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The Potential Role of Molybdenum Treatment on The Residual Effect of Both Nitrate and Nitrite Levels in Navel Orange Fruits

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***Abstract* – This investigation was implemented during (2012/2013) and (2013/2014) seasons on navel orange trees (*Citrus sinensis L.*) to study the effect of molybdenum (Mo) treatment on the residual effect of both nitrate and nitrite in navel orange fruits. Molybdenum can reduce nitrate to ammonium in plants and transform it to amino acids and eventually proteins. According to the World Health Organization (WHO) the acceptable daily intake for nitrate is 0–3.7 mg•kg−1 body weight. The study involved two experiments in different two locations, the first was carried out in a private orchard located in El- kalubia governorate, on trees budded on sour orange rootstock (*Citrus aurantium*), grown in a clay soil under flood irrigation. The second was done in a private orchard located in El- Bustan county, El Behera Governorate where the trees were budded on Volkamer lemon rootstock (*Citrus volkameriana*, Ten of pasq.), grown in a sandy soil under drip irrigation system. Trees in both two experiments were subjected to four treatments, control (untreated), and foliar sprays with ammonium molybdate at (0.2, 0.4 and 0.6 %) at three weeks before harvest. Obtained results indicated that, foliar application with ammonium molybdate at 0.2% was the best treatment for achieving the lowest fruit juice content of nitrite and nitrate, increasing fruit juice protein content, fruit weight, juice weight %,T.S.S/Acid and Vitamin C. Fruits of navel orange trees in El- kalubia region had lower residual effect of both nitrate and nitrite and it had higher fruit quality than the other fruits taken from El- Bustan region. It is recommended to adopt foliar application of molybdenum for other crops before crop harvest especially vegetables that having high concentrations of nitrate and nitrite due to continuous additives of fertilizers which cause risks to human body health.**

***Keywords* – Navel Orange, Nitrate, Nitrite, molybdenum, Protein and Fruit Quality.**

I. Introduction

Nitrates and nitrites are chemicals used in fertilizers, in pesticides rodenticides (to kill rodents), and as food preservatives [1]. Excessive nitrogen (N) application by fertilizers is an economic loss to the growers in terms of unnecessary input costs, and may also result in greater pest management problems [2]. From an environmental perspective, overuse of chemical (N) fertilizer has been associated with increased levels of nitrate-nitrogen (No_3-N) in ground and surface water [3]. However, when input of nitrogen exceeds the demand, plants are no longer able to absorb it, and nitrogen then builds up in the soil, mostly as nitrates [4]. This causes imbalance of nutrients in the soil and increases the nitrate level in ground water supplies [5] which influences the nitrate content of plants [6].

Investigations have indicated that a high nitrate accumulation in plants results in nitrite production, which is converted into nitric oxide (NO) which, together with $O2^-$, could be rapidly catalyzed by nitrate reductase into peroxy nitrite ($ONOO^-$) which is highly toxic to plants [7]. Therefore, high nitrate accumulation in plants is harmful to human health [8] as well as to plant growth [9]. Several human health hazards due to nitrate toxicity have been identified. The toxicity of nitrate is thought to be due to its reduction to nitrite and conversion to nitrosamines and nitrosamides through reaction with amines and amides, whose carcinogenic action is well known [10]. The principal mechanism of nitrite toxicity is the oxidation of the ferrous iron (Fe2+) in haemoglobin to the ferric (Fe3+) valence state, producing methaemoglobin. As a consequence of methaemoglobin formation, oxygen delivery to human tissues is impaired [11], [12]. The percentage of total methaemoglobin in oxidized form determines the clinical picture of oxygen deprivation with cyanosis, cardiac dysrhythmias and circulatory failure, and progressive central nervous system (CNS) effects. The CNS effects can range from mild dizziness and lethargy to coma and convulsions [13].Clinical findings vary with methaemoglobin concentrations. Methaemoglobinemia, earlier believed to occur in infants only, has been reported by [14] in people of different ages with high nitrate ingestion, the infant and above 45 age groups being most susceptible to nitrate toxicity.

Nitrate contamination of drinking water is of special concern in agricultural areas [15]. Nitrate-contaminated drinking water often arises as a result of fertilizers applied to crops, which are converted to nitrate in the soil and then seep into ground water and into private residential wells. Of particular concern in proximity of animal feed lots to some ground water contamination with nitrates from run-off from these feed lots [16]. Nitrates have been detected in breast milk, and concentration increased with increasing consumption of nitrated by the mother [17]. Health effects that were significantly associated with nitrate or nitrite exposure during pregnancy include increased incidence of intrauterine growth retardation [18] Cardiac defects [19],central nervous system defects [20] and sudden infant Death syndrome (SIDS) [21].The most sensitive health effect end point for nitrate exposure is methemogloobinemia in infants, also called "blue baby syndrome" when humans metabolize nitrate, an alternative form blue baby syndrome" when humans metabolize nitrate, an alternative form of hemoglobin, called methemoglobin, is formed and is detectable in blood. Infants with blue baby syndrome turn blue because their red blood cells, which contain methemoglobin, have a decreased ability to carry oxygen. Blue baby syndrome has been reported following exposure of infants to nitrate contaminated drinking water [15]. Infants of ages 0-3 months are at higher risk for blue baby syndrome because their normal intestinal flora contribute to the generation of methemoglobin, older children and adults can experience this syndrome, but at higher concentration of nitrates [16]. Also, exposure to higher levels of nitrates or nitrites has been associated with increased incidence of cancer in adults, and possible increased incidence of brain tumors, leukemia, and nasopharyngeal tumors in children [22].

The Joint Expert Committee of the Food and Agriculture (JECFA) Organization of the United Nations/World Health Organization (WHO) and the European Commission (EC) Scientific Committee on Food have also set an acceptable daily intake for nitrate of 0–3.7 $mg \cdot kg^{-1}$ body weight [23]. The U.S. Environmental Protection Agency (EPA) reference dose for nitrate is equivalent to about 7.0 $mg \cdot kg^{-1}$ body weight per day [12].

Molybdenum (MO) fertilizer is an important component of an enzyme in plants required to reduce nitrate to ammonium, an important component of amino acids and eventually proteins. Therefore, the plants being fed predominantly nitrate nitrogen may have a greater need for molybdenum because of need to convert nitrate nitrogen in leaf ammonium for growth [24]. Also, molybdenum is an essential component of the major enzyme nitrate reductase in plants. In the presence of Mo-deficiency, low nitrate reductase activity results in high accumulations of No_3^- in plants with many physiological implications. Disorders such as leaf burn/scorch of Clementine (*Citrus reticulate*) trees [25] have been related to nitrate accumulation in the presence of a short supply of molybdenum.

This study aimed to evaluate the effect of molybdenum treatment on the residual effect of both nitrite and nitrate in navel orange fruits from trees grown in two different locations in sandy and clay soil types.

II. Materials and Methods

This investigation was conducted during (2012/2013) and (2013/2014) seasons on navel orange trees (*Citrus sinensis L.*) to study the effect of molybdenum treatment on the residual effect of both nitrate and nitrite on navel orange fruits. The study involved two locations as follow:

1-Private orchard located in El- kalubia governorate on 20- year- old trees, budded on sour orange rootstock (*Citrus aurantium.*) planted at 5×5 m spacing in clay soil under flood irrigation. Irrigation was added at intervals of about 15 days in summer and 21-30 days in winter. **2-** Private orchard located in El- Bustan county, El Behera Governorate on 8- years old trees, budded on Volkamer lemon rootstock (*Citrus Volkameriana*, Ten of pasq.) planted at 4×6 m spacing in sandy soil under drip irrigation system. Twelve trees of navel orange were used for each location according to vigor and number of fruits for data collection and to study the effect of foliar spray of molybdenum on the residual effect of both nitrate and nitrite on navel orange fruit quality.

Both Two Locations Involved the Following Treatments

Control trees (untreated), were sprayed with water, and trees sprayed with ammonium molybdate as a source of molybdenum at (0.2, 0.4 and 0.6 %) at three weeks before harvest.

Fertilizer programs that used in two orchards are shown in (Tables 1 & 2).

Table 1. Fertilizer program used at El- kalubia region (clay soil) under flood irrigation.

	Nutrient requirement (Kg)/ fed.		
Month	N	P	K
December	------	30	------
February	70	-----	24
May	60	-----	-----
August	50	-----	24
Total	180	30	48

Table 2. Fertilizer program used at El- Bustan region (sand soil) under drip irrigation.

	Nutrient requirement (Kg / Month/ fed.)		
Month	N	P	K
January	---	1.88	6.7
February	---	1.88	8.04
March	11.39	1.88	9.38
April	14.74	1.88	10.72
May	16.08	1.88	12.06
June	10.05	2.01	6.7
July	10.72	---	7.37
August	22.78	---	13.4
September	11.39	---	14.74
October	10.05	---	16.08
November	---	---	10.05
December	---	---	5.36
Total	107.200	11.400	120.600

From (Tables 1 & 2) It could be noticed that there were difference between the two fertilizers programs used at the two orchards at El- Kalubia and El- Bustan regions specially in the rates of the nitrogen fertilizer application, whereas, nitrogen fertilization of navel orange trees at El-Kalubia is higher than El- Bustan region, in more detail, 180 kg Nitrogen / Feddan are added during the three intervals (February, May and August) under flood irrigation at El- Kalubia region, while, 107.2 kg Nitrogen / Feddan were added by different doses from March to October under drip irrigation system at El- Bustan region.

The experiments design were completely randomized block with 3 single tree replicates with one tree for each replicate. Also, balanced foliar fertilization of all microelements was applied three times yearly (February, May and August).

The Following Parameters were Studied

1. Nitrite and nitrate in fruit Juice content: A sample of (10) ml of fruit Juice was taken from each replicate to

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determine No_2 and No_3 by ppm according to the methods outlined by [26].

2. Protein content in fruit juice. Total soluble protein content was estimated as percentage with the method of [27].

3. Fruits quality. Ten fruits were randomly sampled or picked in the two seasons for each replicate and the following determinations were carried out: Average fruit weight (gm.) was determined. Juice weight percentage was calculated and recorded. Total soluble solids (T.S.S %) was determined by using Zeiss hand refractometer. Total acidity (%) was determined in fruit juice according to [28]. Total soluble solids/acid ratio was calculated from the values of total soluble solids divided by values of total acids. Ascorbic acid (Vitamin C) was calculated as mg/100 ml juice according to [29].

Statistical Analysis: The experiment was designed in completely randomized block design with four replicates for each treatment and each replicate was represented by one tree. The obtained data of both seasons were subjected to analysis of variance according to [30] and the means were differentiated using Duncan multiple range test at 5% level [31].

III. Results and Discussion

A. Nitrite and Nitrate in Fruit Juice Content.

It could be noticed from (Tables 3 & 4) that, all the concentrations of ammonium molybdate used under study led to a decrease in the level of nitrite and nitrate of fresh juice of navel orange fruits as compared with control treatment. As for fruit juice nitrite content,data in (Table 3) showed that, the best treatment was in the trees treated by ammonium molybdate at 0.2% which scored the smallest average of two seasons (1.18 ppm) and (1.88 ppm) followed in an ascending order by trees treated by ammonium molybdate at 0.4% (2.37 ppm) and (2.72 ppm) then trees treated by ammonium molybdate at 0.6% (2.45 ppm) and (2.85 ppm) while the maximum level of fruit nitrite content was in control treatment (3.12 ppm) and (4.41 ppm) in El- Kalubia and El-Bustan locations, respectively .

Regarding the fruit juice nitrate content, data in (Table 4) indicated that, superiority of ammonium molybdate treatment at 0.2% for achieving the lowest average for two seasons (23.58 ppm) and (30.45 ppm) as compared with other treatments, while control treatment scored the highest average (34.58 ppm) and (45.56 ppm) in El-Kalubia and El-Bustan locations, respectively. In general it could be noticed that the concentrations of nitrite and nitrate of fruit juice of navel orange in El- Kalubia region under flood irrigation is lower than El- Bustan region under drip irrigation system, (Tables 3 &4).

It could be deduced from the above mentioned results, the role of molybdenum for reducing nitrite and nitrate in navel orange fruits. These results are in agreement with those finding of (24), who reported that, molybdenum is an important component of an enzyme in plants required to reduce nitrate to ammonium, an important component of amino acids and eventually proteins. Therefore, the plants being fed predominantly nitrate nitrogen may have a greater need for molybdenum because of need to convert nitrate nitrogen in leaf ammonium needed for growth.

Also, the reduction of nitrate to ammonia proceeds in two independent and well defined steps: (a) the reduction of nitrate to nitrite, catalyzed by the flavomolybdoprotein NADH-nitrate reductase; and (b) the reduction of nitrite to ammonia, catalyzed by the iron protein ferredoxin-nitrite reductase [32]. Moreover, [33], [34] reported that, in molybdenum-deficient plants grown in the presence of nitrate, molybdenum is required for the synthesis of nitrate reductase and have suggested that it is involved in the induction process and acts not merely as the constituent metal. Anyhow, the optimum level of nitrite (No_2) in oranges is (less than 1 ppm) as reported by [35].

Despite that nitrate fertilization added in El- Kalubia region (180 kg N/ fed.) under flood irrigation is more than added in El- Bustan region (107.2 kg N/ fed.) under drip irrigation, but our results indicated that, nitrite and nitrate contents in fruit juice of navel orange in El- Kalubia region are Less than El- Bustan region. This is probably due to the flood irrigation system in El- Kalubia region, which washes excess nitrate at the ground water and also may be due to the high light intensities at this region that reflected the reduction in nitrate content in fruit juice of navel orange.

These results are in harmony with those found by [36] who indicated that, nitrate content can be reduced significantly both by limiting the nitrogen availability and by increasing the light intensity; they also found that, reducing the nitrogen availability significantly reduces the contribution of nitrate to the osmotic potential and increases that of chloride, glucose and sucrose. Furthermore, contribution of nitrate to the osmotic potential becomes significantly low and that of sucrose significantly high at a high light intensity. As the reduction in nitrate content with supplementary light becomes relatively slight, growth is greatly enhanced. The reduced nitrate content under high light intensity is accompanied by an increased content of sucrose, suggesting an increased rate of photosynthesis under high light intensities.

On the other hand, the type of nitrogen fertilizer plays an important role in decreasing or increasing the level of nitrite and nitrate in the plant. In this respect [37], [38] reported that, the accumulation of nitrates in the edible parts of crops is directly related to the type of nitrogen fertilizer used. Also, the use of fertilizers based on ammonia or a mixture of nitrate and ammonium can reduce the nitrate content in plants [39].Nitrate accumulation in products is a function of increasing supply of nitrate by fertilization and mineralization of soil organic matter on the one hand, and the reduced availability of assimilate on the other hand. Therefore, the higher the nitrogen availability (mineral fertilizer > liquid manure > manure > compost) and the lower the assimilation intensity (e.g. by site conditions and season effects), the greater would be the nitrate accumulation. Moreover, the poorly controlled flux of soil nitrogen resulting from active mineralization of organic matter may lead to excessive accumulation of nitrate in plants [40].

To have a quality yield with low nitrate content is possible by manipulating the nitrogen nutrition of plants [41]. Proper application of nitrogenous, phosphate, potassium fertilizers, as well as the green and farmyard manures, could materially reduce the nitrate accumulation in vegetables [42]. Nitrate concentration in plants can also be reduced by replacing nitrate (N) with sulfate, ammonium or amino acids a few days prior to crop harvesting [39]. Nitrate concentration in plants can also be manipulated by prohibiting the nitrogen supply for some days before crop harvesting [43]. In this way, nitrate will be removed from vacuoles and plants will guard the organic vacuoles needed to make up for the decreased osmotic value.

Table 3. Nitrite content in fruit juice navel orange trees in El – Kalubi and El – Bustan regions

	Nitrite (NO_2 ppm)					
	El- Kalubia			El- Bustan		
Treatments	**Season, 2013**	**Season, 2014**	**Mean**	**Season, 2013**	**Season, 2014**	**Mean**
Control	3.09 a	3.14 a	**3.12**	4.62 a	4.20 a	**4.41**
Ammonium molybdate at 0.2%	1.25 d	1.10 c	**1.18**	1.91 d	1.85 d	**1.88**
Ammonium molybdate at 0.4%	2.30 c	2.44 b	**2.37**	2.82 c	2.61 c	**2.72**
Ammonium molybdate at 0.6%	2.40 b	2.50 b	**2.45**	2.94 b	2.75 b	**2.85**

Mean separation within columns by Duncan’s multiple range test, 5% level. Values that don’t share the same letter are significantly different.

Table 4. Nitrate content in fruit juice navel orange trees in El - Kalubia and El –Bustan regions

	Nitrate (NO_3 ppm)					
	El- Kalubia			El- Bustan		
Treatments	**Season, 2013**	**Season, 2014**	**Mean**	**Season, 2013**	**Season, 2014**	**Mean**
Control	32.93 a	36.22 a	**34.58**	43.67 a	47.45 a	**45.56**
Ammonium molybdate at 0.2%	21.74 d	25.41 c	**23.58**	29.09 d	31.81 b	**30.45**
Ammonium molybdate at 0.4%	25.83 c	28.15 bc	**26.99**	36.81 c	40.66 ab	**38.74**
Ammonium molybdate at 0.6%	28.67 b	31.34 b	**30.01**	40.47 b	49.77 a	**45.56**

Mean separation within columns by Duncan’s multiple range test, 5% level. Values that don’t share the same letter are significantly different.

B. Protein Content in Fruit

Data in (Table 5) showed the averages of protein content (gm%) in fruit juice of navel orange trees at El- Kalubia and El- Bustan regions in (2013 & 2014) seasons. It could be noticed that foliar application with ammonium molybdate at all concentrations that used increased juice protein fruit content as compared with control treatment. Fruits treated with ammonium molybdate at 0.2% scored the maximum level of protein content (0.87 gm%) and (0.61 gm%) followed by at 0.4% (0.78 gm%) and (0.53 gm%) then the treatment at 0.6% (0.75 gm%) and (0.49 gm%), while, fruits of control treatment recorded the lowest averages of protein content (0.61 gm%) and(0.43 gm%) in El- Kalubia and El- Bustan regions, respectively. On the other hand, the results indicated that, fruit juice at El- Kalubia region had higher protein content than El-Bustan region.

It is clearly evident from the results the role of molybdenum in increasing fruit protein content. This finding is in the same line with those finding by [24] who mentioned that, molybdenum is an important component of an enzyme in plants required to reduce nitrate to ammonium, an important component of amino acids and eventually proteins. Therefore, the plants being fed predominantly with nitrate nitrogen may have a greater need for molybdenum because of need to convert nitrate nitrogen in leaf ammonium in for growth. In this respect, [44], [45] stated that, molybdenum is directly related to metabolic function of nitrogen in the plant through reductase enzyme that reduces the nitrate to nitrite and the first step of the incorporation of nitrogen to proteins.

Our results are in harmony with those found by [46] who mentioned that the highest % amount of protein recorded in grapefruit juice containing (0.92 gm%) followed by lemon juice with 0.85 gm% protein, lime juice with 0.679 gm% protein and orange juice with 0.51 gm% protein, indicating that the fruits are very safe for consumption with respect to protein content.

Table 5. Protein content in navel orange fruits in El- Kalubia and El- Bustan regions

Treatments	Protein in fruit (gm %) El- Kalubia Season, 2013	El- Kalubia Season, 2014	El- Kalubia Mean	El- Bustan Season, 2013	El- Bustan Season, 2014	El- Bustan Mean
Control	0.62 d	0.60 c	**0.61**	0.41 c	0.45 b	**0.43**
Ammonium molybdate at 0.2%	0.85 a	0.88 a	**0.87**	0.62 a	0.60 a	**0.61**
Ammonium molybdate at 0.4%	0.77 b	0.78 b	**0.78**	0.54 b	0.51 b	**0.53**
Ammonium molybdate at 0.6%	0.70 c	0.79 b	**0.75**	0.50 b	0.48 b	**0.49**

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

C. Fruit Quality.

Data tabulated in (Table 6) in El- Kalubia and (Table 7) in El- Bustan locations showed the effect of the foliar application of ammonium molybdate on improving fruit quality of navel orange. The results indicated that, the superiority of ammonium molybdate at 0.2% treatment for achieving the highest values of fruit weight (gm), juice weight (%), T.S.S/Acid and Vitamin C. as compared with other treatments while the control treatment scored the lowest averages in this regard during two seasons (2013 & 2014). This is may be attributed to the role of molybdenum for enhancing absorption of potassium which plays a direct role in the plant's cell structure, however, it is fundamental because it catalyzes important reactions such as respiration, photosynthesis, chlorophyll formation, water regulation and improving fruit quality[47].

In this respect [48] mentioned that, application f molybdenum led to an increased accumulation of K+ ions up to 2-fold compared to the respective Mo-untreated plants. Also [48] studied the effect of molybdenum on nitrate reductase and nitrogenase activities as well as the growth and mineral nutrition of wheat inoculated with *Azospirillum brasilense* in greenhouse pot experiments under drought stress conditions. They found that, molybdenum application affected positively wheat growth, total plant N-yield, saccharides, protein, potassium and magnesium contents both in control and inoculated plants under severe water stress (35%).

Table 6. Fruit quality of navel orange trees at El- Kalubia region under flood irrigation system

Treatments	Fruit weight (gm)	Juice weight %	T.S.S %	Acidity %	T.S.S / Acid	Vit. C mg / 100 ml juice
			Season, (2013)			
Control	277 a	57.10 b	12.5 a	1.29 a	9.73 ab	34.07 b
Ammonium molybdate at 0.2%	300 a	61.18 a	12.7 a	1.22 a	10.48 a	39.60 a
Ammonium molybdate at 0.4%	287 a	58.57ab	12.2 a	1.29 a	9.42 b	35.93 b
Ammonium molybdate at 0.6%	282 a	60.03ab	12.5 a	1.31 a	9.64 ab	36.13 b
			Season, (2014)			
Control	264 c	54.67 c	11.83 c	1.31 a	9.01 b	38.60 b
Ammonium molybdate at 0.2%	301 a	59.76 a	12.83 a	1.60 b	11.09 a	42.77 a
Ammonium molybdate at 0.4%	283 b	58.29 b	12.17 b	1.32 a	9.24 b	35.57 c
Ammonium molybdate at 0.6%	281 b	55.45 c	12.33 b	1.33 a	9.25 b	38.03 b

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

Table 7. Fruit quality of navel orange trees at El- Bustan region under drip irrigation system.

Treatments	Fruit weight (gm)	Juice weight %	T.S.S %	Acidity %	T.S.S / Acid	Vit. C mg / 100 ml juice
			Season, (2013)			
Control	343 b	46.67 b	9.83 b	1.05 b	9.36 a	42.33 b
Ammonium molybdate at 0.2%	370 a	49.33 a	11.17 a	1.15 ab	9.76 a	45.67 a
Ammonium molybdate at 0.4%	363 ab	46.71 b	10.33 b	1.50 ab	9.01 ab	42.00 b
Ammonium molybdate at 0.6%	372 a	46.83 b	10.33 b	1.22 a	8.44 b	44.00ab

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Season, (2014)

Control	350 d	42.45 c	9.50 c	1.03 b	9.22 b	39.63 d
Ammonium molybdate at 0.2%	374 a	51.71 a	11.5 a	1.18 a	9.75 a	44.64 a
Ammonium molybdate at 0.4%	365 b	48.32 b	10.45b	1.20 a	8.70 c	42.61 c
Ammonium molybdate at 0.6%	360 c	47.34 b	10.33b	1.21 a	8.53 d	43.49 b

Mean separation within columns by Duncan's multiple range test, 5% level. Values that don't share the same letter are significantly different.

IV. Conclusion and Recommendations

Overall, the current study focused on the role of molybdenum for reducing nitrate to ammonium in plants and transforms it to amino acids and eventually proteins. Foliar application of trees with ammonium molybdate at 0.2% was the best treatment for achieving the lowest average of fruit juice nitrite and nitrate, increasing fruit juice protein content, juice weight %,T.S.S/Acid and Vitamin C. Also, it could be noticed that, navel orange fruits in El- kalubia region had lower residual effect of both nitrite and nitrate and it had high fruit quality than the other fruits at in El-Bustan region. In this concern, we recommend to use foliar application of molybdenum to other crops before crop harvesting especially vegetables that have major source of the daily intake of nitrate by human beings, supplying about 72 to 94% of the total intake [49].

While there is a lot of published research on strategies for reducing nitrate accumulation in plants yet, it remains to be translated into practice due to lack of information for farmers. Therefore, there is a need to bridge the gap between research laboratories and farmers' fields. Decision-makers must formulate relevant agricultural policies encompassing education and training of farmers to let them understand the effects of nitrate on human health and the importance of nutrient management and other strategies for minimizing the nitrate content in plant tissues. Consumers also need to be informed regarding the nitrate content in vegetables and its health implications. They must be motivated to adopt practices that help in minimizing nitrate consumption.

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2-Impact of Gibberellic Acid Enhancing Treatments on Shortening Time to Budding of Citrus Nursery stocks. [Journal of American Science, 2010; 6(12):410- 426]. ISSN: 1545-1003).

3-Effect of foliar chemical spray on the incidence of fruit cracking on four Navel orange strains.
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4-Evaluation of two different orange varieties on some different interstocks using Macrophylla Lemon as promising rootstock comparing without using interstocks in alcareous soil.[Egyptian Journal of Applied Sciences, 2011; Vol.26 No.3 March:140-159] (ISSN:1110- 1571).

5-Effect of Planting time on Growth, Flowering and Harvesting time and Fruit Quality of Williams Banana Grown in Reclaimed Sandy Soils.[Minufiya J. Agric. Res. 2011; Vol.36 No.3 June: 613-622] (ISSN 1110-0265).

6-Effect of GA3 and potassium nitrate in different Dates on fruit set, yield and splitting of Washington navel orange. [Nature and Science, 2012; 10(1) pp.148-157].

7-Regulation of Navel orange cropping and improvement of fruit quality using Sitofex and Gibberellic Acid. [Nature and Science, 2013;11(6) pp.13-21].

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