Impact of the Nutritional Status on Yield of Nine Mango Cultivars Grown Under Farm Conditions at Giza Governorate, Egypt

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Abstract: A field study was carried out at some private farms in Giza Governorate, Egypt during seasons 2006-2010 with the nine mango cultivars: Zebda, Langra, Fagri Kalan, Hindi Khassa, Misk, Hindy Sinnara, Ewais, Alphons and Golk. The study aimed at investigating nutrient status of the orchards grown under flood irrigation system to discover deficiencies and suggest solutions. The obtained data revealed that orchard's soils were alkaline in reaction, sandy loam in texture in the surface layer (0-30cm) and sandy in texture in the subsurface layer (30-60cm) with deficient levels of available macro and micronutrients in the absorption root zone. Leaf analysis showed that nutrients concentration in the sufficient range but Ca, Mn and Zn were severely deficient along the course of the study which became limiting factors led to very low yields. The highest yield upon all was obtain by the cultivar Zebda which suggests its higher resistance to unfavorable soil conditions and nutrient deficiencies, while the cultivar Alphons gave the lowest yield which may indicates its higher sensitivity. More studies should be done to establish suitable fertilizer programs depend upon soil test and leaf analysis, taking in consideration choice of the efficient cultivars for nutrient deficiencies to be cultivated.
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1. Introduction

Imbalanced nutrition of mango is a very serious problem in Egypt leads to low production and lower fruit quality. Normal yields allover Egypt ranged from 5.6 to 18.7 t/ha and the most producing centers are in Sharkia, Ismailia, Giza, Fayoum, Qena and Beheira Governorates (**Riad, 1997**). However, in Giza orchards, average mango yields are dramatically lower due to the combined effects of climate changes, poor soil fertility with plant nutrient deficiencies, and a lack of understanding by farmers to the benefits of proper fertilization (**Fawzi *et al*., 1996**).

To fertilize mango trees adequately, an integrated strategy should be considered for the different growth phases (**Nascimento *et al*., 2008**). On the other hand, when the trees faced imbalanced nutritional strategy, the biannual bearing phenomenon (a high yield in a year is followed by a low yield in the subsequent year) is strongly appeared (**Avilan, 1971**).Micronutrients deficiency also became limiting factors for growth which leads to low yield and reduces fruit quality (**Stino *et al*., 2011**). The continuous nutritional diagnosis through soil test and leaf analysis can be a useful tool to set proper fertilization programs. Few studies on the relation between the low production and reduction of fruit quality and imbalance of nutrient status of mango trees were done (**Shaaban, 1995, Fawzi *et al*., 1996, Shaaban *et al*., 1999**).

The objective of the present investigation is to evaluate the nutrient status and yield of mango trees grown in sandy soils under flood irrigation system, to be used as a tool to improve nutrient management.

2. Materials and Methods

The study was conducted at flood-irrigated private orchard farms in El-Mansoria, Giza, Egypt during the successive years. 2006-2010 with nine of forty years old Mango (*Mangifera indica* L.) trees, cultivars: Fagri Kalan, Langra, Zebda, Hindi Khassa, Misk Hindy Sinnara, Ewais, Alphons and Golk. The orchards were planted at 8 x 8 m distance. Physio-chemical characteristics of the soil of the experimental fields were shown in Table1. Trees were flooding irrigated from deep well water (Table 2) every 20 days except during harvesting.

Sampling:

Soil:

Thirty six surface and sub-surface soil samples from 0-30 and 30-60 cm depths of the nine cultivars were collected yearly from the orchards in Oct-Nov. (before fertilizer application).

Leaves:

Leaf samples were collected randomly around the tree from the fully mature leaves of the spring flush (4- 7 months old) young shoots in the first half of August. Thirty matured and completely developed leaves per tree from the central position of branches were collected dried and analyzed.

Analysis:

Soil:

Soil samples were air- dried, ground to pass through a 2 mm sieve pores. Soil fractions were determined using the hydrometer method (Bauyoucos, 1954). E.C. and pH were determined in a soil/water extract (1:2.5) according to Jackson (1973). The $CaCO_3$ content was determined using the calcimeter method according to Black (1965). Organic matter was determined using the potassium dichromate method according to Walkely and Black (1934).Soil P was extracted using sodium bicarbonate ($NaHCO_3$) (Olsen *et al*., 1954). Magnesium and potassium were extracted using ammonium acetate ($C_3H_3O_2NH_4$) (Chapman and Pratt, 1978). Iron, Mn, Zn and Cu were extracted using DTPA-solution (Lindsay and Norvell, 1978).

Nutrients extraction:

Leaves:

Samples were washed with tap water, 0.001 N HCL and distilled water, respectively, then dried at 70° C for 24 hours and ground in a stainless steel mill, then passed through a 40 mesh nylon sieve and stored in plastic bottles. A part of the dry leaves was wet-digested according to the method of Chapman and Pratt (1978).

Nutrient measurements:

Plant material was digested using an acid mixture consisting of nitric, perchloric and sulfuric acids in the ratio of 8:1:1 (v/v), respectively (Chapman and Pratt, 1978). Nitrogen (N) was determined in the dry plant material using the boric acid modification described by Ma and Zuazage (1942), and distillation was done using a Buechi320-N_2-distillation. Phosphorus was photometrical determined using the molybdate-vanadate method. Potassium was measured using Dr. Lang -M8D Flame-photometer. Mg, Fe, Mn, Cu and Zn were determined using the Atomic Absorption Spectrophotometer (Perkin-Elmer 100 B).

Evaluation of the nutrient status:

Soil nutrient concentrations were evaluated according to the tentative values of Ankerman and Large (1974) and shoot tissue nutrient concentration ratios were based upon the values of Robinson (1986).

Statistical analysis

Data were subjected to statistical analysis as specified by Snedecor and Cochran (1990). Treatment means were calculated and subjected to the one-way Anova analysis and Student-Newman Keuls (SNK) and LSD ($p \leq 0.05$) tests-multiple comparison of means, using Costate 2 Program (Cohort software) for different treatments

3. Results and Discussion

Soil Conditions

Data in Table 1 show the physical characters and nutrient concentrations of the soil under which mango varieties are grown. According to the tentative values of **Ankerman and Large (1974), Silvertooth, (2001)** data revealed that soil texture is sandy loam in surface layer (0-30cm) and sandy in subsurface layer (30-60cm) tented to alkalinity in reaction. It has medium or low content of calcium carbonate and E.C. Surface soil layers had medium contents of organic matter due to crop residue decomposition, but content of subsurface soil layers was very low. P, Ca, Zn and Cu tended to be high in the surface soil layers but low to very low in subsurface soil layers. Other nutrients concentrations ranged between medium, low and very low in the two soil layers.

While mango roots absorb most of water and dissolved nutrients from the deep soil layers (**Medina-Urrutia, 1984**) the obtained data suggest that the trees suffering from complex nutrient deficiencies. The observed high or medium concentrations of P, K. Ca and Mg in the surface soil layers can be explained by the lower magnitude of nutrient absorption from this layer while fertilizers were added annually. High concentrations of micronutrients in the surface soil layers can be attributed to the relatively medium organic matter content in this layer which keeps phosphorus and micronutrients from leaching to the subsoil layers (**Krull *et al*., 2004**).

However the dissolved nutrients in the irrigation water (Table 2) can partially contribute in the amendment of some nutrient deficiencies like K, Mg and Ca.

Table 1. Physical and chemical characteristics of the orchard's soil

Depth (cm)	Sand %	Silt %	Clay %	Texture	pH (1:2.5)	EC (1.2.5) dS m^{-1}	$CaCO_3$ %	O.M %	P	K	Mg	Ca*	Na	Fe	Mn	Zn	Cu
									Macronutrients (mg.100g^{-1} soil)					Micronutrients (mg.kg^{-1} soil)			
2006																	
0-30	62	14	24	Sandy loam	8.10 H	1.00 M	4.40 M	2.60 M	2.88 H	31.20 H	103.5 M	520 H	6.81 VL	7.5 L	2.35 VL	3.40 H	2.1 H
30-60	90	4	6	Sandy	8.50 H	0.16 L	2.00 L	0.31 VL	0.58 L	7.11 VL	10.0 VL	81 L	2.85 VL	2.3 VL	0.55 VL	0.45 VL	Traces VL
2010																	
0-30	57	13	30	Sandy loam	8.16 H	0.14 L	1.29 L	2.42 M	4.68 VH	14.7 L	30.5 M	318 H	8.0 VL	20.0 H	9.22 M	3.13 H	3.9 VH
30-60	80	7	13	Sandy	8.17 H	0.07 L	1.33 L	0.63 VL	3.26 H	7.22 VL	10.1 VL	224 H	2.58 VL	15.0 M	4.24 VL	2.00 M	0.4 L

L: low, VL = very low, M= medium, H: High, VH= very high (**Ankerman and Large, 1974, Silvertooth, 2001***)

Leaf analysis

Leaf macronutrients N, P, K, Ca and Mg concentrations of the nine mango cultivars are shown in Fig. 1. All nutrient concentrations during the course of the study (2006-2010) for all cultivars were more or less in the adequate range, except of calcium which was severely deficient (Robinson, 1986). Moreover, N, K and Mg tended to increase to be higher than the adequate levels in the years 2009/2010, causing imbalance of nutrients within the plant tissues. A fluctuation of the nutrient concentrations during the course of the study was also observed indicated the random NPK fertilizer addition. This may be because the absence of knowledge by the farmers about mango trees nutrition and their fertilizer requirements during different growth stages (Fawzi, 1986, El-Sayed *et al*., 1991). A luxury level of nitrogen in mangoes is undesirable as it leads to excessive vegetative growth and internal fruit disorders (Mozafar, 1993). Potassium is often foliar sprayed two times at flowering stage to increase yield and at pre-harvest to enhance fruit coloring (Stino *et al*., 2011). Calcium deficiency inhibits cell growth and enlargement, and it can be also foliar sprayed to improve fruit cell development and internal fruit quality (Wahdan *et al*., 2011). Normally, the concept of mango fertilization is interpreted as amendment of the nutrients removed by fruits, vegetative growth and root growth including the losses from leaching and fixation. It was calculated that for every one tone per hectare of fruit yield, the total nutrient amendment under normal growing conditions is approximately: 3.0kg N, 1.0 kg P, 4.0kg K, 1.0 kg Ca and 0.5 kg Mg (Dirou, 2004).

Table 2.Chemical composition of deep well water

Characters	Water wells			
	1	2	3	4
pH	7.39	7.40	7.28	7.25
EC dS m-1	0.59	0.44	0.40	0.46
ppm				
K	1.16	1.16	1.17	1.17
Mg	1.2	1.2	1.3	1.2
Ca	80	70	82	79
Na	76.8	64.6	60.2	65.3
SO_4	9.91	10.4	10.2	10.3
Cl	227.2	198.8	142	142
HCO_3	368.4	370.9	285.5	285.5

The same trend was observed in the leaf iron and copper concentrations (Fig.2). However, Mn was deficient along the course of the study and Zn was deficient in the period 2006-2008 and in the lower limit of the adequate range in the period 2009-2010 (**Robinson, 1986**). Manganese deficiency is most prevalent in calcareous soils, in the soils where pH ranged between 7.3 and 8.5 (**Lindsay, 1979**). Manganese acting as an activator of the dehydrogenases, transferases, hydroxylases, and decarboxylases involved in respiration, amino acid, lignin and hormone synthesis (**Graham, 1983, Burnell, 1988**) Thus, its deficiency leads to growth retardant and low yields. Zinc deficiency is catastrophic for growth and development for mango trees. It is an integral component of enzyme structures and has catalytic, coactive and structural functions in plants (**Vallee and Auld, 1990, Vallee and Falchuk, 1993**). Zinc structural enzymes include alcohol dehydrogenase, and the proteins involved in DNA replication and gene expression (**Coleman, 1992**). Due to zinc deficiency many physiological processes within the plant tissues are inhibited and low yield and fruit quality reduction are expected. In such cases of high pH values and low level of micronutrients in the soil, foliar fertilization with micronutrients is the best solution to obtain good growth and satisfactory yields (**Stino *et al*., 2011, Wahdan *et al*., 2011**).

Yield analysis

Yield of the nine different mango cultivars (kg.tree^{-1}) along the course of the study is shown in Fig.3. and average yields (ton/ha^{-1}) are shown in Fig.4. Figures clearly illustrated that yields of all cultivars were very low and located below the lower limit of the normal range of the Egyptian mango yield. The highest significant yield under these conditions was obtained by Zebda cultivar, while the lowest was the yield of the cultivar Alphons. Yields of other seven cultivars were in between. This may proved that the cultivar Zebda is more tolerant to the unfavorable soil conditions and nutrient deficiencies than other cultivars and the cultivar Alphons is the most sensitive. To obtain a satisfactory yield, resistant cultivars should be chosen for cultivation and fertilizer programs depend upon soil test and leaf analysis should be designed taking in consideration the fertilizer requirements of the trees during different growth stages.

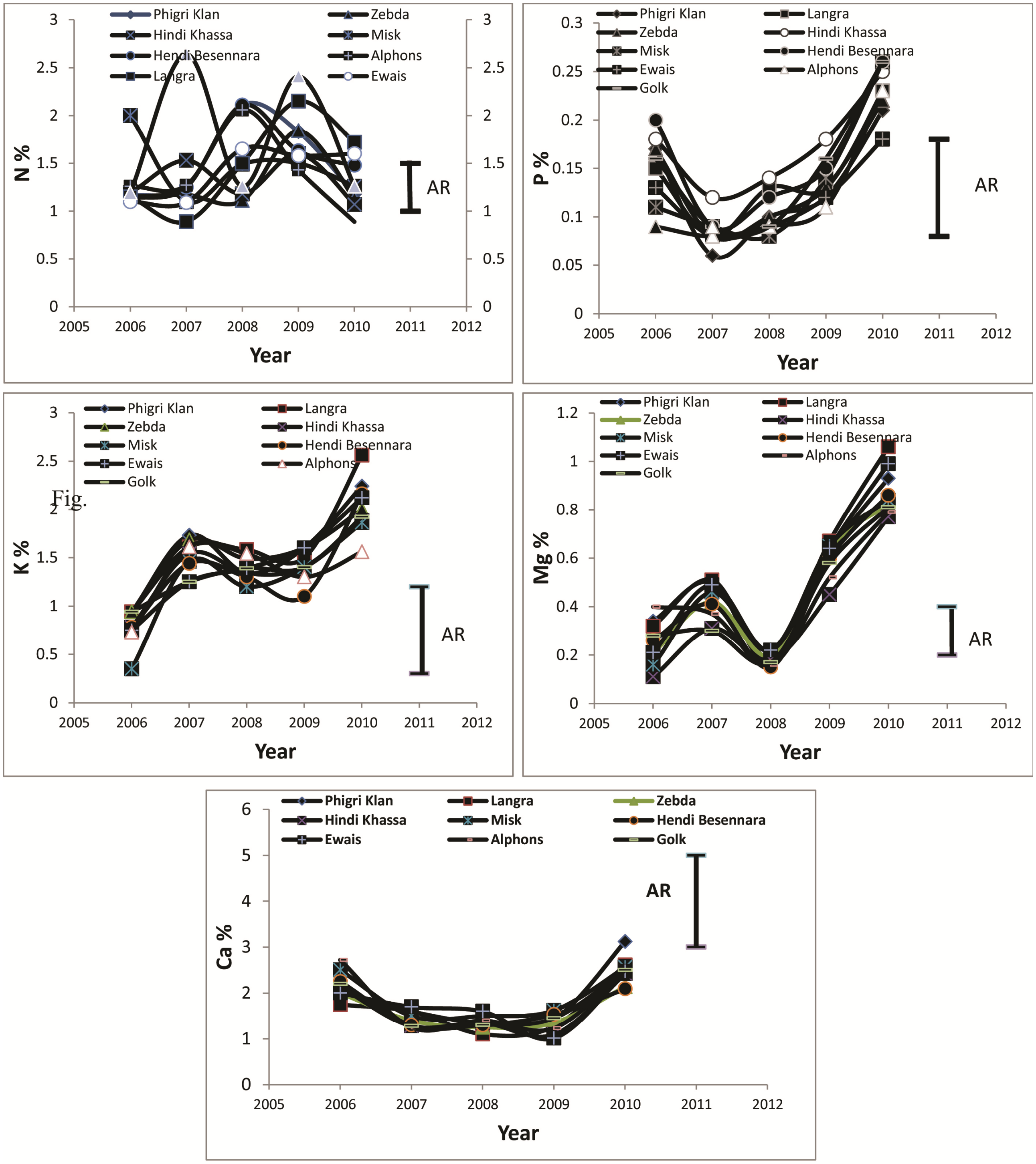

Fig.

1: Macronutrient status in the leaves of different mango cultivars grown under farm conditions and flood irrigation system- AR= Adequate range (Robinson, 1986)

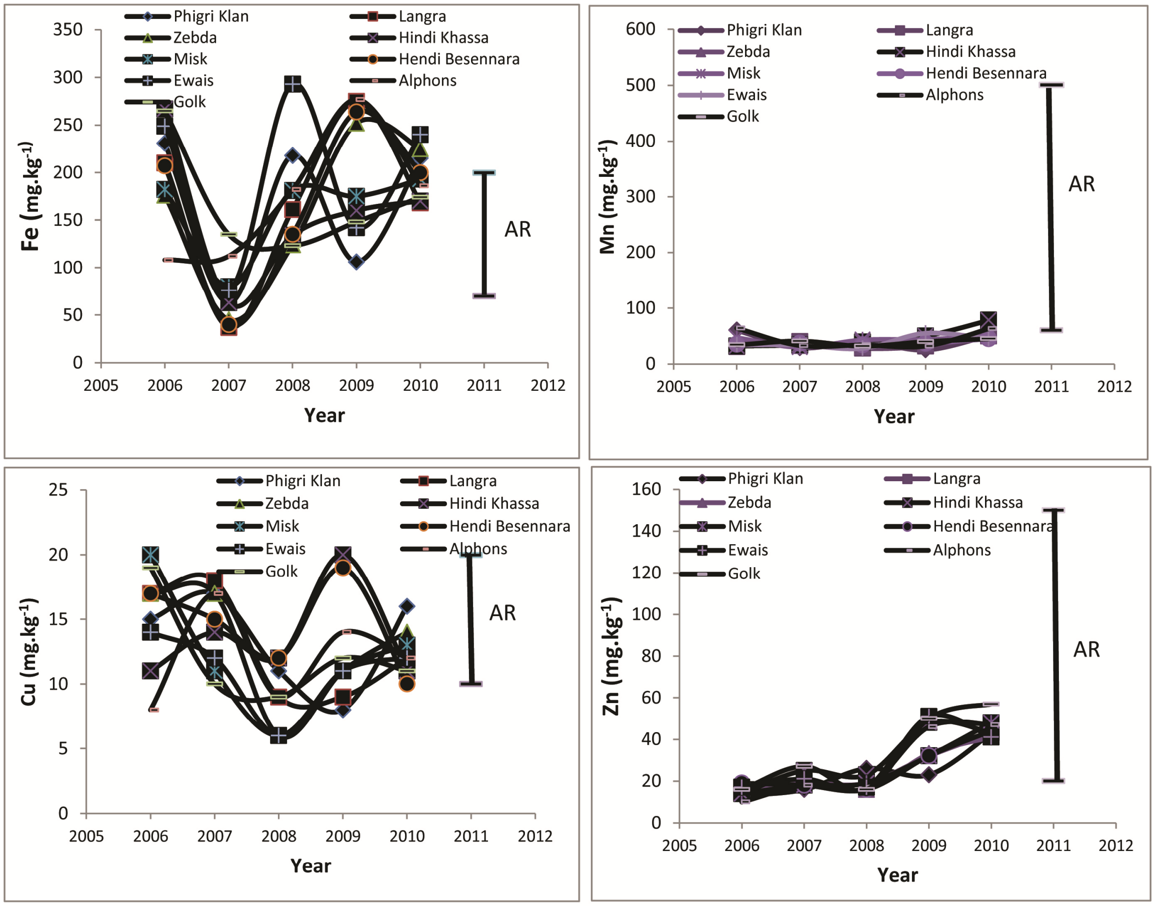

Fig. 2: Micronutrient status in the leaves of different mango cultivars grown under farm conditions and flood irrigation system- AR= Adequate range (Robinson, 1986)

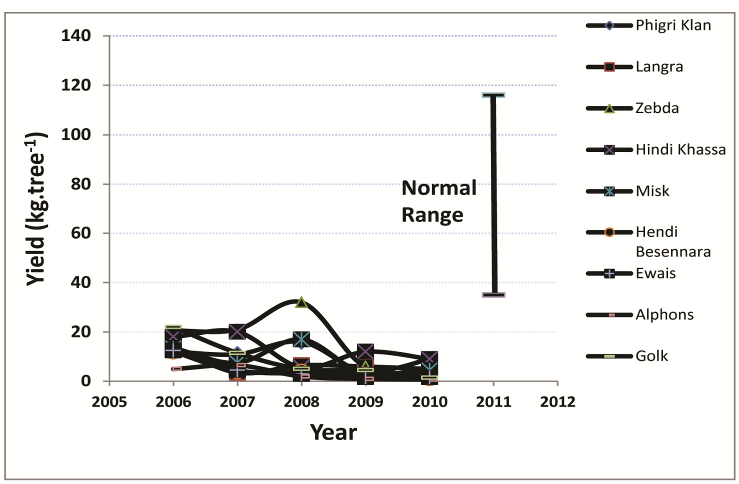

Fig. 3: Yield of different mango cultivars grown under farm conditions as affected by nutrient deficiencies

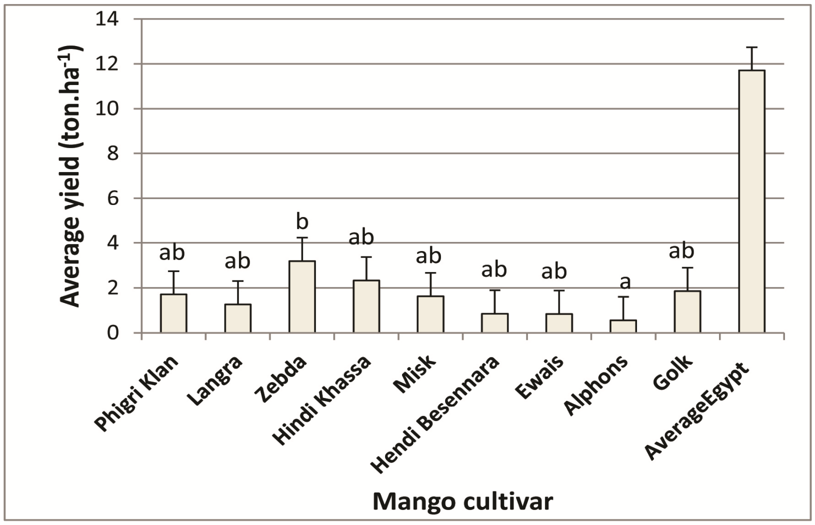

Fig. 4: Average yield of different mango cultivars grown under farm conditions as affected by nutrient deficiencies

Conclusions

From the present study it can be concluded that:

- Average yield of mango cultivars grown in sandy soil conditions under flood irrigation system is very low because of the wrong fertilizer practices
- The cultivar Zebda is the best to resist the Egyptian soil unfavorable conditions and nutrient deficiencies while the cultivar Alphons is the most sensitive.
- To achieve a good growth and higher yields, the resistant cultivars such as Zebda, Hendi khassa and Golk should be chosen for cultivation and good fertilization programs depend upon soil test and leaf analysis should be applied.

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