Original Research Article

Effect of Dolomitic Lime and Muriate of Potash on Mango Jelly Seed Disorder and Fruit Tissue Mineral Content

Abstract

One of the factors contributing to mango (*Mangifera indica* L) losses in Kenya and other parts of the world is jelly seed physiological disorder. It is thought to be related to imbalances of N, K, Mg and Ca supply to the fruit. The objective of this study was to establish the effect of dolomitic lime and muriate of potash (MOP) fertilization on mango jelly seed disorder and fruit tissue mineral content. MOP at a rate of 0, 1.0 and 2.0 kg/tree/year and dolomitic lime at a rate of 0 and 2 kg/tree/year were applied on 'Tommy Atkins' and 'Van Dyke' trees in 2013 and 2014. Split plot design was used with dolomitic lime treatment as the main plot and MOP as the sub-plot treatment. A sample of ten tree ripe fruits per treatment was scored for jelly seed incidence using hedonic scale. Another fruit sample was analyzed for K, Ca and Mg content. Data collected were analyzed using SAS package. Dolomitic lime and MOP fertilization did not significantly influence jelly seed score however they significantly increased the fruit K, Mg and Ca content compared to control.

***Key words**: Mango, Jelly seed, lime, MOP, minerals*

1. INTRODUCTION

Mango is one of the most important and popular fruit crops in Kenya [1, 2] Njuguna *et al*., 2013) and is ranked second after bananas in terms of value [1, 3]. Mango production in Kenya is dominated by small-scale farmers who constitute about 80 % of the production [2, 3]. Although a small proportion of the fruits are exported, the fruits are mainly sold in the domestic market. Mango makes an important part of the diet of Kenyans since it is an excellent source of vitamin A, a good source of vitamin B6 (Pyridoxine), vitamin C and vitamin E among others [4]. It also contain amino acids, carbohydrates, fatty acids, minerals, organic acids and proteins [5]. Mango production in Kenya has been on the increase due to increased demand for fruits as people are more aware of its health benefits. Although mango has great potential with respect to economic and nutritional security especially for the smallholder farmers involved in its production, this potential remains largely untapped due to challenges at various stages of the value chain. The challenges include; lack of information on site-specific fertilizer requirement which makes it difficult to improve productivity and fruit quality, Lack of proper disease and insect management, poor agronomic practises such as incorrect spacing and pruning, high post-harvest losses of about 40 % caused by poor harvest and storage techniques. Other challenges include poor infrastructure and lack of market linkages for farmers [1, 6].

Adequate and balanced mineral nutrition is important not only for productivity but also quality of the fruits. Poor nutrient management in mangoes results in poor quality and predisposes the fruit to physiological disorders. One of the physiological disorders of importance in mango is jelly seed disorder which affects most of the commercial mango varieties grown in Kenya [7]. According to a survey carried out in major mango production regions in Kenya, farmers lose up to 30% of their fruits due to jelly seed [8]. The disorder results from disintegration of flesh around seed into a jelly-like mass compromising their shelf life and consumer acceptance [9, 10]. The affected fruits are either unmarketable or fetch lower prices [11]. This disorder was first described in 1932 [12]. Some varieties such as Van Dyke are reported to be more prone to jelly seed than other varieties [11]. The disorder is attributed to poor or inadequate calcium nutrition leading to low calcium in the tissues [12]. It is also been reported that this condition may relate to inherent as well as ecological conditions. Calcium moves with the transpiration stream and binds with polysaccharides to strengthen cell walls. This is needed in order to produce firm fruit tissue, and is associated with a good shelf life. In addition Ca prevents cell wall degradation, "leaky" membranes and premature senescence. The importance of Ca has been demonstrated in other fruits such as water melon and apple. In watermelon deficiency of Ca causes blossom end rot (BED) while in apple it causes bitter pit [13]. Previous efforts to address this disorder in mango therefore include; liming to increase tissue calcium (Ca). In studies conducted in Central and Eastern Kenya for example, dolomitic lime ($CaCO_3MgCO_3$) significantly reduced jelly seed incident [2, 7]. However while liming seems to offer a short-term solution to the problem, continuous application of lime could result in increased soil pH which could affect the uptake of other elements. Additionally, Ca from lime application should be balanced with fruit tissue potassium (K) otherwise fruit quality will be affected [14]. It is well documented in other fruits such as apple and pear that while a high Ca:K ratio is required for good keeping quality, a lower ratio is preferred for better eating quality. The objective of this study therefore was to establish the effect of dolomitic lime and muriate of potash (MOP) fertilization on the occurrence of jelly seed disorder in mango fruits as well as fruit tissue mineral content

2. MATERIALS AND METHODS

This study was carried out in 2013 and 2014 at Karurumo orchard which is situated in Embu County in the eastern part of Kenya. The area lies at coordinates $0^0$32'S $37^0$37E and 1350 m a.s.l elevation. This area is considered to be (lower Midland)LM3 agro-ecological zone and has an average annual precipitation of 1206mm per annum. The soil types are arenosal and nitosols [15]. The experiment was conducted using 10 years old trees of two commercial varieties namely Tommy Atkins and Van Dyke arranged in a split plot design with three replicates. The selected trees were treated with two rates (0 and 2 kg/tree/year) of dolomitic lime (CaO: 390g/kg; MgO: 130g/kg) and three rates (0, 1.0 and 2.0 kg/tree/year) of muriate of potash fertilizer (MOP) (60 % K_20). Dolomitic lime treatment was the main plot while MOP was the sub-plot treatment. Application of these nutrients was done at fruit set in accordance to recommended timing of application [16] and in consideration of the recommended rate of application [17]. Dolomitic lime was incorporated at a depth of 20cm as recommended by [18] while MOP was applied through top-dressing method since it relatively more mobile in the soil. At the beginning of the study, soil analysis was conducted to determine the nutritional status of the soil. The experimental plot was maintained using standard cultural practices for mango in Kenya [19]

2.1 Determination of jelly seed occurrence

To determine the jelly seed incidence for the different treatments, random samples of ten tree-ripe-fruits were harvested then halved (sliced along endocarp) and scored for jelly seed incidence using a hedonic scale [20] as follows:

0= without symptoms

1=slightly decomposition of the petiole base without affecting the flesh

2=slightly affected flesh near the seed

3= 1/3 of the flesh affected

4= 2/3 of the flesh affected

5= Almost all fruit decomposed

2.2 Fruit tissue Mg, K and Ca

These minerals were analysed using the [21] method. Five grams of the pulp per treatment was charred in the oven for 30 minutes then put in a muffle furnace at 550℃ for eight hours to ash. The ash was allowed to cool and diluted with 10ml of 1N hydrochloric acid. The mixture was then filtered and diluted with 100ml of distilled water. Calcium and magnesium were subsequently analysed using atomic absorption spectrophotometer (Model AA-6200, Shimadzu Corp., Kyoto, Japan). The setting used were; lamp Current Low(mA) of 6, Wavelength(nm) of 422.7, Slight Width(Nm) of 0.7, Fuel Gas Flow Rate (L/min) of 2 and lamp mode BGC-D2. Potassium on the other hand was analyzed using flame emission photometer (Model FA- 410, Shimadzu Corp. Kyoto, Japan).

2.3 Data Analysis

Data collected was subjected to ANOVA using GLM procedure of SAS version 8 programme and means separated using the Student-Newmann-Keul (SNK) test at 5 % level of significance. In addition, Coefficient Correlation between jelly seed score and fruit Ca, Mg and K was calculated.

3. RESULTS AND DISCUSSIONS

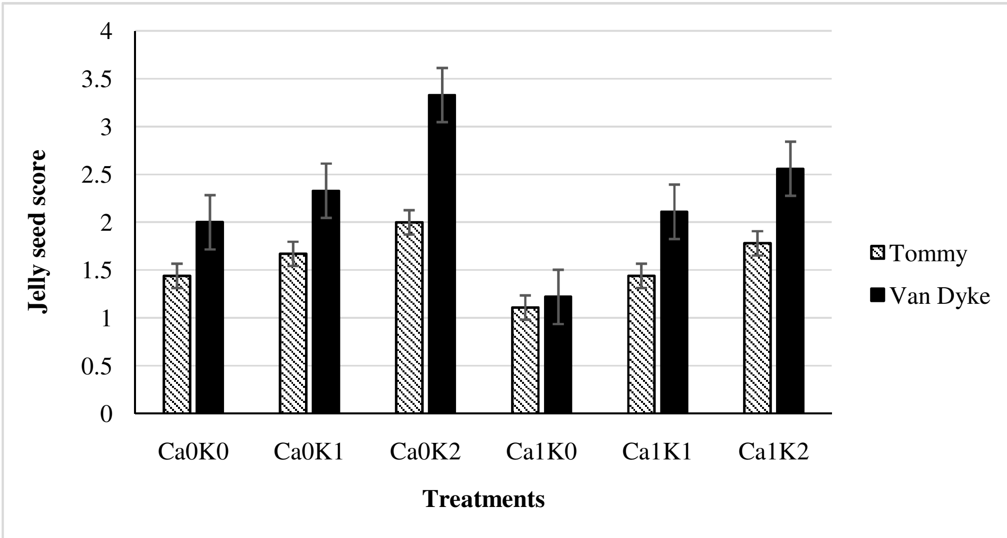
3.1 Varietal differences in jelly seed incidence

“Van Dyke” had higher score of jelly seed than “Tommy Atkins” and the problem was generally higher in 2014 season than 2013 season for “Tommy Atkins”. (Fig 1 and Fig 2). However, the interaction between treatment and variety was not significant in both seasons. Higher susceptibility of “Van Dyke” as compared to “Tommy Atkins” is perhaps due to genetic characteristic that make the later to have greater ability to absorb Ca into the plant thus enhancing the integrity of the cell wall. These findings concur with previous studies reported by [20] as well as [17] which indicated that some varieties are more sensitive to jelly seed disorder than others. Another study reported by [11] specifically indicated that “Van Dyke” is more sensitive to internal fruit breakdown than “Tommy Atkins”. The seasonal differences in the jelly seed occurrences with higher incidents in 2014 than 2013 could be attributed to higher rainfall that was received in 2014 (2875.3mm) compared to 637.8mm received in 2013. Previous studies have shown that, environmental factors, such as moist microclimate, are conducive to the expression of this disorder [12].

3.2 Effect of Muriate of potash and dolomitic lime application on jelly seed incidence

Muriate of potash generally increased the incidence of jelly seed in the fruit of the treated mango trees (Fig 1 and Fig 2). This can be attributed to the effect of competition between K and Ca for uptake by the plant thus affecting Ca:K ratio and subsequently leading to the increase in the incidence of jelly seed. These findings concur with what has been reported by [22, 23] and [12] that jelly seed incidence is correlated with high levels of K and N fertilization. According to [24] this observation can be attributed to K causing imbalance in Ca and Mg in the fruit leading to occurrence of jelly seed**.** This position is further supported by [25] who reported that K taken up by the plant is rapidly translocated from leaves to fruits towards fruit maturity thus de-stabilizing the Ca:K ratio. Nevertheless, when properly administered, K improves fruit quality, particularly fruit colour, fragrance, size and shelf life [17].

Dolomitic lime on the other hand generally reduced the incidence of jelly seed of both "Van Dyke" and "Tommy Atkins" (Fig 1; Fig 2 and Fig 3). This can be attributed to enhanced uptake of Ca by the plant with application of dolomitic lime which subsequently enhanced the integrity of the cell wall. These findings concur with what is reported by [17] that internal breakdown in "Tommy Atkins" was reduced by 27 % by application of Ca in form of Gypsum. In a related study, [26] reported that Ca in form of either $CaN0_3$ or $CaCl_2$ delayed mango ripening subsequently extending shelf life by four days. The beneficial effect of Ca is attributed to its being capable of increasing fruit tissues consistency during maturation and this results in fruit of better quality free of jelly seed [24]. However, like other studies carried out previously, the effect of dolomitic lime in reducing jelly seed incidence in the short term was small which can be attributed to the relatively long time it takes for mango trees to uptake Ca due to its low mobility in the soil [25, 27]. The low response could also be attributed to competition in uptake of various elements. According to [23], Ca deficit in the fruit can be caused by either insufficient absorption or competition between growth points on the plant and fruits for available Ca [12].



Ca0K0=0kg lime/tree/year + 0kg MOP/tree/year (control); Ca0K1=0kglime/tree/year + 1kg MOP/tree/year; Ca0K2=0kglime/tree + 2kg MOP/tree/year; Ca1K0=2kglime/tree/year + 0kg MOP/tree/year; Ca1K1=2kglime/tree/year + 1kg MOP/tree/year; Ca1K2=2kglime/tree + 2kg MOP/tree (n=3; ɪ = standard errors)

Fig. 1. Mean jelly seed score for “Tommy Atkins” and “Van Dyke” mangoes treated with different rates of dolomitic lime and muriate of potash in Embu County in 2013 season

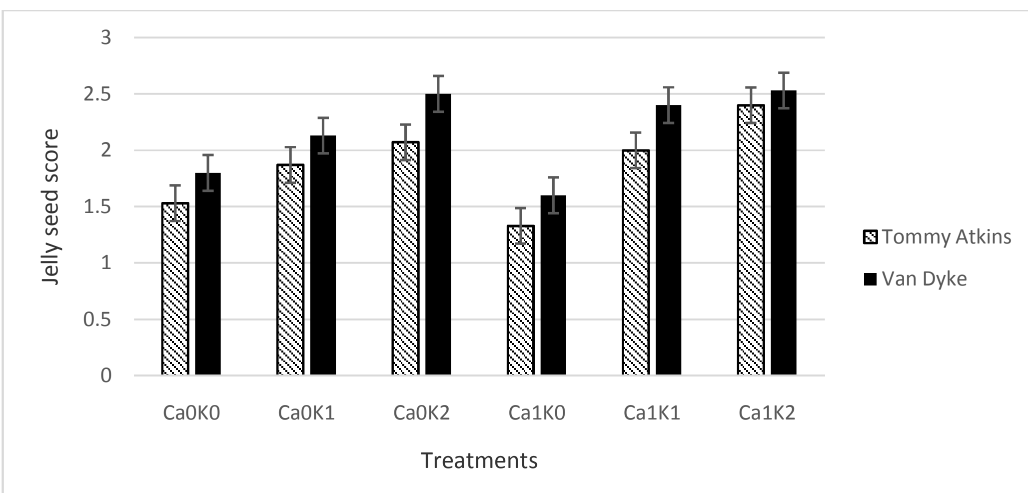


Fig. 2. Mean score of jelly seed for “Tommy Atkins” and “Van Dyke” mangoes treated with different rates of dolomitic lime and muriate of potash in Embu County in 2014 season (n=3; ɪ = standard error)

Key: Ca0K0=0kg lime/tree/year + 0kg MOP/tree/year (control); Ca0K1=0 kg lime/tree/year + 1kg MOP/tree/year; Ca0K2=0kglime/tree/year + 2kg MOP/tree/year; Ca1K0=2 kg lime/tree/year + 0kg

MOP/tree/year; Ca1K1=2kglime/tree/year + 1kg MOP/tree/year; Ca1K2=2kglime/tree/year + 2kg MOP/tree/year

A B

Fig. 3. Mango fruits from trees treated with dolomitic lime and the control

Key: A= 0 kg lime/tree/annum + 0 kg MOP/tree/year (control); B=2 kg lime/tree/annum + 0 kg MOP/tree/year

3.3 Effect of muriate of potash and dolomitic lime application on fruit mineral content

"Van Dyke" trees treated with 2 kg MOP/tree had significantly ($P < 0.05$) higher mean K fruit content (9.99 mg/100g) compared to control (6.53 mg/100g) in 2013 season. Similarly "Tommy Atkins", trees treated with 2 kg MOP/tree had significantly ($P < 0.05$) higher K content (12.82mg/100g) compared to control (9.10 mg/100g) in the same season (Table 1). Similar trend was observed in 2014 season and the difference between treated trees and control was significant at $P < 0.05$ (Table 2). Dolomitic lime on the other hand significantly influenced Mg content of the fruit with trees treated with 1 kg Dolomitic lime/tree having significantly higher Mg content (0.617mg/100g) compared to control (0.04mg/100g) in 2013 season (Table 2) while in 2014 season the difference was not significant. Fruit Ca on the other hand was generally higher for trees treated with dolomitic lime for the two varieties however the difference was only significant ($P < 0.05$) in 2014 season (Table 2). Lack of significance difference in fruit Ca content for trees treated with lime in 2013 season can be attributed to the long time it takes for dolomitic lime to dissolve and subsequently become available for uptake by the tree. These results are supported by the findings of [14] who reported that, Ca from lime application advances approximately 17cm per year reaching the subsoil (where most of the mango roots are found) after 3 years although, the actual time taken is determined by the nature of the soil. A study conducted by [28, 14] indicated that lime application to acid sandy soils increased leaf Ca content within a shorter time than when applied on alkaline soil. For this study, the soil was slightly acid (pH 6.5) and the time after application in 2013 season was one year thus Ca might not have sufficiently reached the root zone for uptake by the tree by end of this season. Similar findings have been reported by [25].

Table 1: Effect of dolomitic lime and muriate of potash treatments on the mineral content in 'Tommy Atkins' and 'Van Dyke' fruits (2013)

Treatments			Fruit mineral content(mg/100g)		
Variety	Lime Kg/tree/year	MOP Kg/tree/year	Calcium (Ca)	Potassium (K)	Magnesium(Mg)
Tommy Atkins	0	0	0.016c	**9.103l**	0.040b
		1	0.029abc	9.856j	0.032b
		2	0.035abc	**12.820c**	0.032b
	2	0	0.019c	9.116l	0.023b
		1	0.038abc	9.457k	0.036b
		2	0.039abc	14.646a	0.035b
Van Dyke	0	0	0.056ab	**6.535k**	0.037b
		1	0.049abc	11.852d	0.045b
		2	0.042abc	**9.993Ji**	0.031b
	2	0	0.042abc	8.462m	**0.040b**
		1	0.027abc	9.571k	**0.617a**
		2	0.038abc	10.288h	0.036b
CV			33.39	10.66	16.00
P Value			0.0041	0.0001	0.0001

Means followed by the same letter along the column are not significantly different at p<0.05 according to Student-Newman-Keuls test.

Table 2: Effect of dolomitic lime and muriate of potash treatments on the mineral content in 'Tommy Atkins' and 'Van Dyke' fruits (2014)

Treatments			Fruit mineral content(Mg/100g)		
Variety	Dolomitic lime (Kg/tree/year)	MOP (Kg/tree/year)	Calcium (Ca)	Potassium (K)	Magnesium(Mg)
Tommy Atkins	0	0	14.847 cd	138.192 fe	12.560b
		1	16.127cd	157.070 d	12.700b
		2	17.906 cd	141.551 e	19.978a
	2	0	29.227a	124.098 fe	15.290 ab
		1	18.936bcd	126.482 fe	15.239ab
		2	27.518ab	129.019 fe	17.279ab
Van Dyke	0	0	10.184d	**116.325 f**	18.533a
		1	20.290 abc	129.007fe	18.283a
		2	28.699a	**281.147 a**	18.784a
	2	0	27.683ab	125.921 fe	18.376a
		1	27.982ab	174.067 c	15.688ab
		2	29.637a	197.017 b	18.002a
CV			28.2	9.87	18.59
P Value			0.001	0.001	0.001

Means followed by the same letter in a column are not significantly different at $p<0.05$ according to Student-Newman-Keuls test

3.4 Correlation Coefficient

There was a positive correlation between K content of the fruit and jelly seed score (r^2=0.0578) as shown in Table 3. In addition, there was a negative correlation (r^2=0.0586) between fruit Ca content and jelly seed score and low negative correlation (r^2=0.0056) between magnesium content and jelly seed score (Table 3). These findings concur with what has been reported by [12] that there is a relationship between K and fruit jelly seed occurrence and that this effect can be counteracted by application of Ca in form of lime.

Table 3: Pearson Correlation Coefficients between jelly seed and tissue mineral content

	Jelly seed score	Potassium	Magnesium	Calcium
Jelly seed score	1.0000	0.24044	-0.07509	-0.24444
Potassium	0.24044	1.0000	-0.09564	-0.20489
Magnesium	-0.07509	-0.09564	1.0000	-0.10932
Calcium	-0.24224	-0.20489	-0.10932	1.0000

4. CONCLUSION

The results show that application of dolomitic lime slightly reduces the incidence of jelly seed while MOP exacerbates it. For fruit mineral content, dolomitic lime application increases the fruit Ca and Mg content but the response is slow while MOP application increases the fruit K content. It can therefore be concluded that judicious application of dolomitic lime and MOP on mangoes can improve mango fruit nutritional quality.

REFERENCES

1. Kehlenbeck K., Rohde E., Njuguna J. and Jamnadass R. Mango Production in Kenya. In: Valavi S.G. (Ed) Mango Cultivation in different countries Studium Press LLC, India. 2012; 2: 186-207
2. Njuguna J.K., Chege B.K., Muriuki .S.N and Wanjala S. Effect of Dolomitic lime and Potassium Nitrate application on incidence of jelly seed physiological disorder on Tommy Atkins mango variety. Proc HAK conference 2013
3. MoA. Horticultural production report, Nairobi, Kenya; 2011
4. Kundiu, S. 2012. Baby food from mango. In: Valavi S.G. (Ed) Mango production and processing technology Stadium Press LLC, India, 2012; 33

5. Mukherjee S.K. Introduction: Botany and Importance In: Litz R.E (ED) The Mango Botany, Production and Uses. University Press, Cambridge UK. 1997; 1-19

6. KARI. Fruit sector analysis document, 2010

7. Chege, B.K., Wepukhulu S.B., Njuguna J.K. and Gitau D.N. Management of Mango (*Mangifera Indica*) Seed Jelly for Increased Shelf Life and Prime Marketing Proc. HAK conference 2010

8. Gitonga K.J., Gathambiri C., Kamau M., Njuguna J.K., Muchui M., Gatambia E., Kiiru S. Enhancing small scale farmer's income in mango production through agro-processing and improved access to markets. Paper presented at 12th KARI Biennial Conference, Nairobi, Kenya; 2010

9. Burdon, J.N., Moore K.G. and Wainwright, H. A preliminary examination of the physiological disorder "soft nose" in mango fruits. Acta Horticulture, 1992; 296:15-22

10. WainWright, H., and Burbage, M.B. Physiological disorder in mango (Mangifera indica L) fruit. J. Hort. Sci. 1989; 64(2):125-135

11. Cracknell T., Cid Ballarin, M.C., Socorro Monzon A.R., Fernandez Galvan D., Rosell Garcia P. and Galan Sauco V. Incidence of Internal Fruit Breakdown in various mango (Mangifera indica L.) Cultivar Acta Hort 2004a; 645: 315-317

12. Cracknell T., Cid Ballarin, M.C., Socorro Monzon A.R., Fernandez Galvan D., Rosell Garcia P. and Galan Sauco V. Effect of Nitrogen and Calcium supply on the incidence of internal fruit breakdown in "Tommy Atkins" mangoes (*Mangifera indica* L.) Grown in a soilless system Acta Hort 2004b; 645: 387-393

13. Freitas S.T and Mitcham E.J. Horticultural Review. Janick J. (Ed). John Wiley & Sons, Inc 2012; 40

14. Torres M.D, Farre J.M., and Hermoso J.M. Influence of Nitrogen and Calcium fertilization on Productivity and Fruit quality of the mango cv. Sensation. Acta Hort 2004; 645, 395-400

15. Jaetzold and Schmidt (1983) Farm management hard book of Kenya.
Ministry of Agriculture, Nairobi 1983; (2, 3)

16. Bally, S.E Mangoes in Australia In: Valavi S.G (Ed) Mango cultivation in different countries Volume 2. Stadium Press LLC, India 2012;314-330

17. Samra, J.S and Arora, Y.K. Mineral nutrition. In: Litz, R.E.The Mango. Botany, Production and Uses. New York: CAB International. 1997;175-201

18. Mouco, C. A., Silva, J.D., Prado, M.R. Mango cultivation in Brazil. In: Valavi S.G. (Ed) Mango Cultivation in different countries Volume 2. Studium Press LLC, India, 2012; 331-345
19. Griesbach, J. Mango Growing in Kenya. ICRAF, Nairobi, Kenya; 2003
20. Galan Sauco, V., Fernandez Galvan, D., and Calvo, R. Incidence of soft-Nose on mangoes in the Canary Islands. Proc. Fla State Hort Soc. 1984; 97:358-360
21. AOAC. Official Methods of Analytical Chemists. Association of Official Agricultural
Chemist, Washington, D.C, 1996
22. Young T.W and Miner, T.J Response of "Kent" mangoes to Nitrogen fertilization. Proceeding of the Florida state Horticultural Society 1960; 73, 344-336
23. Young T.W., Koo, R.C. J., Miner, J.T. Effects of Nitrogen, Potassium and Calcium fertilization of Kent mangoes on deep, acidic soil. Proc. Fla. State Hort. Soc. 1962; 75: 364-371
24. Prado R.M., Caione G and Silva D.J.Macronutrient and Micronutrient Deficiency Symptoms in Mango. *In*: Valavi S.G. (Ed) Mango Cultivation in different countries Volume 2. Studium Press LLC, India,2012; 470-478
25. Medeiros A.A., Amorim J.R.A., Silva, D.J. Mineral Composition of Leaves and Fruits of Irrigated Mango Trees in Rio Grande do Norte State, Brazil. Acta Hort 2004; 645: 403-408
26. Singh, B.P., Tandon, D.K. and Kalra, S.K. Changes in post-harvest quality of mangoes affected by Pre-harvest application of Calcium salts. Scientia Horticulturae 1993; 54, 211-219
27. Almelda V., Fernandes F.M., Prado R.M., Boliani A.C., and Correa L.S Mango tree
response to lime applied during the production phase. Open Journal of Soil Science, 2012; 2:155-161
28. Young, T.W and Koo, R.C.J. Mineral composition of Florida mango leaves. Proceedings of the Florida state Horticultural Society, 1969; 82: 324-328