, 13.9 & 6.22% in height of pseudo stem, leaf area, leaf-N % and leaf-K% compared with use 100% mineral-N (N_1), respectively. On the other hand, such fertilization treatment induced a decrease by 6.56% in maturity days compared to N_1 (Table 1).

2- Effects on bunch weight:

It is obvious that data in Table (2) clarify that fertilizing of Williams banana plants with different nitrogen fertilizer sources increased bunch weight significantly compared to use only minerals (check treatment). It is obvious from the data in the previously table that fertilizing of Williams banana plants by a combination of mineral-N with organic and bio-form increased bunch weight significantly compared to use only the RDN via mineral-N source (check treatment, N_1).The heaviest weight of bunch (27.80 & 29.16 kg) was recorded on the plants that fertilized by 25% mineral-N plus 25% organic and 50% EM. The bunch weight values were found in the following descending order as $N_4 > N_3 > N_5 > N_6 > N_2 >$ control. The increment percentage of bunch weight was attained (7.48, 10.79, 10.90, 10.20 and 10.28 av. the two studied seasons) due to N_2, N_3, N_4, N_5 and N_6 over N_1, respectively. Therefore, it is clear that fertilization using mineral-N and organic plus bio-fertilizer have beneficial effects on the bunch weigh of Williams banana plants.

3- Effects on quality of fruits:

It is obvious from the data in Tables (2 & 3) that using N as 25% mineral plus 25 to 50% organic enriched with 50 or 25% of bio-form enhanced fruit quality significantly in terms of increasing finger weight, pulp %, TSS%, sugar contents and decreasing the total acidity compared with recommended dose of nitrogen (RDN) via mineral-N source only. Moreover, there was an insignificant difference in these studied traits due to fertilize with the three forms at any dose. Treating plants with the RDN via 25% mineral & 25% organic enriched & 50% EM gave the highest values of fruit traits.

The recorded finger weight was (98.32, 105.01, 110.11, 112.99, 111.55 and 112.17 g av. the two studied seasons due to N_1, N_2, N_3, N_4, N_5 and N_6, respectively. The corresponding TSS% 19.68, 20.77, 20.74, 20.95, 20.95 and 20.92%, respectively. Hence, the increment percentage of finger weight attained 6.80, 11.99, 14.92, 13.46 and 14.09% due to N_2, N_3, N_4, N_5 and N_6 over N_1 (check treatment), respectively. Whereas, the increment percentage of TSS% was attained 5.53, 5.39, 6.45, 6.45 and 6.30% av. the two studied seasons due to N_2 to N_6 compared to N_1 (Check treatment) over the studied seasons, respectively.

Hence, cost wise evaluation of applying of these N sources is in favor of three forms. Such fertilization program is very important for the production of banana fruits, since the improve of the fruit quality induces an increase in packable yield. In addition, such fertilization treatments reduce cost of production and environmental pollution.

Table 2. influence of different nitrogen fertilizer sources on maturity days and weight of bunch & finger of Williams banana during 2018 and 2019 seasons.

	Maturity days			Bunch weight (kg)			Finger weight (g)		
	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
N_1	116A	112A	114.0	25.13B	26.22B	25.68	95.81C	100.83C	98.32
N_2	109B	106B	107.5	26.81A	28.38A	27.60	101.12B	108.90B	105.01
N_3	108B	105B	106.5	27.52A	29.38A	28.45	105.42AB	114.80A	110.11
N_4	107B	106B	106.5	27.80A	29.16A	28.48	108.11A	117.86A	112.99
N_5	108B	106B	107.0	27.63A	28.96A	28.30	107.00A	116.10A	111.55
N_6	108B	105B	106.5	27.40A	29.25A	28.33	108.10A	116.23A	112.17

Value followed by same letter in the same column is not significantly different at 0.5/level of probability

Table 3. influence of different nitrogen fertilizer sources on some chemical traits of Williams banana during 2018 and 2019 seasons.

	Pulp %			TSS			Total sugar			Acidity		
	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean	2018	2019	Mean
N_1	66.41C	66.83C	66.62	19.20A	20.15B	19.68	15.21B	16.50B	15.86	0.334A	0.354A	0.344
N_2	68.73B	68.81B	68.77	20.15A	21.38A	20.77	16.62A	17.80A	17.21	0.290B	0.311B	0.300
N_3	70.16AB	70.50AB	70.33	20.23A	21.25A	20.74	16.81A	17.68A	17.24	0.293B	0.306B	0.300
N_4	71.53A	71.25A	71.39	20.40A	21.50A	20.95	16.95A	17.89A	17.42	0.283B	0.297B	0.290
N_5	70.25AB	70.11AB	70.18	20.55A	21.36A	20.95	16.90A	17.75A	17.33	0.284B	0.298B	0.291
N_6	70.18AB	69.68AB	69.93	20.30A	21.54A	20.92	16.75A	17.80A	17.28	0.291C	0.305B	0.298

Value followed by the same letter in the same column is not significantly different at 0.5/level of probability

Discussion

Nitrogen fertilization is the limiting factor for banana plant's growth and productivity. Bananas owing to its large size and rapid growth rate requires relatively high amounts of nitrogen to get high yield with good fruit quality (Nijjar, 1985). Pollution is one of the most negatively problems that affecting on human health, especially when the edible part of the plant is contaminated with any pollutants. Using mineral-N fertilizers causes accumulation of harmful residual substances in the pulp of the fruits.

The organic fertilization has a positive action in increasing activity of microflora, water holding capacity, soil structure aggregation, soil organic matter, soil humus content and the availability of most nutrients. Such stimulation on the uptake of nutrients leads to improving the biosynthesis of organic foods and cell division (Miller *et al.,* 1990).

Bio-fertilization has an important role on biological, as well as, activating the availability and incidence of soil borne diseases,facilitating the fixation of atmospheric N, and then improving soil fertility (Subba Rao, 1984; Kannaiyan, 2002; El-Salhy, 2004).

The best results regarding to growth, fruit quality and yield due to use EM were altrated to positive action of EM on enhancing soil fertility, the availability of nutrient, organic matter, root development, activity of organisms and N-fixation (Formowit *et al*., 2007).

Continuous application of organic and bio-fertilizers is promising in the long run of banana, as sources of organic matter, essential nutrients, amino acids, natural hormones, antibiotics and vitamins. Also, improving both physical and chemical characters of soil.

Accordingly, it can be concluded that the fertilization using bio and organic fertilizers affect positively on improving the plant vigor expressed as an increase in leaf surface expansion and its nutrient status. These findings emphasize the vital importance of these fertilization sources in order to overcome the losses of nutrients by leaching, volatilization and mobility of movement elements. These sources also, improve the soil fertility due to the highest values of the residual nutrients, the enhanced solubility of nutrients and the increased activity of microorganisms. In addition, the importance of such fertilization treatments is considered for the organic farming production.

The results were consistent with what had been achieved by El-Shamaa (2001), Soliman (2001), Kamel (2002), Hammam *et al*. (2003), Ahmed *et al*. (2003), Gobara (2004), Sayed (2004), El-Sawy (2005), Bhalerao *et al*. (2009), Roshdy (2010), Badgujar *et al*. (2010), Barakat *et al*. (2011), Kuttimani *et al*. (2013), Abdel-Rahman and Mansour (2015), Baiea and El-Gioushy (2015) and Abdel-Hafiz *et al*. (2016). They concluded that application in either organic or bio-form along mineral-N sources was effective on improving growth vigor and nutrient status of banana plants in favor of improving the fruiting.

CONCLUSION

From this study, it can be concluded that using three sources of nitrogen fertilization improves the fruit quality leading to increase in the packable yield. In addition, it reduces the production costs and environmental pollution that can be occur due to excess of chemical fertilizers.

These advantages will eventually enable growers to obtain high yield with good fruit quality. Furthermore, using organic and bio-fertilization sources improve the soil fertility and reduce the added fertilizer requirements. Thus, the growers are able to produce organic farming products.

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تأثير إستخدام مصادر مختلفة من الأسمدة النيتروجينية على نمو وإنتاجية نبات الموز الوليامز

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أجريت هذه الدراسة خلال موسمي ٢٠١٨/٢٠١٧ و ٢٠١٩/٢٠١٨ لدراسة تأثير إستخدام المصادر المختلفة للأسمدة النيتروجينية على نمو وإنتاجية صنف الموز ويليامز المنزرعة في مركز نجع حمادي , محافظة قنا ، مصر. وكان تطبيق ٢٥ ٪ من جرعة النيتروجين الموصى بها مع ٢٥ : ٥٠ % مع ٢٥ إلى ٥٠ ٪ من النيتوجين العضوي بالأضافة إلي المخصب الحيوي EM حيوي بنسبة ٢٥ أو ٥٠ ٪ فعالاً للغاية في تحسين جميع صفات النمو وجودةالمحصول مقارنةً بالكنترول. حيث كان استخدام خليط من مصادر النيتروجين المختلفة أفضل من استخدام مصدر النيتروجين المعدني منفردا. لذلك ، يمكن الاستنتاج أن استخدام ثلاثة أشكال من الأسمدة النيتروجينية يحقق إنتاجية عالية مع جودة ثمار جيدة من صنف الموز ويليامز. بالإضافة إلى ، إنه يقلل من تكاليف الإنتاج والتلوث البيئي الذي يمكن أن يحدث بسبب زيادة الأسمدة الكيماوية