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Impact of Inorganic and Bio-organic Fertilization on Growth, Yield and Fruit Quality of Young Fruitful Mango Trees "Fajri Kalan cv."

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ABSTRACT

This experiment was conducted during two successive experimental seasons (2013-2014) and (2014-2015) on mango trees "Fajri Kalan cv." to study the impact of inorganic, bio-organic fertilization and spraying with potassium silicate and bento cide as growth stimulants on yield and fruit quality. The obtained results, revealed that all investigated treatments except the fertilization with compost at 100% level significantly enhanced most of the investigated parameters. Fruiting aspects (initial fruit set %, fruit retention % and yield), fruit physical and chemical characteristics (fruit weight, volume, fruit juice total soluble solids (TSS), TSS/acid ratio, ascorbic acid and sugar content) were highly improved with the fertilization with NPK in mineral form at 50% + organic (compost) at 50% coupled with bento cide at either 10g/L or 20g/L. Meanwhile the least values of the investigated parameters were associated with the fertilization with organic (compost) fertilizer only at 100% level.

Key words: Mango trees, Fajri Kalan, potassium silicate, bento, cide fruit physical and chemical characteristics

Introduction

Mangoes *(Mangifera indica* L.) belong to family Anacardaceae. native to South Eastern Asia and considered one of the most important fruits of the tropical and sub tropical countries.

Mango trees were introduced to Egypt around year 1825. It ranks the third after citrus and grape. The total cultured area in Egypt reached about 240804 feddans that produced about 4.29 tons/feddan with total fruit production 786533 tons from produced area 183341 feddans (FAO, 2013). It is production areas are focused in Ismailia, Sharkia and Giza governorate.

Undoubtedly, there are many problems facing fruit trees growers which affected the productivity and fruit quality of mango trees. High costs of mineral fertilizers needed to fruit trees are one of these problems. Additionally, the uses of mineral fertilizers have an increased role in the health problems of mankind. However, they are considered as air, soil and water polluting agent results from leached chemical fertilization into the soil led to disturbance in the natural biological balance in the soil and accumulates in food chain causing hazardous effects for human health.

Organic fertilizer improve physical, chemical and biological properties of nearly all soil types; adjusting soil pH and increasing solubility production of the plants (Zhou *et al*., 2001). The addition of organic fertilizer (compost) to the soil encouraged proliferation of soil micro organisms, increased microbial population and activity of microbial enzymes i.e. dehydrogenize, urease and nitrogenase (Youssef *et al.,* 2001 and Abou-Hussein *et al.*, 2002).

Bio-fertilizers are the most importance for plant production and soil as they play an important role in increasing vegetative growth, yield and fruit quality (Hasan *et al*., (2013)

Potassium silicate is a source of highly soluble potassium and silicon. It is used in agricultural production system primarily as a silica amendment and has added the benefit of supplying small amounts of potassium (Tarabih *et al.*, 2014) Silicon is also known to increase drought tolerance in plants by maintaining plant water balance, photosynthetic activity, erectness of leaves and structure of xylem vessels under high transpiration rates.

Foliar spray of micronutrients helps in efficient utilizing of nutrients to plants directly through leaves within few days we can realize the effect of micronutrient spray (Nafees 2011).

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The main objective of this study, is to carry out a comparison between using organic manure (compost) or inorganic (NPK) fertilizer or the combination between them as a source of (NPK) soil fertilization, as well as foliar spray with potassium silicate and microelements (bento cide) as effective nutritive stimulants in order to know which NPK fertilizer source and the actual nutritional demand to be more beneficial for Fajri kalan mango trees productivity grown under Ismailia Governorate condition as well as adjusting the best NPK management that responsible for obtaining an economical and safety health yield is considered another target.

Materials and Methods

This investigation was carried out at El-Kassasien Horticultural Research Station, (HTC) Ismailia Governorate during two successive (2013-2014) and (2014-2015) experimental seasons. Four - year - old mango trees of "Fajri Kalan cv." were the plant materials used in this investigation, planted at 5 × 5 meters apart (168 trees / feddan) in sandy soil under drip irrigation system.Fifty four young fruitful mango trees were carefully selected and devoted for this work. Those trees were similar as possible as we could in their growth vigor, size shape and diseases free as well as they received the same culture managements adopted in (HTC).

This work included five investigated substances:

1- Chemical (mineral) fertilizers (NPK)
2- Organic fertilizer (compost)
3- Bio- fertilizers
4- Potassium silicate
5- Bento cide

Rate and application Method of Chemical fertilizers (NPK):

Two rates of chemical fertilizers NPK were employed in this study. The first rate was 100% of NPK (205, 50, and 145g per tree, respectively). The second rate was 50% of NPK (102.5, 25 and 72.5g per tree, respectively). The chemical fertilizers were added into two equal doses at the first week of February and two weeks later of fruit set through drip irrigation system during both seasons of study. Ammonium nitrate (NH_4NO_3, 33.5 % N) at 612g, Mono Calcium Phosphate (15.5 % P_2O_5) at 323 g and Potassium Sulphate (K_2SO_4- high soluble 50% K_2O) at 290 g were used as a source of N, P and K respectively to 100% level.

Rate and application Method of organic manure:

Two rates of organic (compost) fertilizer were used, the first rate was 100% level (17 kg compost per tree), such rate release 205, 103 and 145g of N,P and K per tree respectively and equivalent to the same quantities delivered by using (100 %) mineral NPK fertilizers. The second rate was 50% level (8.5 kg compost per tree). Moreover, in early December of both seasons of study, one trench (50 x 50 x 50 cm) was excavated on two side of the tree, then the given amount of compost as well as apart of surface soil were mixed together and added to the chuck hole followed by irrigation.

Rate and application method of Bio-fertilizers:

Four types of bio-fertilizers were investigated through out this study, those types namely Phosphorene, Nitrobein, Potassein and Effective Micro organisms (EM).

Each of the four abovementioned bio-fertilizers was soil added (15cm depth) to the wetted compost in three equal doses in (December, March and June) at the rate of 30g/tree/dose for 1, 2 and 3 While, the bio-fertilizer (EM) was added at 250 ml/tree/dose and the irrigation was conducted after each application.

Rate and application method of potassium silicate and bento cide:

Bento cide is a natural compound supplied by Al- Ahram mining company, it contains some micro-nutrient elements such as Fe, Zn, Cu, Bo and S which controlled mango flowers malformation as well as it improves flowering and fruiting rate of many plant species. Potassium silicate (KSi)

contents 15% silicon and 10% potassium., two rates of Potassium silicate (5ml/litter and 10ml/litter) and bento cide (10g/ litter and 20g/ litter) were employed in this study as foliar spray growth stimulant. Spraying was repeated on each tree at fifteen days intervals from full blooms to fruit mature stage .

The investigated substances including organic manure (compost), NPK mineral fertilizers, bio-fertilizers (Phosphorene, Nitrobein, Potassien and EM), potassium silicate and bento cide were arranged and designed in different combinations in order to build up the skeleton of the following investigated treatments:

T1. NPK 100 % (Mineral form)
T2. Organic (Compost) fertilizer 100%
T3. Organic (Compost) fertilizer 100% + EM
T4. Organic (Compost) fertilizer 100% + three bio-fertilizers (Phosphorene, Nitrobein and Potassien)
T5. NPK 50 % + Compost 50%
T6. NPK 50 % + Compost 50% + potassium silicate 5ml / litter
T7. NPK 50 % + Compost 50% + potassium silicate 10ml / litter
T8. NPK 50 % + Compost 50% + bento cide 10g / litter
T9. NPK 50 % + Compost 50% + bento cide 20g / litter

The Complete randomized block design was used for arranging the abovementioned nine soil fertilization and spraying treatments, whereas each treatment was replicated three times and each replicate was represented by two mango fruitful trees.

Methodology which has been followed in this study is being determined as follows:

Fruiting parameters: At full bloom forty panicles/ tree distributed at the four directions were random chosen and tagged in the 1st week of April for both seasons. The following parameters were determined:

Number of initial fruit set: Number of flowers /panicle was counted at full bloom, then number of developed fruitlets / panicle was counted 15 days after petal fall stage, initial fruit set % was calculated according to the following equation:

Fruit set % = total number of developed fruitlets per panicle / total numbers of flowers per panicle X 100

Fruit retention percentage: it was determined at harvesting time by the following equation: Fruit retention percentage = (number of mature fruit per panicle / number of fruit set per panicle) X100.

Number of fruits/tree: at fruit maturity stage, the total number of fruits that were born on each considered tree was counted and recorded.

Yield (kg/tree): At harvesting time (which was extended to September 15th during both seasons of study), fruits of each individual tree (replicate) were counted and weighed in Kgs, then yield was expressed as fresh fruits weight either as Kg/tree or as ton/feddan.

Fruit quality: Samples of twenty mature fruits at harvesting time from each tree were randomly collected and the following measurements of both physical and chemical properties were determined as follows:

Fruit physical characteristics: The average values of fruit weight (g), fruit volume (cm^3), and fruit firmness ($Ib/inch^2$) which was determined by using penetrometer (pressure tester) were estimated.

Fruit chemical characteristics: The following four fruit juice chemical properties of mature fruits were determined according to Hussein and Youssef (1972) as follows:

*Total soluble solids percentage (TSS %):*was determined using a Carl Zeiss hand refractometer.

Total titratable acidity percentage: according to the method described by A.O.A.C., 1995.

TSS/acid ratio:

Ascorbic acid (v. c): according to A.O.A.C., 1995.

Total sugars content: according to the method described by Dubaist *et al.* (1956).

Statistical Analysis:

All the obtained data in the two seasons of study were statistically analyzed using the analysis of variance method according to Snedecor and Cochran (1980). However, means were distinguished by the Duncan's multiple range test (Panse and Sukhatme, 1978).

Results and Discussion

1- Fruiting aspect:

Regarding initial fruit set %, fruit retention %, number of fruits per tree, fruit yield (Kg/tree and ton/ feddan) of mango trees "Fajri Kalan cv." data presented in tables (1 &2) indicate that the trees which received their demands of NPK in mineral and organic forms by 50% of each source and combined with bento cide as growth stimulant at either 10g/L (T8) or 20 g/L (T9) reflected the highest values of those parameters, as such the above mentioned two treatments maximized the investigated parameters, during 1st and 2nd seasons of study. Meanwhile, the trees which received their demands of NPK in the mineral form fertilizer only at 100% level (T1), standing the second one in this respect, during both seasons of study. On the other way around, the minimum values of those parameters were detected with those fertilized trees with NPK in organic form (compost) at 100% level (T2).

These results are in accordance with those found by Jitendra and Maurya, (2004), Ebeed *et al*. (2007) and Kumar *et al.* (2008) who reported that foliar application of mineral nutrients on Amrapali mango trees was the most effective treatments in improving the number of mango fruit per tree. Also, Yadav *et al*. (2011) who found that the organic nutrients (compost), inorganic fertilizer (NPK), bio-fertilizers and micronutrients (zinc and iron) enhancing the initial fruit setting of mango Amrapali cv.

Table 1: Initial fruit set% and Fruit retention % of mango trees Fajri Kalan cv. in response to mineral, bio-organic fertilizers and growth stimulants during (2013-2014) and (2014-2015) experimental seasons.

Treatments	Initial of fruit set (%)		Fruit retention (%)	
	(2013-2014)	(2014-2015)	(2013-2014)	(2014-2015)
T1: NPK 100 %	19.00 B	20.67 B	9.01 B	9.41 B
T2: Compost 100%	13.00 E	16.67 E	6.28 E	7.58 E
T3: Compost 100% + EM	14.00 D	18.66 D	7.11 D	7.42 D
T4: Compost 100% + three bio-fertilizers	14.67 D	18.68 D	7.60 D	8.10 D
T5: NPK 50 % + Compost 50%	16.00 C	19.68 C	8.50 C	8.64 C
T6: NPK 50 % + Compost 50%+ potassium silicate 5cm / litter	17.66 C	19.33 C	8.81 C	8.62 C
T7: NPK 50 % + Compost 50% + potassium silicate 10cm / litter	16.33 C	19.00 C	8.45 C	8.60 C
T8: NPK 50 % + Compost 50% + bentocide 10g / litter	21.00 A	22.33 A	10.36 A	11.95 A
T9: NPK 50 % + Compost 50% + bentocide 20g / litter	21.00 A	22.33 A	10.48 A	11.77 A

**values within each column followed by the same letter are not significantly different at 5% level.*

Table 2: Number of fruits/ tree and yield as kg/ tree and ton/ feddan of mango trees Fajri Kalan cv. in response to mineral, bio-organic fertilizers and growth stimulants during (2013-2014) and (2014- 2015) experimental seasons.

Treatments	No .of fruit/tree		Yield (kg/tree)		Yield (ton/feddan)	
	(2013-2014)	(2014-2015)	(2013-2014)	(2014-2015)	(2013-2014)	(2014-2015)
T1: NPK 100 %	43.67 B	47.67 B	23.95 B	25.50 B	4.024 B	4.284 B
T2: Compost 100%	31.33 D	34.67 D	15.37 D	16.51 D	2.582 D	2.774 D
T3: Compost 100% + EM	35.00 C	37.00 C	17.96 C	18.72 C	3.017 C	3.145 C
T4: Compost 100% + three bio-fertilizers	37.33 C	40.33 C	19.42 C	20.76 B	3.263 C	3.488 C
T5: NPK 50 % + Compost 50%	42.33 B	42.67 B	26.24 B	25.46 B	4.408 B	4.277 B
T6: NPK 50 % + Compost 50%+ potassium silicate 5cm / litter	42.67 B	41.33 B	26.21 B	24.59 B	4.403 B	4.131 B
T7: NPK 50 % + Compost 50% + potassium silicate 10cm / litter	44.00 B	45.00 B	27.65 B	26.82 B	4.645 B	4.506 B
T8: NPK 50 % + Compost 50% + bentocide 10g / litter	50.67 A	51.67 A	33.64 A	33.71 A	5.652 A	5.663 A
T9: NPK 50 % + Compost 50% + bentocide 20g / litter	51.00 A	53.00 A	33.08 A	34.47 A	5.557 A	5.791 A

**Values within each column followed by the same letter are not significantly different at 5% level.*

2 – Fruit characteristics:

2. a. fruit physical characteristics:

Data in table (3) clear that, the highly remarkable positive difference in fruit weight was detected when the trees were fertilized with NPK in mineral form at 50% + organic (compost) fertilizer at 50% combined with bento cide as growth stimulant either at 10g/L (T8) or at 20 g/L (T9) as compared with the other studied treatments, as such two treatments significantly maximized the value of fruit weight during both seasons of study. On the other way around, the reverse was true with those trees which have gotten their NPK demands from compost as an organic fertilizer source at 100% level (T2), where such treatment reflected the minimum significant value of fruit weight during both seasons of study. Furthermore, the investigated treatments reflected two clearly distinguished trends in relation to fruit volume, the first was associated with those treatments which included NPK in the mineral form at 50% + NPK in organic form (compost) at 50%. Such treatments either were used as it is i.e. growth stimulants free treatment (T5) or supplemented with potassium silicate at 5ml/L (T6) or at 10ml/L (T7) or supplied with bento- cide at 10g/L (T8) or at 20g/L (T9). The abovementioned five treatments were the superior ones in this respect as their impact were relative closed to each other and recorded the highest value of the investigated parameter, during both seasons of study. The second trend was related to the fertilization with either NPK in mineral form only at 100% level (T1) or NPK in organic form (compost) only at 100% level (T2) or (T2) combined with EM as soil stimulant (T3) or the three investigated bio-fertilizers (T4). The Four such treatments (T1, T2, T3 and T4) were matched in their impacts and in turn came in the second rank in this respect during both seasons of study.Data dealing with fruit firmness, reflected that there were no significant differences among the investigated treatments.

Similar results were reported by Ebeed *et al*. (2007) who reported that the spraying with some micronutrients and growth substances (Fe, Zn, Mn, Fe + Mn, Fe + Zn, Mn + Zn, Fe + Zn + Mn) of "Mesk cv." mango trees were increasing fruit weight and volume. Also, Hasan *et al*. (2013) who found that the organic and inorganic fertilizers and foliar spry with nutrient elements (nitrogen, phosphorus, potassium, zinc and boron) were effective in enhancing fruits length, width and weight of fruits mango trees. Moreover, Zaen El-deen *et al.* (2015) They showed that the interaction between

compost with spraying with potassium silicate recorded the highest significant effect on improving and increasing fruit physical parameters on "Keitt cv."mango trees.

Table 3: Fruit weight, volume and firmness of mango trees Fajri Kalan cv. in response to mineral, bio-organic fertilizers and growth stimulants during (2013-2014) and (2014- 2015) experimental seasons.

Treatments	Fruit weight (g)		Fruit volume (cm^3)		Fruit firmness ($Lb/ inch^2$)	
	(2013-2014)	(2014-2015)	(2013-2014)	(2014-2015)	(2013-2014)	(2014-2015)
T1: NPK 100 %	548.33 C	535.00 C	495 C	507.00 C	2.183 B	1.950 C
T2: Compost 100%	440.67 D	484.67 D	445 .67 D	462.33 C	2.700 AB	2.250 BC
T3: Compost 100% + EM	513.00 C	506.00 CD	446.67 CD	475.33 C	2.617 AB	2.433 AB
T4: Compost 100% + three bio-fertilizers	520.33 C	514.67 CD	474.67 CD	482.33 C	2.200 B	2.550 AB
T5: NPK 50 % + Compost 50%	620.00 B	596.67 B	559.33 B	581.67 B	2.533 AB	2.550 AB
T6: NPK 50 % + Compost 50%+ potassium silicate 5cm / litter	614.33 B	595.00 B	560.67 B	590.33 AB	2.600 AB	2.633 A
T7: NPK 50 % + Compost 50% + potassium silicate 10cm / litter	628.33 B	596.00 B	557.33 B	575.67 B	3.550 A	2.733 A
T8: NPK 50 % + Compost 50% + bentocide 10g / litter	664.00 A	652.33 A	597.00 AB	604.00 AB	2.250 B	2.450 AB
T9: NPK 50 % + Compost 50% + bentocide 20g / litter	657.33 A	650.33 A	625.33 A	637.00 A	2.200 B	2.467 AB

**Values within each column followed by the same letter are not significantly different at 5% level.*

2. b. fruit chemical characteristics

Data in tables (4 & 5) showed that the fertilization with NPK in two forms (mineral and organic) by sharing with 50% of each coupled with bento cide either at 10g/ L (T8) or at 20g/ L (T9) were the best two treatments, as both treatments achieved the highest significant values of the tss %.On the other hand, the least value of the investigated parameter was detected with those treated trees with organic (compost) fertilizer form at 100% level as unique source of NPK (T2). Furthermore, the least value of fruit acidity % was detected with the trees which either fertilized with mineral form at 100% level as the unique soured of NPK (T1) or received their NPK demand as mineral fertilizer and organic (compost)fertilizer at the rate of 50% of each fertilizer coupled with bento cide at 20 g/L (T9).The reverse was true with those trees which fertilized with compost at 100% level(T2) as the unique source of NPK, as such treatment recorded the highest value of the acidity %.

Moreover, the highest value of TSS/acid ratio was detected with those trees treated with NPK in mineral form at 50% level +compost as an organic source of NPK at 50% level coupled with bento cide at 20 g/L (T9). While, the least values of TSS/acid ratio and V.C were detected with the trees were fertilized with compost at 100% level as an organic source of NPK. Furthermore, the trees which were fertilized with NPK in mineral form and organic form by sharing 50% of each fertilizer combined with bento cide at either 10 g/L(T8) or 20 g/L (T9) maximized fruit pulp sugar and V.C content as compared with the other investigated treatments.

The reverse was true with those trees which fertilized with compost as an organic source of NPK at level 100% alone (T2) or coupled with EM (T3) or with the three investigated bio-fertilizers (T4), as those treatments reflected the least values of fruit pulp sugar content. These results agreed with those found by Tarabih *et al.* (2014) who found that exogenous application of silicon (si) in the form of potassium silicate at 0.2% reduced total acidity compare to the untreated Anna apple fruits. Also, Zaen El-Deen *et al.* (2015) reported that the application of compost and monthly foliar application (from April to August) with anti-transpiration materials such as kaolin (aluminum silicate) and silicon (potassium silicate), on four years old mango trees (*Mangifera indica* var, Keitt) improved and enhanced total sugar fruit content. Moreover, Abd-El-Rahman (2015) who found that foliar

application of potassium silicate at 0.2% was very effective in increasing fruit TSS, vitamin C. and total sugar content of Keitt mango fruits.

Table 4: Fruit juice total soluble solids, total titratable acidity and TSS/ acid ratio of mango trees Fajri Kalan cv. in response to mineral, bio- organic fertilizers and growth stimulants during (2013-2014) and (2014- 2015) experimental seasons.

Treatments	TSS (%)		Total Acidity (%)		TSS/Acid ratio	
	(2013-2014)	(2014-2015)	(2013-2014)	(2014-2015)	(2013-2014)	(2014-2015)
T1: NPK 100 %	18.13 B	18.67 B	0.309 C	0.276 C	58.67 B	67.64 B
T2: Compost 100%	15.33 D	16.33 D	0.340 A	0.317 A	45.09 D	51.51 D
T3: Compost 100% + EM	17.50 C	16.83 C	0.330 B	0.299 B	53.03 C	56.29 C
T4: Compost 100% + three bio-fertilizers	17.16 C	17.16 C	0.325 B	0.295 B	52.80 C	58.17 C
T5: NPK 50 % + Compost 50%	18.12 B	18.67 B	0.328 B	0.294 B	55.21 B	63.50 B
T6: NPK 50 % + Compost 50%+ potassium silicate 5cm / litter	18.12 B	18.63 B	0.322 B	0.289 B	56.27 B	64.46 B
T7: NPK 50 % + Compost 50% + potassium silicate 10cm / litter	18.16 B	18.54 B	0.331 B	0.293 B	54.86 B	63.28 B
T8: NPK 50 % + Compost 50% + bentocide 10g / litter	19.67 A	19.83 A	0.327 B	0.292 B	60.15 A	67.91 B
T9: NPK 50 % + Compost 50% + bentocide 20g / litter	19.33 A	19.63 A	0.307 C	0.273 C	62.96 A	71.90 A

**Values within each column followed by the same letter are not significantly different at 5% level.*

Table 5: Fruit pulp ascorbic acid (mg/100ml juice) and total sugar (g/100 gF.W) content of mango trees Fajri Kalan cv. in response to mineral, bio-organic fertilizers and growth stimulants during (2013-2014) and (2014- 2015) experimental seasons.

Treatments	Ascorbic acid content (mg/100ml juice)		Total sugar (g/100gF.W)	
	(2013-2014)	(2014-2015)	(2013-2014)	(2014-2015)
T1: NPK 100 %	25.57 B	26.58 B	12.62 B	12.83 B
T2: Compost 100%	23.39 D	24.40 D	10.62 D	10.79 D
T3: Compost 100% + EM	24.61C	25.61 C	10.88 D	10.98 D
T4: Compost 100% + three bio-fertilizers	24.44 C	25.45 C	10.88 D	10.95 D
T5: NPK 50 % + Compost 50%	25.38 B	26.39 B	11.85 C	11.94 C
T6: NPK 50 % + Compost 50%+ potassium silicate 5cm / litter	25.88 B	26.89 B	11.78 C	11.99 C
T7: NPK 50 % + Compost 50% + potassium silicate 10cm / litter	25.92 B	26.93 B	11.71 C	11.92 C
T8: NPK 50 % + Compost 50% + bentocide 10g / litter	27.44 A	27.45 A	13.39 A	13.51 A
T9: NPK 50 % + Compost 50% + bentocide 20g / litter	27.51 A	27.52 A	13.29 A	13.41 A

**Values within each column followed by the same letter are not significantly different at 5% level.*

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