NITROGEN AND POTASSIUM NUTRIENTS REQUIREMENTS (FERTIGATION) OF ZIV CV. BANANA ON GROWTH, YIELD AND FRUIT QUALITY IN SANDY SOIL

Hosny S. Samia; Mahdy, H.A. and El-Kholy M.F.

Tropical Fruit Dept., Horticulture Research Institute, ARC, Giza, **Egypt.**

*Corresponding author: essam.1972n@yahoo.co.uk   **Received:** 25 Mar. 2020 ; **Accepted:** 19 Apr. 2020

ABSTRACT: The present work was done in a private farm at El-Khatatba region during three successive seasons of 2016/2017 (first ratoon), 2017/2018 (second ratoon) and 2018/2019 (third ratoon) of Ziv banana plants (*Musa cavendishii* L.) grown on sandy soil to study NK nutrients requirements (fertigation) on vegetative growth, yield fruit quality, NK-efficiency and economic return. Nitrogen and Potassium were applied at different rates and their combinations, Nitrogen (600g, 750 and 900 g actual N/plant/year) and potassium (750, 1000 and 1250 g actual K_2O/plant/year). They were used 240 unequal doses around the year and were add as solution by fertigation. Results revealed growth parameters of plant i.e. pseudostem height, circumference, number of green leaves and assimilation area at bunch shooting stage significantly increased by increasing the rate of NK fertilizer. The rate of 900g actual N and 1250g actual K_2O gave the highest values for the above characters compared with other treatments. Growth cycle of plants tended to decrease as fertilizers was increase. Increase the rate of fertilizers shortened the growth cycle duration of Ziv banana. The highest yield, bunch weight, finger weight and fruit characteristics were achieved from Ziv banana plants fertilized with 900g actual N with 1250g actual K_2O/plant/year. NK utilization efficiency was affected with the rate of fertilizers. The better value of NUE (42 &48 & 44.4Kg. fruit/g actual N) was obtained from plants fertilizer with 750 g actual N+1250 g actual K_2O while highest value of KUE was (40.8 & 48 & 45.6) with the rate900 g actual N+750 g actual K_2O under tested seasons. The economic return of Ziv banana plants gradually increase by increasing NK fertilizers. Plants were fertilized with the 900 g. N + 1250g. K_2O/plant/year gave the highest income compared with other treatment. While the lowest rate of NK fertilizer (600 g N+ 750 g K_2O plant/year) gave the cheap income.

Keywords: Nutrients, Ziv cv., fertigation, banana plant, productivity, yield, NUE, KUE, Economic return

INTRODUCTION

Fertigation (application of water-soluble solid or liquid fertilizer through drip irrigation system) is an attractive method of fertilization in intensive agricultural systems. Banana (*Musa cavendishii* L.) need and consume large amount of fertilizers from a limited soil depth, especially N and K, due to its shallow root system (**Amin *et al*., 2016**). Fertilization is one of the most important factor which limiting growth and productivity in banana like all economical plant species. The high cost of intensive use of only chemical fertilizers to achieve high production of banana facing major problem for growers. nitrogen (N) and Potassium (K) are the most extracted macronutrients by banana plants, as they are directly related to plant growth, yield and banana fruit quality (**Moreira, 1999**). Potassium is the macronutrient extracted in greater amounts by banana plants (62 % of the total macronutrient and 41% of the plant nutrients), which directly affects photosynthesis, the translocation of photosynthetic and the water balance in plants and fruits (**Kumar & Kumar, 2008 and Moreira, 1999**). Nitrogen acts directly on vegetative growth, emissions and the development of shoot plants and increases the amount of dry matter in plants (**Moreira, 1999**). **Edson *et al*.,2017** found that the N and K fertilization levels influenced most of the phenological and production parameters of 'Grand Naine' and 'Nanicão IAC 2001'. 'Nanicão IAC 2001' and 'Grand Naine' achieved maximum yield with an application of 525 kg N ha-1 year-1 and 855 kg K_2O ha-1 year-1.

This research aimed to identify the best fertilizer recommendation levels containing N and K and their effects on the phenological and productive characteristics of Ziv banana cultivar.

MATERIAL AND METHODS

The present work was done in a private farm at El-Khatatba region during three successive seasons of 2016/2017 (1st ratoon), 2017/2018 (2nd ratoon) and 2018/2019 (3rd ratoon) of Ziv banana plants

(*Musa cavendishii* L.) produced through tissue culture to study nutrients requirements (fertigation) from nitrogen and potassium on vegetative growth and yield. Banana plants were similar in growth, free of diseases, received the same horticultural managements and cultivated 3×3.5 meters apart. Soil samples from surface layer (0-30) were collected from different locations, mixed, analyzed physically and chemically according to **Wilde *et al*., (1985)** and the data are presented in Table (1).

Table 1. Certain properties of soil used

Properties	Depth (cm)		
	0-30	**30-60**	**60-90**
Coarse %	51.50	44.60	64.0
Fine sand %	23.0	28.40	22.0
Silt %	15.25	16.50	11.0
Clay %	13.25	10.50	3.0
Texture	**Loamy sand**	**Sandy**	**Sandy**
Black density gm/cm	1.56	1.64	1.70
Ph	5.0	8.2	8.4
E.C.m.mhos/cm	0.53	0.61	0.70
CaCO₃	0.72	0.81	0.78
Na meg/L	1.79	1.84	2.21
K meg/L	0.015	0.17	0.17
Ca meg/L	2.20	1.44	1.92
Mg meg/L	0.84	0.74	0.54
H CO₃	2.16	2.44	2.93
Cl meg/L	1.74	1.50	1.59
SO₄ meg/L	0.82	0.89	0.74

Randomized complete block design was used with 3 replicates (3 hools per each) in experimental seasons. Nitrogen and Potassium were applied in different rates and their combinations, Nitrogen (600, 750 and 900 g actual/plant) and potassium (750, 1000 and 1250 g actual K_2O/plant) were added

in the form of ammonium nitrate NH_4NO_3 (33.5 % N) and potassium sulphate (48% K_2O) respectively with the drip irrigation system. All the considered NK rates were divided into 240 doses / year applied starting with February to December for each season. (Table 2).

Table 2. Time and amount of actual NK fertigated around the year to the experimental Ziv banana plants

Teat months	Actual N g/ plant/ year			Actual K₂ O g/ plant/ year		
	600	750	900	750	1000	1250
February	30	38	45	22.5	30	37.5
March	35	43.75	50	30	40	50
April	40	50	60	45	60	75
May	50	63	75	60	80	100
June	75	93.75	100	75	100	125
July	80	100	120	105	140	175
August	80	100	120	112.5	150	187.5
September	85	105.25	115	112.5	150	187.5
October	60	75	90	90	120	150
November	40	50	60	60	80	100
December	25	31.25	35	37.5	50	62.5
Total	600	750	900	750	1000	1250

Nitrogen, potassium were applied dissolved a trickle irrigation system in 20 doses / month.

Data recorded

Vegetative growth parameters

At bunch shooting stage, the following growth characteristics were recorded in three seasons: pseudostem height (cm) as measured from the soil surface up to the petiole of the last emerged leaf, Pseudostem circumference (cm) was measured at height of 20 cm above soil surface, number of green leaves per plant as well as leaf area of the 3rd full expended leaf from the plant top was estimated using the formula of **Murry (1960)** (leaf area = length x width x 0.86). Assimilation leaf area (ALA) was calculated according to **Ibrahim (1993)** using the formula: ALA= leaf area x number of leaves/ plant at bunch shooting.

Flowering

1- Time to flowering: the period from sucker emergence to bunch shooting (in days) date was calculated in the tested seasons.

2- Time to harvesting: the period from bunch shooting to date of harvesting (in days) was calculated.

3- Cropping cycle (life cycle duration): It was calculated (in days) from sucker emergence to date of harvesting

- Yield and bunch characteristics, harvesting was took place in three seasons, when the fingers reached to the full maturation. Yield (ton)/fed, bunch weight (Kg) and finger weight (g) were measured and recorded.

- Leaf minerals content

Leaf sample was taken from the third upper leaf (counted from the top of the plant) in each individual plant at bunch shooting stage was taken as recommended by **Hewitt (1955).** Leaf sample was washed by tap water then with distilled water and dried using oven at 70°C to a constant weight then grounded and subjected to the following determinations: the following mineral elements:

A - Total nitrogen: total N was determined by Micro-Kjeldahle method as described by **Pregl (1945)**.

B- Potassium concentrations were determined by using the Atomic Absorption Spectrometer (Perkin–Elemer, Model 3300) according to the methods described by **Chapman and Pratt (1964)**.

NK use efficiency was calculated according to the following equation according **to Infana *et. al.,* 2015**

N use efficiency = yield (kg/ fed.)/ amount of actual N/fed.

K use efficiency = yield (kg /fed.)/ amount actual K_2O/fed.).

Net returns

- Total cost of fertilizers estimated using the following formula (according to Infana ***et. al.,* 2015**): TC= TFC+T P C.

- Net returns were estimated using the following formula:NR= TI – TC.

Statistical analysis

Data were subjected to analysis of variance for factorial plot design in randomized complete blocks (**Snedecor and Cochran 1990**). Differences between treatments Means were separated by the (New L.S.D) (**Waller and Duncan 1969**) least significant differences test at a 0.05 probability level.

RESULTS AND DISCUSSION

Vegetative growth

Data presented in Table (3) showed that, increase nutrients significantly increased the vegetative growth of Ziv banana plants. The fertigation treatments induced significant differences in vegetative growth parameters at the three rates of 600, 750 and 900 g actual N/plant/year (299.1, 313.6 and 320.7 cm) in the 1st ratoon, (303.3, 318.0 and 327.7 cm) in the 2nd ratoon and (301.0, 317.3 and 327.3 cm) in the 3rd ratoon, respectively. As well as for three rates of K-fertigation (750, 1000 and 1250 g actual K_2O/plant/year) the height values were (291, 308.5 and 333.8 cm), (295.6, 313.2 and 340.3 cm) and (294.6, 312.9 and 339.1 cm) at three ratoons, respectively. Yet the pseudostem height tented to increase with increase rates of NK fertilizers. The highest value recorded 340, 348.5 and 347.3 cm with the rate of 900, 1250 NK in three tested seasons. As for the pseudostem circumference, 750 g actual N/plant/year significantly induced the thickest pseudostems (86.44, 90.28 and 89.39 cm) throughout the three studied seasons, respectively. At the same time, 1250 g actual K_2O/ plant/ year significantly resulted in the highest circumference in the first, second and third seasons, respectively (87.44, 90.72 and 90.00 cm). hence, the combination 750 g actual N + 1250 g actual K_2O gave the highest results (90.33, 93.6

and 93.00 cm). The shortest pseudostem and narrowest pseudostem circumference plants were at the lowest rate of NK (600, 750 g) and recorded 274.2, 278, 271.1 cm and 71, 74, 75 cm, respectively in three seasons. Assimilation area and number of green leaves sprout on the plant at bunch shooting stage increased with increasing rate of nutrients. The rate of (900, 1250) NK increased the emerged green leaves (15, 14, 13 leaf/plant) and assimilation area (22.9, 20.9, 20.9 m^2/ plant) in comparison with the lowest rat of NK (600, 750) which recorded (11, 10, 10 leaf/plant) and (15, 13, 13.5 m^2/plant) in Ziv banana cultivar in tested seasons respectively.

The pseudostem is constituted by wrapped leaf sheaths, making it rigid, as the emergence of new leaves occurs. The proper nutrient supply furthers leaf development, and consequently, the pseudostem increases its height and diameter. Pseudostems stores large amounts of nutrients, especially N and K (67.9 and 233.1 kg ha-1, respectively), which is used for fruit filling.

These results are true during the three growing seasons. In this connection **Loredana** *et al.*, **(2015)** who mentioned that growth vigor is greatly affected by soil treatment, efficiency as well as quantity and availability of nutrients. However, there is no significant effects were detected between 750, 900 g N and 1000, 1250 g actual K$_2$O in Pseudostem circumference through 2nd and 3rd seasons as well as number of green leaves/plant and assimilation area. Similarly, all interaction treatments increased height, circumference and number of leaves and leaf area of Zive banana plants grown during the three growing seasons.

The number of active leaves at blooming is an important parameter for banana bunch development because it reflects the potential yield, as these leaves are directly related to the plant photosynthetic rate (**Soto-Ballestero, 2008**) and promote starch accumulation in fruits.

Banana plant height and pseudostem diameter are important parameters in crop management because they are related to plant vigour and they affect bunch harvesting and breaking/tipping adult plants, consequently causing fewer losses in yield (**Farias** *et al.*, **2010**).

Flowering

The period from sucker emergence to bunch shooting (time to flowering), in addition, the period from bunch shooting to harvesting date were affected by the rate of N and K nutrients. Data showed significant decreases in time to flowering and harvesting compared to the other treatments. It may be recorded due to the increase in absorption of nutrient from the soil and thus promote plant growth.

Results in Table (4) show that increasing rate of N- fertigation gradually and significantly short ended the time to flowering. The period to flowering of plant is (414, 392, 368 days), in 1st season (413, 389, 368 days) in 2nd season and (412, 388 & 367 days) in 3rd season in 600, 750, 900g N/plant treatments, respectively. With the effect of K–ferigation rates on the period to flowering, the uppermost tested rate (1250g K$_2$O/plant) shortened the period to flowering than the other treatments (377, 373 & 370) days compared with (402, 404, 405 and 395, 393, 392 days) for 750 and 1000 g K$_2$O/plant/year treatments in three seasons respectively. The interaction studies between the two main factors concerning the time to flowering was statistically significant. It was clear that the combinations (900N + 1250 K$_2$O/ plant/year), was the most effective in shortening the time to flowering in three seasons.

Time to harvesting of plants was clearly decreased by increasing the rate of N and K fertilization in here seasons. In this respect manner, the interaction of 900g N with 1250 g K$_2$O/plant/year gave shortest period to harvesting (100, 105 and 100 days) in tested seasons, respectively.

Life cycle

Application of nitrogen at the level 900 g/ plant markedly reduced the total duration of the crop in three tested seasons (Table 4). Applied nitrogen exerted its effect on total crop duration mainly by influencing the days to shooting. There was a reduction of 63, 65, 65 days in the total crop duration when nitrogen level was increased from 600 to 900 g plant-1. Nitrogen reduced phyllochron and increased the leaf area in a short span of time thereby helping the plant to attain early physiological maturity. Thus, shooting occurred early which in turn reduced the total crop duration (**Geetha, 1998 and Indira and Nair, 2008**).

Potassium applied at 400 g plant-1 reduced duration of the crop. This might be due to the enhanced vigour of the plant and increased vegetative growth. Higher levels of potassium might have contributed much to early flowering. (**Indira and Nair, 2008**).

Table 3. Effect of N and K fertigation on vegetative growth of Ziv banana plants at bunch shooting stage (2016/2017, 2017/2018 and 208/2019 seasons)

Pseudostem height (cm)											
N-fert. rate g actual / plant /year	**First season**				**Second season**				**Third season**			
	K – fertigation rates g actual K₂O /plant/year											
	750	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**
600	274.0	295.0	304.0	291	278.0	298.0	311.0	295.6	271.1	298.0	312.0	293.6
750	296.0	312.0	318.0	308.5	300.0	316.0	324.0	313.2	301.0	315.0	323.0	312.9
900	327.0	334.0	340.0	333.8	332.0	340.0	349.0	340.3	331.0	339.0	347.0	339.1
Mean	299.0	314.0	321.0		303.0	318.0	328.0		301.0	317.0	327.0	
New L.S.D. at 0.05	N: 5.976; K: 0.976; NK: 7.691				N:4.091; K:5.091; NK: 6.889				N:5.008; K:5.008; NK: 6.747			

Pseudostem circumference (cm)											
N-fert. rate g actual / plant /year	**First season**				**Second season**				**Third season**			
	K – fertigation rates g actual K₂O /plant/year											
	750	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**
600	71.00	82.00	83.00	78.70	74.00	87.70	87.00	82.89	75.00	85.50	86.00	82.17
750	83.00	86.00	90.3	86.44	87.70	89.50	93.70	90.28	86.67	88.50	93.00	89.39
900	85.00	87.00	89.0	87.0	88.00	90.00	91.50	89.33	87.50	89.00	91.00	89.17
Mean	79.70	85.20	87.40		83.20	89.10	90.70		83.06	87.70	90.00	
New L.S.D. at 0.05	N:1.479; K:2.479; NK: 2.829				N:1.438; K:2.438; NK: 2.758				N:1.503; K:1.503; NK: 2.871			

Assimilation area (m²)											
N-fert. rate g actual / plant /year	**First season**				**Second season**				**Third season**			
	K – fertigation rates g actual K₂O /plant/year											
	750	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**
600	15.0	16.2	17.8	16.3	13.0	15.0	16.7	14.9	13.5	16.0	17.0	15.5
750	18.9	18.2	18.9	18.7	16.5	18.0	16.5	17.0	17.1	19.0	18.5	18.2
900	20.7	21.7	22.9	21.8	17.8	20.1	20.9	19.6	18.2	20.2	20.9	19.8
Mean	18.2	18.7	19.9		15.8	17.7	18.0		16.3	18.4	18.8	
New L.S.D. at 0.05	N: 0.694; K: 0.694; NK: 1.202				N: 0.611; K: N.S.; NK: 0.1.059				N: 0.694; K: 0.694; NK: 1.202			

Number of green leaves/plant											
N-fert. rate g actual / plant /year	**First season**				**Second season**				**Third season**			
	K – fertigation rates g actual K₂O /plant/year											
	750	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**
600	11.0	12.0	13.0	12.0	10.0	11.0	12.0	11.0	10.0	11.0	12.0	11.0
750	13.0	13.0	14.0	13.3	12.0	13.0	14.0	13.0	11.0	12.0	13.0	12.0
900	14.0	14.0	15.0	14.3	13.0	14.0	14.0	13.7	12.0	13.0	13.0	12.7
Mean	12.7	13.0	14.0		11.7	12.7	13.3		11.0	12.0	12.7	
New L.S.D. at 0.05	N: 0.626; K: 0.626; NK: N.S.				N: 0.577; K: N.S.; NK: N.S.				N: 0.577; K: N.S.; NK: N.S.			

Table 4. Effect of N and K fertigation on flowering time, harvesting time and crop duration of Ziv banana plants at bunch shooting stage (2016/2017, 2017/2018 and 208/2019 seasons)

Flowering time (days)												
N-fert. rate g actual/plant/year	**First season**				**Second season**				**Third season**			
	K – fertigation rates g actual K₂O /plant/year											
	750	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**
600	427	415	401	414	428	413	398	413	427	415	395	412
750	403	398	375	392	401	392	374	389	403	390	370	388
900	377	373	354	368	382	373	348	368	384	371	346	367
Mean	402	395	377		404	393	373		405	392	370	
New L.S.D. at 0.05	N: 5.856; K:3.856; NK: 6.214				N: 5.119; K: 6.119; NK: 9.938				N: 5.209; K: 5.209; NK: 6.094			

Harvesting time (days)												
N-fert. rate g actual/plant/year	**First season**				**Second season**				**Third season**			
	K – fertigation rates g actual K₂O /plant/year											
	750	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**
600	130	120	115	122	140	130	125	132	130	120	110	120
750	120	115	105	113	130	120	115	122	120	110	100	110
900	110	105	100	105	120	110	105	112	100	100	100	100
Mean	120	113	107		130	120	115		117	110	103	
New L.S.D. at 0.05	N: 1.549; K: 1.549; NK: 2.684				N: 1.332; K:1.332; NK: 2.307				N: 1.521; K: 1.521; NK: 2.635			

Life cycle												
N-fert. rate g actual/plant/year	**First season**				**Second season**				**Third season**			
	K – fertigation rates g actual K₂O /plant/year											
	750	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**
600	557	535	516	536	568	543	523	545	557	535	505	532
750	523	513	480	505	531	512	489	511	523	500	470	498
900	487	478	454	473	502	483	453	479	484	471	446	467
Mean	522	509	483		527	513	488		521	502	474	
New L.S.D. at 0.05	N: 7.068; K: 7.068; NK: 9.582				N: 6.043; K: 6.043; NK: 10.538				N: 8.938; K: 8.938; NK: 9.357			

Note: In the table K₂O is written as K_2O.

Chemical constituents of the leaves

Data presented in Table (5) show that N concentration in leaf of fertilized plants increased by increasing rate of N-fertigation in the three tested seasons. The highest values of N concentration were show with 750 and 900 g N/plant/year. Concerning of K-concentration data tended to decreased with increasing rate of N-fertigation. NK-concentration were (2.58, 3.01, 3.18 & 2.53, 2.93, 3.33 & 2.27, 2.36 & 2.81 %) and (3.37, 3.17, 3.03 & 3.69, 3.47, 3.33 & 3.63, 3.42, 3.33 % in treatments of 600, 750, 900g N/plant/year in three tested seasons for Leaf N and K contents. K-concentration in Ziv banana leaves tended to increase as K-fertigation rates were increased. The greatest values of K concentration in the leaves were noticed with 1250g K₂O/plant/year (3.67, 4.0, 4.0 %) respectively, However, low rate of K-fertigation (750g K₂O/plant/year) minimized the K concentration (2.67, 3.1, 3.09 %) than other tested treatment in three seasons respectively. Interaction showed significant differences between N and K rates which leaf K content in response to N and K fertigation. These results harmony with **Ibrahim (2003)** and **Hosny (2010)** on banana plants where noticed that adding chemical fertilizers particularly NPK enhance chemical activities and N, P and K releasing thereby increased these elements in rooting zone, consequently increasing their absorption by the plant. By these possibilities, the concentration of NK in the root zone increased which encouraged NK absorption and consequently its accumulation in leaves.

Table 5. Effect of N and K fertigation on chemical constituents of the leaves of Ziv banana plants at bunch shooting stage (2016/2017, 2017/2018 and 208/2019 seasons)

	Leaf N content (%)											
N-fert. rate g actual/plant /year	**First season**				**Second season**				**Third season**			
	K – fertigation rates g actual K$_2$O /plant/year											
	750	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**
600	2.81	2.61	2.31	2.58	2.74	2.54	2.31	2.53	2.41	2.20	2.20	2.27
750	3.11	3.01	2.91	3.01	3.04	2.91	2.85	2.93	2.59	2.30	2.20	2.36
900	3.25	3.10	3.30	3.18	3.10	3.00	3.90	3.33	2.62	2.50	3.30	2.81
Mean	3.06	2.91	2.84		2.96	2.82	3.02		2.54	2.33	2.57	
New L.S.D. at 0.05	N: 0.314; K:0.314; NK: 0.544				N: 0.303; K: N,S.; NK: 0.525				N: 0.134; K: 0.134; NK: 0.231			

	Leaf K content (%)											
N-fert. rate g actual/plant /year	**First season**				**Second season**				**Third season**			
	K – fertigation rates g actual K$_2$O /plant/year											
	750	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**
600	2.81	3.39	3.90	3.37	3.30	3.68	4.10	3.69	3.20	3.60	4.10	3.63
750	2.70	3.20	3.60	3.17	3.10	3.30	4.00	3.47	3.06	3.20	4.00	3.42
900	2.50	3.10	3.50	3.03	2.90	3.20	3.90	3.33	3.00	3.10	3.90	3.33
Mean	2.67	3.23	3.67		3.10	3.39	4.00		3.09	3.30	4.00	
New L.S.D. at 0.05	N: 0.210; K:0.210; NK: 0.364				N:0.097; K:0.097; NK: 0.168				N:0.140; K:0.140; NK: 0.243			

Bunch weight and yield

As for yield and its components, data in Table (6) show that plants fertilized with the highest doses from N and K significantly increased bunch and finger weight as well as yield in three seasons. This increase in weight may be attributed to an increase in cell division and elongation which caused an induction of vegetative growth, favoring physiological processes reflected on increasing yield and its components. Similar results were concluded (**Jothimani *et al*., 2013**). Finger weight/bunch, bunch weight/plant and yield/Fed. significantly varied according to the N and k fertigation. All interaction treatments increased these parameters and showed an additive effect in this respect. The heaviest bunches, (or yield/ Fed.), finger/plant were produced in plants received the rate of 900 and 1250 g/plant/year NK treatment were (44 & 47 & 46 kg/plant., 34.83 & 42.3 & 41.4ton/fed., 254.9 & 266.4 & 260g/fruit.) on three tested seasons, and the lightest bunches(or yield/Fed.), fingers/plants were obtained from the plants fertilized with lowest NK doses (600, 750 NK g/plant/year) treatment were (20 & 25& 18 kg, 18 & 22.5 & 16.2 ton /fed. 121.2 & 154.8 & 109 g/fruit).

Concerning increasing rate of yield results show significantly varied according to increase in NK-fertigation. Treatment 900 g actual N +1250 g actual K$_2$O recorded the highest percentage of (48.2,45.8,61.3 %) compared with the other treatment in the tested seasons. The increase in fruit weight might be due to the removal of flower bud after formation of the bunch which helped in conservation and utilization of photosynthetic in the more efficient way. Potassium improves fruit weight and number of fingers per bunch, and increases the content of starch and sugar content (**Bhargava *et al.*, 1993**). Also, **Pandey and Sinha (1999)** who reported that the increase in weight of the hand, weight of the bunch and yield per hectare are due to sulphur present in the sulphate of potash which might be responsible for the formation of iron-sulphur protein in plants which might have a direct impact in activating the catalase and peroxidase enzymes. Moreover, the increase in bunch weight can be attributed to the cumulative effect of yield attributing characters like finger weight, length of the finger, circumference of the finger and pulp to peel ratio. The favourable influence of K$_2$SO$_4$ as compared to other nutrients on the production of heavier bunches might be attributed to the heavier dry matter and starch accumulation and additionally promoted by the sulphur present in K$_2$SO$_4$ (**Kumar and Kumar, 2008**).

Table 6. Effect of N and K fertigation on bunch weight(kg), yield(ton), finger weight (g) and Increasing rate of yield (%) of Ziv banana plants at (2016/2017, 2017/2018 and 208/2019 seasons)

Finger weight (g)											
N-fert. rate g actual / plant /year	**First season**				**Second season**				**Third season**		
	K – fertigation rates g actual K$_2$O /plant/year										
	750	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**
600	121.1	151.6	191.4	154.7	154.8	185.2	196.5	178.8	109.0	130.4	179.0	139.5
750	163.7	196.0	201.2	187.0	193.5	216.0	217.4	209.0	169.0	180.5	201.0	183.5
900	188.9	224.9	254.6	222.8	222.2	233.9	266.4	240.8	206.4	227.8	260.0	231.4
Mean	157.9	190.8	215.7		190.2	211.7	226.8		161.5	179.6	213.3	
New L.S.D. at 0.05	N: 3.765; K: 3.765; NK: 6.522				N: 3.295; K:3.295; NK: 5.706				N: 3.414; K:3.414; NK: 5.912			

Bunch weight (Kg)											
N-fert. rate g actual / plant /year	**First season**				**Second season**				**Third season**		
	K – fertigation rates g actual K$_2$O /plant/year										
	750	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**
600	20.0	28.0	31.0	26.3	25.0	30.0	32.0	29.0	18.0	21.0	29.0	22.7
750	28.0	32.0	35.0	31.7	34.0	38.0	40.0	37.3	32.0	34.0	37.0	34.3
900	34.0	38.0	44.0	38.7	40.0	43.0	47.0	43.3	38.0	41.0	46.0	41.7
Mean	27.3	32.7	36.7		33.0	37.0	39.7		29.3	32	37.3	
New L.S.D. at 0.05	N: 0.421; K: 0.421; NK : 0.730				N :0.353; K: 0.353; NK: 0.612				N: 0.421; K: 0.421; NK : 0.730			

Yield/Fed. (ton)											
N-fert. rate g actual / plant /year	**First season**				**Second season**				**Third season**		
	K – fertigation rates g actual K$_2$O /plant/year										
	750	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**
600	18.0	25.2	27.9	23.7	22.5	27.0	28.8	26.1	16.2	18.9	26.1	20.4
750	25.2	28.8	31.5	28.5	30.6	34.2	36.0	33.6	28.8	30.6	33.3	30.9
900	30.6	34.2	34.83	33.2	36.0	38.7	42.3	39.0	34.2	36.9	41.4	37.5
Mean	24.6	29.4	31.4		29.7	33.3	35.7		26.4	28.8	33.6	
New L.S.D. at 0.05	N 0.300; K: 0.300; NK: 0.520				N: 0.281; K: 0.281; NK: 0.486				N 0.300; K: 0.300; NK: 0.520			

Increasing rate of yield (%)											
N-fert. rate g actual/ plant /year	**First season**				**Second season**				**Third season**		
	K – fertigation rates g actual K$_2$O /plant/year										
	750	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**	**750**	**1000**	**1250**	**Mean**
600	0.0	28.5	35.5	21.3	0.0	16.7	21.9	12.9	0.0	14.3	37.9	17.4
750	28.5	37.5	42.9	36.3	26.5	34.2	37.5	32.7	43.8	47.1	51.4	47.4
900	41.2	47.4	48.2	45.6	37.5	41.8	45.8	41.7	52.6	56.1	61.3	56.7
Mean	23.2	37.8	42.2		21.3	30.9	35.1		32.1	39.2	50.2	
New L.S.D. at 0.05	N : 3.092; K: 4.092; NK: 5.159				N : 3.081; K: 4.081; NK: 6.140				N: 6.092; K: 7.092; NK : 9.159			

Nitrogen use efficiency (Kg. fruits/one Kg N-fertilizer)

Results in Table (7) obtained that nitrogen or Potassium use efficiency (NUE) or (KUE), is expressed as the amount of Grand Nain banana fruits in Kg. that could be produced from one kg. of N or K-actual fertilizer. NUE and KUE clearly affected by fertilizer. The results show that the highest value of NUE was (38, 44.7, 41.2 kg fruit/kg fertilizer) with the rate of (750g actual N/plant/year) while, in the KUE results recorded highest value (41.8 & 47.8 & 41.6) at the rate 1250g actual K_2O/plant/year). In other words, N-use efficiency increased with increasing potassium fertilizers while K-use efficiency increased with increasing nitrogen fertilizers. These results agree with **Jaime *et al.*, (2017)** whose reported that high dose of nitrogen showed a trend to increase the nutrients accumulation during the banana plant development but especially, until fructification stage, with the exception of Mg and Ca, which achieved the greatest accumulation in harvest timing. Studies on fruit crops showed that use efficiency of N, P, and K fertilizers were negatively correlated with the fertilizer rates (**Zhang *et al.*, 2010** and **Quaggio *et al.*, 2019**). Overall, a rational nutrient management is therefore even more crucial for balancing yield and environmental concern in countries like China, India and other countries where fertilizers are generally overused (**Wenli *et. al.*, 2020).**

Table 7. Effect of N and K fertigation on NK use efficiency of the leaves of Ziv banana plants at bunch shooting stage (2016/2017, 2017/2018 and 208/2019 seasons)

N-fert. rate g actual/ plant /year	First season				Second season				Third season			
	N use efficiency											
	K – fertigation rates g actual. K_2O /plant/year											
	750	1000	1250	Mean	750	1000	1250	Mean	750	1000	1250	Mean
600	30.0	33.6	46.5	36.7	37.5	45.0	48.0	43.5	27.0	31.5	34.5	31.0
750	33.6	38.4	42.0	38.0	40.5	45.6	48.0	44.7	38.4	40.8	44.4	41.2
900	34.0	38.0	36.9	36.3	40.0	43.0	47.3	43.4	38.0	41.0	46.0	41.7
Mean	32.5	36.7	41.8		39.3	44.5	47.8		34.5	37.8	41.6	
New L.S.D. at 0.05	N: 3.14; K:3.01; NK:4.73				N:6.45; K: N,S; NK: 5.34				N:3.05; K:3.05 ; NK:3.80			

N-fert. rate g actual/ plant /year	First season				Second season				Third season			
	K use efficiency											
	K – fertigation rates g actual K_2O /plant/year											
	750	1000	1250	Mean	750	1000	1250	Mean	750	1000	1250	Mean
600	24.0	25.2	22.3	23.8	30.0	27.0	23.0	26.7	21.6	18.9	20.9	20.5
750	33.6	28.8	25.2	29.2	40.8	34.2	28.8	34.6	38.4	30.6	26.6	31.9
900	40.8	34.2	27.9	34.3	48.0	38.7	33..8	43.4	45.6	36.9	33.1	38.5
Mean	32.8	29.4	25.1		39.6	33.3	25.9		35.2	28.8	26.9	
New L.S.D. at 0.05	N: 3.29; K3.29; NK: 3.72				N:4.71; K:4.71; NK: 4.3				N:2.3; K:2.3; NK:3.1			

Fruit physical properties

Finger length and diameter (cm) data presented in Table (8) revealed that, the values of finger length recorded by 14.6, 17.7, 18.2 in 1st season; 18.9,21.1,21.1in the 2nd season and 18.7, 20.8, 21 in 3rd season, respectively for N fertigation rates gm/plant. Furthermore, the interaction effect between NK gave the highest values (21.60, 21.84, 21.72 cm) in finger parameters recorded by 900 and 1250 in three tested seasons. Contrary, to the low doses fertigation for (600 plus 750) recorded the lowest values through three tested seasons.

Data tabulated in Table (6) obviously that, the highest values of finger diameter (3.28, 3.30 and 3.33) for N fertigation rates gm/plant, in first; second and third seasons, respectively. Moreover, the interaction effect between NK gave the highest values (3.30 and 3.42 cm); (3.31 and 3.43) in finger parameters recorded by 900; 1000 and 1250 for 1st and 2nd season; while the 3rd season give 750; 900 and 750, 1000; 1250 was non-significant between them. In opposite, to the low doses fertigation for (600 plus 750) recorded the lowest values through three tested seasons.

Potassium improves fruit length and finger diameter (cm) and increases the content of starch and sugar content (**Bhargava *et al.*, 1993**). As well as, **Pandey and Sinha (1999)** who stated that the increase in weight of the hand, weight of the bunch and yield per hectare are due to sulphur present in the sulphate of potash which might be responsible for the formation of iron-sulphur protein in plants which might have a direct impact in activating the catalase and peroxidase enzymes.

Table 8. Effect of N and K fertigation on finger length and finger diameter (cm) of Ziv banana plants at (2016/2017, 2017/2018 and 208/2019 seasons)

N-fert. rate g actual / plant /year	Finger length (cm)											
	First season				Second season				Third season			
	K – fertigation rates g actual K$_2$O /plant/year											
	750	1000	1250	Mean	750	1000	1250	Mean	750	1000	1250	Mean
600	14.27	14.43	14.97	14.60	18.51	18.63	19.53	18.90	18.39	18.53	19.25	18.70
750	17.10	17.37	17.88	17.70	20.45	21.17	21.63	21.10	20.28	20.77	21.26	20.80
900	19.00	21.30	21.6	18.20	19.95	21.52	21.84	21.10	19.98	21.41	21.72	21.00
Mean	25.90	17.50	20.60		19.60	20.40	21.00		19.60	20.20	20.70	
New L.S.D. at 0.05	N:0.031; K:0.031; NK:1.054				N: 0.300; K: 0.300; NK: 1.520				N: 0.258; K: 0.258; NK: 1.447			

N-fert. rate g actual / plant /year	Finger diameter (cm)											
	First season				Second season				Third season			
	K – fertigation rates g actual K$_2$O /plant/year											
	750	1000	1250	Mean	750	1000	1250	Mean	750	1000	1250	Mean
600	2.09	2.35	2.41	2.28	2.23	2.45	2.53	2.40	2.37	2.55	2.64	2.52
750	2.87	3.17	3.10	3.05	2.89	3.19	3.16	3.08	2.91	3.20	3.24	3.12
900	3.11	3.30	3.42	3.28	3.17	3.31	3.43	3.30	3.22	3.31	3.45	3.33
Mean	2.69	2.94	2.98		2.76	2.98	3.04		2.83	3.02	3.11	
New L.S.D. at 0.05	N:0.115; K:0.115; NK: 0.199				N:0.097; K:0.097; NK:0.168				N:0.126; K:0.126; NK: 0.219			

Economic return

The economic return of Ziv banana plants (Table 9) showed that net income gradually increase by increasing NK fertilizers. Plants were fertilized with the 900g. N + 1250g. K$_2$O/plant/year gave the highest income (221199 L.E./fed/year) compared with other treatment. While the lowest rate of NK fertilizer (600gN + 750 g. k$_2$o plant/year) gave the cheap income (75240 L.E./fed./year).

Table 9. Effect of N and K fertigation on net-return of Ziv banana plants

Treatment(g) Actual/plant/year	Cost of fertilizers (pound)			Cost of pesticides (pound)	Total	Yield price (pound)	Net – income (pound)
	NH$_4$NO$_3$ (ton)	K$_2$so$_3$ (ton)	Other fertilizer				
600N+750K$_2$O	7360	15750	13050	2000	38160	113400	75240
600N+1000 K$_2$O	7360	21000	13050	2000	43410	142200	98790
600N+1250 K$_2$O	7360	26250	13050	2000	48660	165600	116940
750N+750 K$_2$O	10580	15750	13050	2000	41380	169200	127820
750N+1000 K$_2$O	10580	21000	13050	2000	46630	187200	140570
750N+1250 K$_2$O	10580	26250	13050	2000	51880	201600	149720
900N+750 K$_2$O	11500	15750	13050	2000	42300	201600	159300
900N+1000 K$_2$O	11500	21000	13050	2000	47550	219600	172050
900N+1250 K$_2$O	11500	26250	13050	2000	52800	273999	221199

Conclusion

From the aforementioned results, it can be concluded that, both treatments of (1000 and 1250 K$_2$O) K-fertigation rates (gm) and (750 and 900 NH$_4$NO$_3$) N-fertigation rate gm/plant/year were the more effective and increasing growth, fruiting and fruit quality improving leaf nutrient contents, N-efficiency, K- efficiency as well as economic return of "Ziv" banana plants. On the other world from observed results we could be concluded to fertilized Ziv banana plants with 900 g actual N plant /year and 1250 g K$_2$ O actual /plant/year produced highest yield and highly economic return.

REFERENCES

Amin, O.A.; Abd-El-Gawad, N.M.A.; Emam, H.E. and Abd El- Moneim, E.A.A. (2016). Effect of Soil Application with Humic and Amino acid on Vegetative Growth, Nutritional Statues, Yield and Fruit Quality of Grande Naine Banana Plants. Intern. J. Pharm-Tech. Res., 9(12): 88-96.

Bhargava, B.S.; Singh. H.P. and Chadha, L. (1993). Role of potassium in development of fruit quality. In: Adv. Hort., 2: 947-960.

Chapman, H.D. and Pratt, P.F. (1964). Methods of analysis for soils. Plant and Water. Div. Agric. Sci. Univ., California U.S.A. 150 p.

Edson S. N; Francine, L.C.; Erval, R.D.; Eduardo, J.F. and Ana L. B. (2017). Fertilization with nitrogen and potassium in banana cultivars 'Grand Naine', 'FHIA 17' and 'Nanicão IAC 2001' cultivated in Ribeira Valley, São Paulo State, Brazil. Acta Scientiarum. Agronomy Maringá, 39(4): 505-513.

Farias, H.C.; Donato, S.L.R.; Pereira, M.C.T. and Silva, S.O. (2010). Avaliação fitotécnica de bananeiras tipo terra sob irrigação em condições semi-áridas. Ciência e Agrotecnologia, 34(4): 380-386.

Geetha, K. (1998). Integrated plant nutrition system (IPNS) for maximizing yield in banana, Musa (AAB group) 'Nendran'. Ph. D thesis, Kerala Agricultural University, Thrissur, p. 149.

Hewitt, C. W. (1955). Leaf analysis as a guide to nutrition of banana. Emp. J. Exp. Agric., 23:11- 16 (C.F. Hort. Abst. 31:4346).

Hosny, S. S. (2010). Physiological studies on nutrition of banana plants. Thesis, Ph.D. Cairo university.

Ibrahim, E.G. (1993). Studies on irrigation of banana Ph. D. Thesis, Fac. Agric. Zagazic Univ.

Ibrahim, E.G. (2003). The effect of fertigation with nitrogen and potassium nutrients on "Williams Egypt" banana grown and productivity in newly reclaimed soil. Egypt. J. Appl. Sci., 18 (11): 278-293.

Indira, M. and Nair, S. (2008). Standardization of NPK requirement in banana cv. "Njalipoovan" (Musa AB group) in Onattukara soil of South Kerala. J. Hortl. Sci., 3(2): 127-131.

Infana, N.M.; Sanaulla N. and Barkat A. (2015). Economic efficiency of banana production under contract farming in Sindk Pakistan. J. Clop. Economics, 3 (4): 2-5.

Jaime.T.B.; Jaiver D.S. and Danial, G.C.S. (2017). Nutrient accumulation models in the banana (*Musa AAA Simoonds* cv. Williams) plant under nitrogen doses. Acta Agron., 66(3): 391-396.

Jothimani, P.; Sangeetha, R.; Kavitha, B. and Senthilraja, K. (2013). Effect of compost on growth and yield of Banana. Inter. J. Advanced Life Sci., 6(3): 131-138.

Kumar, A. R. and Kumar, N. (2008 b). Potassium nutrition in banana. The Asian J. Hort., 3(2): 479482.

Kumar, A.R. and Kumar, N. (2008 a). Studies on the efficacy of sulphate of potash (SOP) on the physiological, yield and quality parameters of banana cv. Robusta (Cavendish-AAA). Eur. Asia J. Bio Sci., 2 (12): 102-109.

Loredana, L.; Catello, P.; Donatella, A.; Giuseppe, C.; Massimo, Z. and Marisa, D. (2015). Compost and compost tea management of mini watermelon cultivations affects the chemical, physical and sensory assessment of the fruits. Agric. Sci., 6: 117-125.

Moreira, R. S. (1999). Banana: teoria e prática de cultivo (2aed., CD ROM). Campinas, SP: Fundação Cargill.

Murry, D.B. (1960). Deficiency symptoms of the major elements in the banana. Trop. Agric. Trim. 36:100- 107. National campaign for improving banana productivity in Egypt, 2014. (In Arabi)

Pandey, S.N. and Sinha B.K. (1999). Plant physiology. Vikas Publishing House Private Limited, New Delhi; 1999

Pregl, F. (1945). Quantitative organic micro analysis, I.A. 4th Ed., P. 17 Churchill, Ltd., London.176 p.

Snedecor, G.W. and Cochran, W.G. (1990). "Statistical Methods". 7th Ed., Iowa State Univ. Press Amer. Iowa, USA.

Soto-Ballestero, M. (2008). Bananos: técnicas de produción, poscosecha y comercialización (3rd ed., CD-ROM). San José, CR: Litografía e Imprenta Lil. Teixeira.

Waller, P.A. and D.B. Duncan (1969). A buys rule for the symmetric multiple comparison problem. Amer. State Assoc. J., 64: 1484-1503.

Wenli, Li., Min, Y., Jie, W., Zhichao, W., Zihan, F., Furong, K., Yuheng, W., Yayin, L.; Dejiao, K.; Zhihui, C.; Chaoyi, G.; Yujia, Li.; Xinhua, He.; Xinping, C. and Yueqiang, Zh. (2020). Agronomic Responses of Major Fruit Crops to Fertilization in China: A Meta-Analysis. Agronomy, 10(1): 15-18.

Wilde, S. A.; Corey, R. B.; Layer, J. G. and Voigt, G. K. (1985). Soils and Plant Analysis for Tree Culture. 3rd Ed. Oxford and IBH publishing Co., New Delhi, India, 529 – 546 pp.