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Evaluation of Nutrient Film Technique and Sand Culture for Year-round Production of Tomato (*Lycopersicon esculentum* Mill.) in Tropical Asia

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Abstract: Nutrient film technique and sand culture were tested for the year round production of tomato in Bangladesh. Two cultivars of tomato viz., Egg tomato and Kingkong were tested for growth in both winter (November 2000-February 2001) and summer (May 2001-August 2001) seasons in NFT (Nutrients Film Technique) and sand culture. Sand culture was more simple to establish and manage incurved lowed cost compared to NFT system, however higher production was observed in NFT system. Egg tomato was found to be suitable for growth in summer, where as winter was suitable for Kingkong tested NFT and sand culture.

Key words: NFT, sand culture, tomatoes, yield, season

Introduction

Hydroponic is a technology for growing plant in nutrient solutions (Water containing fertilizers) with or without the use of an artificial medium (sand, gravel, vermiculite, rock wool, perlite, peat moss, coir or sawdust) to provide mechanical support (Jensen and Collins, 1985). Hydroponic systems are further categorized as open (i.e. the nutrient solution delivered to the plant roots, is not reused or closed (i.e. surplus solution is recovered, replenished and recycled).

The earliest record scientific approach to discover plant constituents was in 1600 when Belgiun Jan Van Helmont showed in his classical experiment that plant obtain substances from water (Resh, 1985). In 1804 De Saussure proposed that plants are composed of chemical elements obtained from water, soil and air (Douglas, 1983). Various research Workers had demonstrated by that time that plants could be grown in an inert medium moistened with a water solution containing minerals required by the plants (Shive, 1938; Hoagland and Arnon, 1950; Armon, 1950; Schwartz, 1968 and Resh, 1985). Nutrient film Techniques (NFT) is the earliest method of hydroponic. Allen Cooper (1965) at the Glasshouse Crop Research Institute on Littlehamptan, England Poineered work on NFT cropping. The sufficient oxygen would be supplied to the plant root by this system. Capital cost and complexity of operation the system can be reduced by use of NFT system.

Tomato is the second most widely grown vegetable crop in the world and most popular vegetable in Bangladesh. It is rich in Vitamins A, C and contains the antioxidant lycopen (Jones, 1998). Tomato, which was once productive in Bangladesh has gradually decrease its yield and production largely due to limited cultivable land and primitive culture processes. As a result loss of production and growth occur, nutrient deficiencies and culture techniques can be recognized which ultimately affected yield.

Great amounts of tomato yield are devastated by proper culture techniques. Here soilless culture is the important method to increase yield of tomato.

Growing hydroponic vegetables is one of the most exacting and intense forms of all agricultural enterprises and becoming increasingly popular. It is highly productive conservative of water and land and protective of the environment. For production of tomato, hydroponic is common in world (Maloupa and Gerasopoulos, 2001).

Hydroponic is a very young science for commercial tomato production. It is a valuable means of growing fresh vegetables. It is therefore necessary to best the possibility of tomato production through water and sand culture. This research program was undertaken to evaluate the water and sand culture for commercial production of tomato in Bangladesh condition.

Materials and Methods

The research work was conducted in the Botanical Garden, Rajshahi University, Bangladesh during the period from November 2000 to August 2001. The area covered for conducting each experiment was 25.86 sq. m. Two cultivars of tomato: Kingkong and Egg tomato were tested. Inorganic fertilizer salts including macro and micronutrient were used in the present study. Tube well water was used for both NFT system and sand (0.6 to 1.5 mm diameter, collection from local padma river) culture as the growing medium. Some equipments were

Table 1: Composition of Resh (1985) nutrient solution in ppm concentration

Elements	A	B	C
Ca^{++}	98.50	148.00	197.00
Mg^{++}	22.00	33.00	44.00
K^{+}	200.00	300.00	400.00
N as NH_4^{+}	80.00	110.00	145.00
P as Po_4^{-}	40.00	55.00	65.00
S as SO_4^{-}	83.20	144.30	197.50
Fe^{++}	2.00	2.00	2.00
Mn^{-}	0.50	0.50	0.50
Cu^{-}	0.03	0.03	0.03
Zn^{-}	0.05	0.05	0.05
B^{-}	0.50	0.50	0.50
Mo^{-6}	0.02	0.02	0.02

A = for seedling (10 to 14 days old)
B = for 14 to 16 inches height until
C = for mature plant

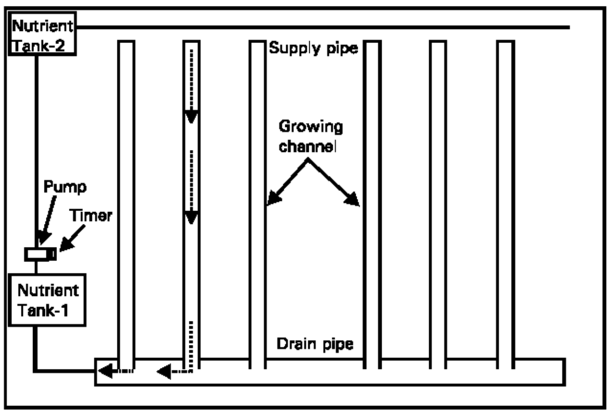

Fig. 1: Lay out of the experimental field of NFT system

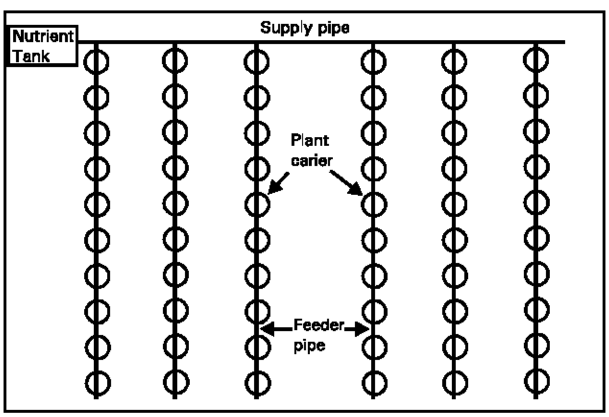

Fig. 2: Lay out of the experimental field of sand culture

also used for experimental setup e.g. PVC pipe, Polyethylene paper, hoose pipe, tank, water pump, timer clock and soil tub.

Nutrient composition was prepared followed by Resh (1985) as shown in Table 1. During preparation of nutrient medium macronutrients were dissolved first followed by micronutrient and pH was adjusted in 6. Plastic ice cube trays were used for growing transplants.

In NFT structure 20.32 cm diameter PVC pipes were placed on the concrete with 60 cm distance between them. The acceptable slope was about 1 in 100. Seedlings were placed in hole on the PVC pipes tighten with foam. Two reservoir tanks were used for supplying nutrient solution. For continuous circulation of solution, pump machine and timer were used in the set up. The nutrient solution was preserved in tank-1 from where it was pumped in to tank-2, then back to tank-1 after required hrs. For fresh supply of the nutrients, the solution was changed after every two weeks up to final harvest.

The sand culture device is shown in Fig. 2. It consists of one nutrient tank connect with main supply pipe, which is linked with several feeder pipes. The feeder pipes have many pores under which one plant carrier is placed. The solution is dripped through the pore of the feeder pipe in such way that the extra amount of solution will be drained out through to side pore of the plant careers and eventually the sand will be in moist. The nutrient was supplied from the tank once or twice in a day depends upon the relative humidity of air.

Results and Discussion

Water culture: Standard error of all characters was less than the corresponding mean as expected. High value of SE was observed for fruit weight in respect of season and variety. Where as, low SE was noticed in stem girth (Table 2). The items cultivar and cultivar x season (CXS) were significant for all characters. The item season was significant for leaf number, root length, fruit number and fruit weight but was non significance for plant height, leaf length, stem girth and branch number. The LSD data reveal that the cultivars Egg tomato and Kingkong were different from each other for the characters plant height, leaf number, leaf length, stem girth, branch number, root length, fruit number and fruit weight. Seasonal difference was observed for the characters leaf number root length, fruit number and fruit weight. Regarding varietal performance in winter and summer seasons, Kingkong produced fruits only in winter seasons. Where as, egg tomato produced fruits in both the seasons but summer was found conducive.

Sand culture: Standard error of eight characters was less than the corresponding means. Here also the highest and lowest SE was observed for weight respectively (Table 2). For variance analysis the items cultivars and C x S were significant for all characters. But the item season was significant only for plant height, leaf number, leaf length, root length, fruit number and fruit weight (Table 3). The calculated LSD shows that Egg tomato was significantly

Table 2: Means with standard error (SE) for eight characters of tomato plant in water and sand culture

Character	Culture type	Season	Kingkong	Egg tomato	Season mean
Plant height (cm)	NFT	Winter	b*a* 95.866±2.056	a*b* 151.833±1.297	123.850
		Summer	b*b* 88.166±1.665	a*a* 160.803±1.829	124.480
		Cultivar mean	92.010 B	156.310 A	
	Sand culture	Winter	b*a* 95.900±2.084	a*b* 151.200±1.200	123.550 *A*
		Summer	b*b* 87.800±1.679	a*a* 160.830±1.850	124.310 *A*
		Cultivar mean	91.850 B	156.010 A	
Leaf number (Plant^{-1})	NFT	Winter	b*a* 38.700±0.353	a*a* 59.100±0.636	48.900 *A*
		Summer	b*b* 28.900±0.369	a*a* 58.657±0.650	43.770 *B*
		Cultivar mean	33.800 B	58.870 A	
	Sand culture	Winter	b*a* 40.466±0.784	a*a* 55.433±1.234	47.950 *A*
		Summer	b*b* 28.433±0.370	a*a* 58.372±0.687	43.403 *B*
		Cultivar mean	34.450 B	56.903 A	
Leaf length (cm)	NFT	Winter	a*a* 30.966±1.027	a*b* 30.300±0.263	30.630
		Summer	b*b* 27.966±0.324	a*a* 35.148±0.617	31.550
		Cultivar mean	29.460 B	32.720 A	
	Sand culture	Winter	a*a* 30.233±0.318	a*b* 30.300±0.263	30.260 *B*
		Summer	b*b* 27.966±0.324	a*a* 35.239±0.622	31.603 *A*
		Cultivar mean	29.100B	32.760A	
Stem girth (cm)	NFT	Winter	a*a* 1.030±0.013	a*b* 1.010±0.015	1.020
		Summer	b*b* 0.903±0.011	a*a* 1.106±0.014	1.004
		Cultivar mean	0.960 B	1.100 A	
	Sand culture	Winter	a*a* 1.023±0.013	a*b* 1.010±0.015	1.016
		Summer	b*b* 0.903±0.011	a*a* 1.103±0.013	1.056
		Cultivar mean	0.963 B	1.056 A	
Branch number (Plant^{-1})	NFT	Winter	a*a* 3.166±0.125	a*b* 3.066±0.124	3.110
		Summer	b*b* 1.966±0.120	a*a* 3.572±0.132	2.760
		Cultivar mean	2.560 B	3.310 A	
	Sand culture	Winter	a*a* 3.166±0.125	a*b* 3.066±0.1241	3.110
		Summer	b*b* 2.033±0.120	a*a* 3.578±0.132	2.800
		Cultivar mean	2.600 B	3.320 A	
Root length (cm)	NFT	Winter	a*a* 37.333±0.246	a*a* 36.500±0.325	36.910 *A*
		Summer	b*b* 27.533±0.192	a*a* 36.927±0.342	32.230 *B*
		Cultivar mean	32.430 B	36.710 A	
	Sand culture	Winter	a*a* 36.866±0.351	b*b* 35.966±0.430	36.410 *A*
		Summer	b*b* 27.133±0.239	a*a* 37.012±0.323	32.070 *B*
		Cultivar mean	32 B	36.480 A	
Fruit number (Plant^{-1})	NFT	Winter	b*a* 36.300±0.718	a*a* 39.766±0.572	38.033 *A*
		Summer	b*b* 0±0	a*b* 37.330±0.473	18.666 *B*
		Cultivar mean	18.150 B	38.550 A	
	Sand culture	Winter	b*a* 34.666±0.593	a*a* 38.733±0.599	36.700 *A*
		Summer	b*b* 0±0	a*a* 37.060±0.532	18.530 *B*
		Cultivar mean	17.333 B	37.897 A	
Fruit weight (g/Plant)	NFT (GM-1307.8)	Winter	a*a* 2464.670±49.168	b*a* 1403.830±12.796	1934.250 *A*
		Summer	b*b* 0±0	a*b* 1362.730±17.166	681.364 *B*
		Cultivar mean	1232.330 B	1383.280 A	
	Sand culture (GM-1228.7)	Winter	a*a* 2213.500±74.748	b*a* 1364±17.684	1788.750 *A*
		Summer	b*b* 0±0	a*a* 1337.580±19.739	668.788 *B*
		Cultivar mean	1106.750 B	1350.790 A	

A,B = Variation between cultivar. a,b = Comparison of cultivars at each season.
A,B = Variation between season. *a,b* = Comparison of season with each cultivar.
GM =Grand mean of cultivar

different from Kingkong for all characters. Regarding varietal performance similar trend like NFT was also noticed.

A soilless medium must provide O_2 for plant root just as does soil. In NFT system film flow of solution could provide this (Cooper, 1973). In sand culture although the nutrient solution was not recycled. Fine particles (0.6 to 1.5 mm) allow lateral movement of water through capillary action, so that solution applied at each plant become evenly distributed though out the root zone (Resh, 1985). pH of hydroponic nutrient solution is very important. Both the culture pH of the solution was controlled in 6 level. High pH (more than 7.0) caused precipitation of Fe^{++}, Mn^{++}, PO_4, Ca^{++} and Mg^{++} to insoluble and unavailable salts (Resh, 1985). Willumsen (1980) was adjusted pH of the flowing nutrient solution with 4.5, 5.5 and 6.5 levels and he concluded the difference in pH level did not directly the tomato yield.

The cultivars performed differently with the change of season. Kingkong performed well in winter season, where as Egg tomato performed well in summer season, in respect of culture medium. There are reports on different

Table 3: Analysis of variance for eight characters of tomato plant in water and sand culture

Character	Source	df	NFT		Sand culture	
			SS	LSD	SS	LSD
Plant height (cm)	Replication	2	142.646		13.031	
	Cultivar	1	13844.810***	5.178	13797.300***	1.070
	Season	1	54.613NS	58.520***	1.070	
	C×S	1	429.603**	7.323	470.0008***	1.513
	Error	6	80.420		3.435	
Leaf number (Plant^{-1})	Replication	2	2.426		0.195	
	Cultivar	1	2117.363***	2.064	1720.808***	2.291
	Season	1	39.603**	2.064	27.907*	2.291
	C×S	1	114.083***	2.919	242.100***	3.241
	Error	6	12.780		15.751	
Leaf length (cm)	Replication	2	3.3750		0.911	
	Cultivar	1	39.240**	1.808	48.803***	0.222
	Season	1	4.940NS	8.670***	0.222	
	C×S	1	55.040**	2.557	47.203***	0.314
	Error	6	9.805		0.148	
Stem girth (cm)	Replication	2	0.002		0.013	
	Cultivar	1	0.031***	0.035	0.032***	0.030
	Season	1	7.500NS		3.330NS	
	C×S	1	0.044***	0.050	0.040***	0.042
	Error	6	0.003883		0.002	
Branch number (Plant^{-1})	Replication	2	0.131		0.140	
	Cultivar	1	2.083**	0.344	1.920***	0.235
	Season	1	0.213NS		0.163NS	
	C×S	1	2.613***	0.486	2.430***	0.333
	Error	6	0.355		0.166	
Root length (cm)	Replication	2	1.271		2.526	
	Cultivar	1	67.687***	0.899	74.500***	0.290
	Season	1	53.340***	0.899	44.467***	0.290
	C×S	1	93.520***	1.272	103.840***	0.411
	Error	6	2.428		0.253	
Fruit number (Plant^{-1})	Replication	2	0.046		0.726	
	Cultivar	1	1487.410***	1.762	1507.520***	1.433
	Season	1	918.750***	1.762	798.701***	1.433
	C×S	1	1060.320***	1.246	1010.170***	1.013
	Error	6	3.106		2.053	
Fruit weight (gm/Plant)	Replication	2	960.875		1037.540	
	Cultivar	1	143993***	24.396	290008***	43.902
	Season	1	4210898***	24.396	3326954***	43.902
	C×S	1	4914560***	17.251	4039701***	31.043
	Error	6	594.958		1926.630	

types of GxE interaction in different crops by several investigation (Ananda, 1968; Nandipuri *et al.*, 1971; Singh and Singh, 1976; Islam *et al.*, 2000).

NFT produced slightly higher yield than sand culture for the studied two cultivars. Mancini *et al.* (1994) also found that higher yields of Chinese cabbage were obtained in NFT than sand culture. Similarly Ismail and Ahmed (1997) reported that plant growth and yield were better in NFT compared to sand culture grown plants in tomato. The highest yield was obtained from plant grown on Kingkong cultivar in winter season of NFT (2.4 Kg/plant). Tuzel *et al.* (2001) were also found higher yield in perlite peat (7.4 kg/plant). But we found sand culture was seemed to be simple and cheaper than the NFT system. The devices and techniques are used in this experiment for both water and sand cultures are found to be suitable for soilless culture of tomato in Bangladesh includes other countries in tropical Asia.

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