Abu Dhabi Food Control Authority
Development Sector
Research & Development Division

Technical Report تقرير فني

Title العنوان	**Improve the use of Chemical Fertilizers-Greenhouse Tomato**
Project Team فريق العمل	Dr. Ihsan Abu Al-rub, Sameer Saleh, Abdel Aziz Awaga
Duration فترة المشروع	**From:** Oct. 2011 **To:** Sept. 2012

Background خلفية عن الموضوع

Tomato (*Lycopersicon esulentum* Mill.) is one of the most consumed vegetables in the world. It is a good source of vitamin A, B, and C, contain about 23 mg/100 g edible portion ascorbic acid (Nonnecke, I. N. 1989). Recent studies suggest that tomatoes contain the antioxidant lycopene, which clinically approved to reduce the risk of cancer (Kucuk, O. 2001). Nitrogen and phosphorus are essential component of many compounds, including proteins, amino acids, and enzymes responsible for biochemical changes in tomato growth (Winsor, G.W. 1973).

In the UAE, tomato has high market values, which encouraged farmers to use high quantity of fertilizers. However not all nutrients applied are taken up by the plant. Many studies reported that tomatoes are unable to recover 100% of applied N (Sweeney et al., 1987). Sylvester-Bradley (1993) found that 10-60% of N fertilizer applied is not utilized by plants, Sweeney et al (1987) reported that N recovered by tomato from N fertilization in Florida ranged from 32 to 53% while Sainju et al (2000a) reported a recovery rate of 13 to 30% with 90 and 180 kg N ha^{-1} in greenhouses in Georgia. The residual N left after harvest in the soil can causing groundwater contamination and degrading water quality and wasting the amount and cost of fertilizer applied. The problem can be severe in sandy soils, which have higher water infiltration and lower NO_3 retaining capacity compared with clay soils and by targeting N and P fertilizer to meet maximum plant demand, it may be possible to reduce the residual in the soil.

High N level in the soil can promote excessive vegetative growth which can delay the setting and maturity of tomato fruits, thereby reducing tomato production (Kaniszewki, S., and Elkner, K. 1990). Nitrogen deficiency in the soil, on the other hand, can decrease the production of number of fruits, fruit size, storage quality, colour, and taste of tomato (Needham, P. 1973).

Despite its low requirements in tomato plants as compared to N and K (Sainju et al. 2003) P still plays a major role in vital growth functions to promote early plant establishment. A suitable combination of both N and P applications to tomato plants enhance growth and yield parameters (Nawaz et al. 2012).

Problems التحديات

- The current chemical fertilizer practices may lead to soil and groundwater degradations.
- No scientific based data is available for the tomato fertilizer application in greenhouse.

Objectives الأهداف

- Evaluate the effects of different levels of N and P fertilizer on the growth, yield and fruit qualities of greenhouse tomatoes

- Determine the optimum fertilization needs that will assist to develop fertilization program for the tomato in the greenhouse.

Methods طريقة العمل

1. Field experiment

The experiment was conducted at AlKuwaitat Research Station in the UAE during 2011 and 2012. Tomato seeds of Elbida e.z variety were sown in potting soils in greenhouse. Four week old seedlings were transplanted into greenhouse in the beginning of November, 2011. Tomato seedlings were planted in plots of 6 m by 2 m and consisted of 2 rows of 12 plants each the distance between rows is 0.5 m, the planting density was 20,000 plant ha^{-1}.

The experiment was laid out in a randomized complete block design with two factors and four replications. The experiment included 12 fertilizer treatments consisting of all possible combinations of four nitrogen rates (0, 300, 600 and 900 kg ha^{-1}) and three phosphorus rates (0, 200, 400 kg ha^{-1}) with a constant rate of potassium application at 900 kg ha^{-1} to all plots. Nitrogen was applied as urea (N 46%), phosphorus as triple super phosphate (P_2O_5 50%) and potassium as potassium sulphate (K_2O 50 %).

N and K fertilizers were applied via irrigation three times per week. Fertilizers were split into three application rates corresponding to three growing stages; i.e. from transplant to flowering (lasted 35 days) used 15% of the total supply, from flowering to beginning of harvest (45 days) used 25% of the total supply and from initial harvest till the end of growing season (150 days) used 60%. P was added by hand twice, before seedling transplanting and after one month from planting.

Recommended cultural practices such as irrigation, removal of weeds and plant protection were adopted uniformly according to standard crop management practices. Weeds were manually controlled.

Matured tomato fruits were harvested once a week and total fruit number and fruit weight were determined. Yield data were summed up of the total fruit weight from 28 consecutive harvests and converted into tons per hectare basis. The assessment of fruit number and average fruit weight (g) per plant was done twice at the third and final harvests, respectively.

2. Fruit quality

Fruit quality parameters were determined for fruits from the second harvest. Fruit firmness was determined by a fruit pressure tester and values were expressed in pounds. Total soluble solid was checked by a digital refractometer and values were expressed as degree Brix. Titrateable acidity was determined using the method of Srivastava and Kumar (1993).

3. Statistical analysis

The statistical analysis was performed using the Statistical Analysis System (SAS). The effect of the treatments was evaluated through the analysis of variance (ANOVA). The Least Significant Difference (LSD) was used to compare differences among treatments at $p \le 0.05$. The regression procedure was used to determine the linear and/or quadratic effects of N fertilizer.

4. Soil analysis

Before transplanting of tomato, soil samples were randomly collected at depth 0-30 cm from each experimental plot and were analyzed for the initial physical and chemical characteristics. Soil samples were also collected after final harvest to evaluate the fertilizer residues in soil of each treatment.

The initial soil in the experimental field had a texture of sandy soil (sand 99.1%, silt 0.76% and clay 0.04%), with average pH 8.1, electrical conductivity 1.5 dSm^{-1}, 1.0 % organic matter content, 18.5% water holding capacity and CEC 2.3 meq/100g. Fertility levels including Total-N, nitrate and available phosphorus, potassium were 127.5, 44.7, 22.6 and 154.7 ppm, respectively.

Results النتائج

1. Tomato yield

Tomato responded significantly to N-P fertilizer. The total yield increased with increasing levels of applied N up to 600 kg ha^{-1} and 200 kg ha^{-1} P ($p < 0.05$), hence beyond this level tomato yield displayed significant decline.

The interactive effects between N and P levels gave the highest yield when 600 kg ha^{-1} N was combined with 200 kg ha^{-1} P (yield 233.9 t ha^{-1}) followed by 600-400 kg ha^{-1} N-P_2O_5 (Fig. 1). This increment was about two folds higher than yields from the control plot without both N and P applications. The results suggest that increasing crop fertilization to an optimum level enables the plants to produce their highest potential yield.

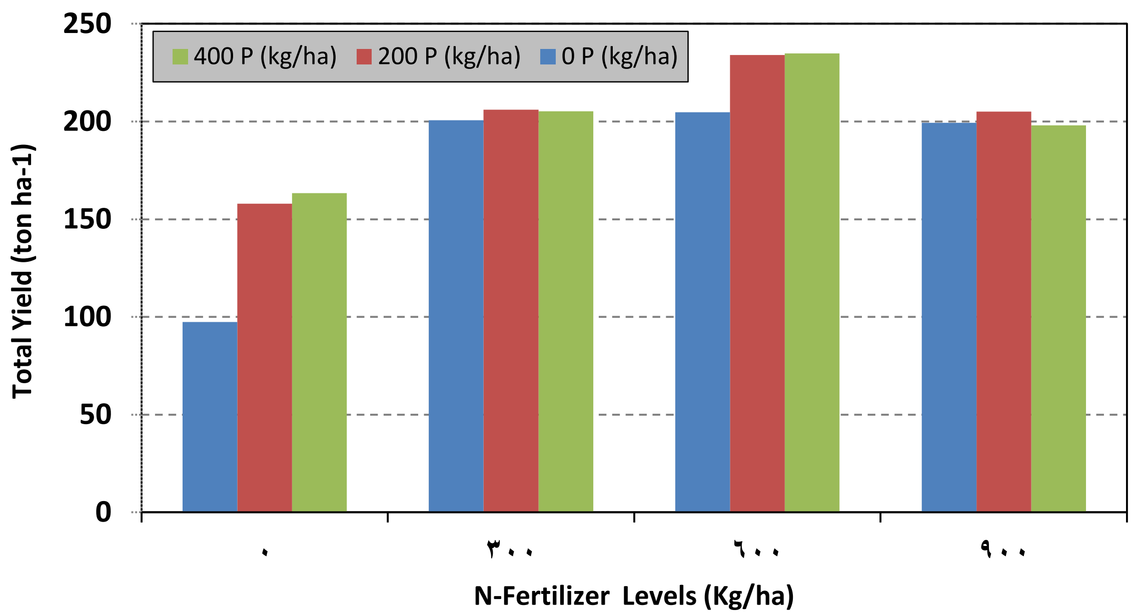

Fig. 1: Tomato Total yields in response to different N and P fertilizer application rates.

LSD at 5% N=3.2, P=2.8 and NXP=5.6

2. Tomato yield parameters

Gradual increases were recorded for average fruit weight and number of fruit per plant with increasing N-P_2O_5 levels (Table 1). Both average fruit weight and fruit number at 3rd harvest were highest at N 600 kg ha^{-1} and P_2O_5 at 200 kg ha^{-1}, i.e. 198.4g and 5.7 fruits per plant, respectively. Similar performance was retained with same fertilizer treatment till the end of harvesting season. Application of nitrogen up to 900 kg ha^{-1} had adverse effects on both fruit number and fruit weight while increasing phosphorus rate from 120 to 240 kg ha^{-1} produced the same average fruit weight and number but without adverse effects. This implies that 600-200 kg ha^{-1} N-P_2O_5 is adequate for improved growth performance of tomato, which was fully reflected in the production of higher number of fruits with bigger size. N fertilization resulted in significant longer plant shoot compared with zero application with no significant differences between N levels at the time of the 3rd harvest as well as at the end of season. The application of P has no significant effect on plant height at the two measuring time.

Table 1. Average plant height and yield parameters of tomato in response to different N and P fertilizer application rates.

Treatment (kg ha^{-1})		3rd harvest			End of season		
		Average fruit weight (g fruit^{-1})	Average No. of fruit (No. plant^{-1})	Plant height (cm)	Average fruit weight (g plant^{-1})	Average No. of fruit (per plant)	Plant height (cm)
0	0	153.8	2.5	2.6	81.5	1.7	3.7
	200	176.5	3.2	2.8	91.9	2.1	3.9
	400	181.4	3.9	2.8	93.3	2.6	3.9
300	0	190.5	4.9	3.4	104.4	3.4	4.8
	200	198.4	5.7	3.5	109.3	3.8	4.5
	400	196.4	5.4	3.3	110.7	3.7	4.8
600	0	202.7	5.4	3.4	111.5	3.7	4.5
	200	220.6	7.3	3.3	131.6	5.1	4.8
	400	214.8	6.6	3.4	124.3	4.9	4.6
900	0	190.1	4.5	3.4	96.3	2.9	4.5
	200	200.4	5.3	3.4	101.1	3.6	4.8
	400	188.7	4.5	3.5	92.9	3.0	4.6
LSD (5%)		8.78	0.78	NS	7.8	0.6	NS

3. Fruit qualities and nutrition values

Table 2 shows the effects of fertilizer treatments on some physiochemical characteristics of tomatoes. Increasing nitrogen fertilizer rate revealed significant increments in nitrate concentration, acidity and citric acid, than the control. The other fruit quality parameters including TSS, sugar and firmness did not show significant response to nitrogen treatments.

Phosphorus fertilizer application had no significant effects on all quality parameters measured in this study. The results show a non significant interaction between nitrogen and phosphorus indicating that the application rate of phosphorous was not significantly affected by the nitrogen level applied.

Table 2. Effects of N and P fertilization on nutrient value and fruit qualities of fresh tomato at the 3rd harvest during 2011 growing season

Treatment	Total soluble solid (°Brix)	Nitrate (ppm)	Phosphorus (ppm)	Sugar (%)	Acidity (%)	Citric acid (%)	Firmness
	Nitrogen rate (kg ha^{-1})						
0	4.1	1.2 b	94.1	4.0	0.27	0.34	2.2
300	4.2	1.7 a	98.8	4.0	0.27	0.35	2.3
600	4.1	1.8 a	94.2	4.4	0.28	0.36	2.1

900	4.1	1.9 a	93.3	4.1	0.31	0.40	2.4
LSD (5%)	ns	0.28	ns	ns	0.025	0.03	ns
	Phosphorus rate (kg ha^{-1})						
0	4.1	1.6	94.3	4.1	0.27	0.34	2.2
200	4.2	1.8	94.7	4.2	0.28	0.36	2.3
400	4.1	1.6	96.5	4.1	0.29	0.37	2.3
LSD (5%)	ns	ns	ns	ns	ns	ns	ns

4. Soil nutrient residues

The influences of fertilizer rates on nutrient residues in soil and EC are presented in Table 3. At all applied N levels soil nitrate and total N concentration was significantly in order of 900>600>300>0 kg ha^{-1}. These results indicated that tomato plants had surplus uptakes of N at rate of 900 kg ha^{-1} that resulted in the highest nitrate accumulation in soils. High nitrate contents in soils receiving N 900 kg ha^{-1} showed that this high rate might have detrimental effects on soil and the environment. Nitrate concentration in soil without N application was lower than the nitrate level before transplanting indicated that there was high nitrate depletion.

Soil EC is a measurement of total soluble salts presented in soil that came from fertilization and other activities. High EC in soils after harvest showed nutrient residues accumulated in soils from fertilization. The changes of EC in soil of each N treatment followed the same pattern of soil nitrate accumulations indicating that high EC attributed to N residues from relevant N application.

Increased P application level had also increased significantly the residual phosphorus in the soil, using 400 kg ha^{-1} phosphorous had almost doubled and tripled the P residues comparing to 200 kg ha^{-1} and control, respectively. However, their P accumulations were less than nitrate accumulations due to less application rates of P fertilizer than N rates. There were no significant interactions between N and P fertilizers treatments on soil nutrients and EC tested in soils after harvest. In other words, N or P fertilizer was the main source of N or P accumulation in sandy soil as in the UAE condition.

Table 3. Soil chemical properties in response to different N and P fertilizer rates post-cropping of tomato.

Treatment	EC (dS m^{-1})	Nitrate (ppm)	Total Nitrogen (ppm)	Available Phosphorus (ppm)
	Nitrogen rate (kg ha^{-1})			
0	2.3	32.5	88.5	20.2
300	3.9	45.7	143.0	19.0
600	5.2	72.9	159.7	19.2
900	5.3	124.3	198.8	23.9
LSD (5%)	1.2	5.0	6.4	NS
	Phosphorus rate (kg ha^{-1})			
0	4.1	66.3	141.8	8.7
200	4.2	69.3	147.6	21.8
400	4.4	71.0	153.0	31.2
LSD (5%)	NS	NS	6.6	3.6

Recommendations التوصيات

- Based on the results of a good balance among productivity, quality and pollution risk, application of 600 kg ha^{-1} nitrogen with 200 kg ha^{-1} phosphorus seemed to be the best fertilizer recommendation for the production of field tomato in the UAE condition.
- Based on derived equation from fitted quadratic model, fertilizer application level of 500 kg ha^{-1} nitrogen with 200 kg ha^{-1} phosphorus (expected yield 232.4 t ha^{-1}) could have potential to meet maximum plant demand, to sustain tomato yield with favourable quality, and more importantly to reduce the potential for salt and nutrient residual accumulations for safer tomato production. A further study is recommended.
- Further studies are recommended to determine the threshing value for nitrate residual in the soil under the UAE environmental condition.
- Beneficiaries: Agriculture Affairs Sector, Farmers' Services Centre, Extension officers.

References المراجع

Kaniszewki, S., and Elkner, K. 1990. Effect of nitrogen fertilization and irrigation on yield and fruit quality of two stated tomato cultivars. Hort. Abstract, p. 406.

Kucuk, O. 2001. Phase II randomized clinical trial of lycopene supplementation before radical prostatectomy. Cancer Epidem. Biom. Prev. 10: 861-868.

Nawaz, H. and M. Zubair and H. Derawadan. 2012. Interactive effects of nitrogen, phosphorus and zinc on growth and yield of tomato (Solanum lycopersicm). African Journal of Agricultural Research Vol. 7 (26): 3792-3769.

Needham, P. 1973. Nutritional disorders. In: The U.K. Tomato Manual. Grower Books, London.

Nonnecke, I. N. 1989. Vegetable production. Van Norstrand Reinhold, New York.

Sainju, U.M., Singh, B.P., Rahman, S., and Reddy, V.R. 2000a. Tillage, cover crop, and nitrogen fertilization influence tomato yield and nitrogen uptake. HortScience 35: 217-221.

Sainju, U.M., Dris, R., and Singh, B. P. 2003. Mineral Nutrition of tomato. Food, Agriculture and Environment Vol. 1 (2): 176-183.

Srivastava, R.P. and Kumar, S., 1993, Important methods for analysis of fruits/vegetables and their products. Fruit and Vegetable Preservation Principles and Practices, 2nd Edition, pp. 321-339.

Sweeney, D.W., Graetz, D.A., Bottcher, A.B., Locaccio, S.J., and Campbell, K.L. 1987. Tomato yield and nitrogen recovery as influenced by irrigation method, nitrogen source, and mulch. HortScience 22: 27-29.

Sylvester-Bradley, R. 1993. Scope for more efficient use of fertiliser nitrogen. Soil Use and Management 9:112-117.

Winsor, G. W. 1973. Nutrition. In: The U.K. Tomato Manual. Grower Books, London.

RD Director: ……………………..……..…….. **Date:** …Jan. 14, 2014..