MINISTRY OF EDUCATION AND TRAINING
THAI NGUYEN UNIVERSITY

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RESEARCH OF TECHNOLOGY SOLUTIONS TO PRODUCE SOME KINDS OF OFF-SEASON LEAF VEGETABLES BY HYDROPONIC METHODS

Major: Crop science
Code: 62 62 01 10

SUMMARY OF DOCTOR-AGRICULTURE THESIS

Thai Nguyen - 2012

DISCLOSURE OF WORKS RELATING TO THE THESIS

1. Nguyen Minh Chung, Hoang Minh Chau, Nguyen Thi An and Tran Khac Thi (2010), "The results of modeling studies in farming leaf vegetables such as lettuce, broccoli, celery by using the circulating hydroponic technology (NFT) in a greenhouse ", *Journal of Agricultural Science and Technology of Vietnam*, No. 5 (18) / 2010, p. 52-56.

2. Tran Khac Thi, Nguyen Thi An, Hoang Minh Chau and Nguyen Minh Chung (2010), "Research and application of Circulating hydroponic technology to produce off-season leaf vegetable", *Journal of Agriculture and Rural Development*, March 2010, p. 93-99.

3. Nguyen Minh Chung, Tran Khac Thi, Nguyen Khac Thai Son, Hoang Minh Chau, and Nguyen Thi An (2009), "Research and valuation of supports to hold hydroponic crops for leaf vegetables", *Journal of Agriculture and rural Development*, No. 2, March 2012, p. 52-57.

INTRODUCTION

1. Urgency of the study

Vegetable is an indispensable source of food in daily life for human. Presently, vegetable production meet many difficulties along with polluted environment that makes no guarantee of vegetable quality, while demands of vegetable for life is increasing. To solve the problem of safe off-season vegetable and fruit, we have lots of ways wherein hydroponic technology is a good choice. However, the application of this technology to produce vegetables do still not bring out the desired results. Therefore, we carried out the study: ***"Research technology solutions to produce some off-season leaf vegetables by hydroponic methods".***

2**. The objective of the study:** Research the effect of the basic technical parameters on growth, yield and quality of some types of leaf vegetables that growth in off-season and propose the off-season production process of these vegetables by the circulating hydroponic method.

3. Scientific and practical significances of the study

3.1. Scientific significances: Provide the data to improve the process of the off-season leaf vegetable production by hydroponic method to add more vegetable production methods that meet the requirements of food hygiene and safety in climate conditions of The North of Vietnam. The findings of the thesis also add theories to the basic sciences such as plant physiology, plant biochemistry, mineral nutrient ...

3.2. Practical significances: Help manufacturers, companies who will produce actively vegetables in greenhouse by using hydroponic technology to meet the vegetable demands that ensure food safety for the local market and export market in the near future.

4. New findings of the study

- The study identified the platforms of vegetables, kinds of leaf vegetables, the nutrient solutions, the nutrient solution container that are suitable for planting off-season leaf vegetables in climatic conditions in the North of Vietnam.

- The study has proposed " The process of off-season safe vegetable production by using circulatinghydroponic technology".

5. Structure of the thesis

Beside parts of Introduction, Conclusion, Appendix, the thesis included 3 chapters with 103 pages, 5 conclusions and 2 proposals. The thesis has 33 tables, 9 graphs, 01diagrams and 112 references (53 documents in Vietnamese, 59 documents in foreign languages) and three published works related to the thesis.

Chapter I
OVERVIEW

Overview of the stady is analysed in 4 main contents, including:

1.1. SCIENTIFIC BASIS OF THE STUDY

Based on the role of water and minerals for plant, Scientists: Salm - Horstmar, Sachs and Knop ... experimented and found 16 basic elements for life of plant, from which they proved that the growth and developments of the plant do not depend on the growing medium with or without soil. Therefore, plant can be grown without soil, but only need to provide enough nutrition to it.

Also, vegetables have a role and a great value for human life, the production of vegetable, especially, safe vegetable meet the increasing demands of people, is an urgent requirements. The hydroponic techniques for growing vegetables is a solution contribute to solving this problem.

1.2. SITUATION OF PRODUCTION AND CONSUMPTI-ON OF VEGETABLES

The growing area, yield and production of vegetables increased continuously over the world and in Vietnam. Demand of vegetables is increasing also, according to FAO's data (2006), the consumption of vegetables and fruits increased 3.6%/year in the world. In Vietnam, many organizations and individuals have been studying, applying a variety of techniques for safe vegetable production combined the off-season vegetable production to increase efficiency, product's quality for export and consumption. In Wherein, there are many studies on hydroponic techniques. There are many built high-tech agricultural zones in many provinces and cities such as Hanoi city, Ho Chi Minh City, Hai Phong city, Lam Dong province...

1.3. OVERVIEW OF HYDOPONIC TECHNOLOGY

Hydroponic method is a cultivating form that plant is grown in a solution that proposed ago by scientists such as Knop, Kimusa, Boyle... Recently, many scientists researched, improved the technology, based on that from the growing system in the deep water solution to the system in the circulating deep water solution, thin nutrition film techniques and from the first nutrient solution made by Knop, nowaday, there are series of the used solutions such as FOA's solution, Imail solution, the solution made by Institute of Soils and Fertilizers, Fruit and Vegetable Research Institute ...

1.4. SITUATION OF RESEARCH AND APPLICATIONS OF HYDROPONIC TECHNOLOGY

The nutrient solution used in hydroponic techniques are studied along with the advent of hydroponic techniques. When it found 16 elements that are necessary for life of plant (C, H, O, N, P, K, Ca, Mg, S, Fe, Cu, Mn, Zn, Mo, B, Cl) many nutrient solutions used to fertilize plants in hydroponic techniques are made also.

The hydroponic technique has gone through many types of equipment for planting from it was born, such as: deep water planting system (Gericke system); floating hydroponic system; circulating deep water planting system; the nutrient film hydroponic system is a dynamic hydroponic system; nutrient mist system is a variation of hydroponic system.

In the hydroponic systems, diseases are being interested in research by many scientists such as Price and Fox, Stanghellini and Rasmussen, Schuerger and Hammer... they have considered the diseases on cucumber, tomato, pepper, leaf vegetables ...

In Vietnam, this technique may be taken into research and applications since 1993 by the collaboration between Hanoi National University and Hongkong R&D organizations. Recently, there have been many hydroponic researches and applications in agriculture, such as studies that have been implemented by Nguyen Thi Dan (1998), Thai Son and Nguyen Khac Nguyen Quang Thach (1999), Nguyen Quang Thach (1998), Ngo Thi Xuyen and Nguyen Van Dinh ... they produced and tested by theirselves the types of nutrient solutions, plants, improving the capacity of containers and platform for planting, application of this technique in seedling production, and research of pests in the hydroponic technique.

The authors such as Tran Khac Thi, Nguyen Minh Chung and their colleagues studied and applicated the circulating hydroponic technique in producing the off-season leaf vegetables in climate conditions of the North of Vietnam.

Chapter II
SUBJECTS, CONTENTS AND METHODS OF THE STUDY

2.1. Subjects, materials and scope of the study.

- Subjects of the study: Research some kinds of leaf vegetables, nutrient solutions, platform and solution pipes that used in planting vegetables in off-season by using hydroponictechnology.

- Scope of the study: Research only a number of technical measures in producing off-season leaf vegetables by hydroponic methods in climatic conditions of the North of Vietnam.

- Materials used in the study

+ The circulating hydroponic system: the improved hydroponic system of Fruits and Vegetables Research Institute.

+ Platform: Except the contents of the studies of the platforms (3 contents), the contents of other studies used the mixed platfrom: 50% of the platfrom made by Soils and Fertilizers Research Institute + 50% coconut fiber powder.

+ Nutrient solution: Except the contents of the studies of the nutrient solutions (2 contents), other contents studied by using nutrient solutions that made by Fruits and Vegetables Research Institute.

2.2. Location and *duration* of the study

- Location of the study: This study was implemented at Fruits and Vegetables Research Institute, Gia Lam, Hanoi, deploying the production model in Ba Chu cooperative, Van Noi commune, Dong Anh and Fruits and Hanoi Vegetables Research Institute; and this study is completed at Thai Nguyen University of Agriculture and Forestry.

- Dduration of the study: This study was implemented during the period from 2007 to 2010.

2.3. The contents of the study

The study includes 5 contents as follows:

2.3.1. Content 1: The study identified the appropriate types of leaf vegetables that can be planted in off-season by the circulating hydroponic technology.

2.3.2. Content 2: Determine some nutrient solutions that are suitable for planting some leaf vegetables by the hydroponic method.

2.3.3. Content 3: Determine some suitable platfroms that can keep plants when we plant some leaf vegetables by the hydroponic method.

2.3.4. Content 4: Research and choose the types of the solution pipes used in the circulating hydroponic system.

2.3.5. Content 5: Develop the trial models to produce some kinds of off-season leaf vegetables by using the hydroponic technology.

2.4. The methods used in the study

2.4.1. Experimental layout.

- Implement experiments to identify the transplant of plants, nutrient solutions, select the appropriate pipes that are suitable for using in Vietnam, the pipes are arranged serially in 2 rows, 4

replicates in the circulating hydroponic system.

- Implement experiments to determine the appropriate platform for the hydroponic vegetable production and they are arranged in type of randomized block with 04 replicates in the circulating hydroponic system.

- The area of plots: 5 m^2/cell. Area of the model is 150m^2. The plants are arranged in the diagonals with 5 points. Each cell has 5 plants.

Whole study includes 10 experiments as follows:

Experiment 1: Compare the off-season lettuces grown in the circulating hydroponic technology.

CT1: Da Lat transplant
CT2: Thailand transplant
CT3: China curly transplant
CT4: Rx 08834067
CT5: Lubsson transplant
CT6: Sweet GRM transplant
CT7: Vulcania transplant
CT8: Facestyle transplant
CT9: Flardria R2 transplant
CT10: Krintine Kz transplant
CT11: Muzai R2 transplant

Experiment 2: Compare the off-season Brassica integrifolia grown in the circulating hydroponic technology.

CT1: BM transplant
CT3: Tosakan transplant
CT2: CX1 transplant

Experiment 3: Compare the off-season celery grown in the circulating hydroponic technology.

CT1: Tropic transplant
CT2: Kyo transplant
CT3: BM 701 transplant

Experiment 4: Compare the off-season Ipomoea aquatica grown in the circulating hydroponic technology.

CT1: Seed Ipomoea aquatica variety.
CT2: White Ipomoea aquatica variety.
CT3: Violet Ipomoea aquatica variety.

Experiment 5: Determine the circulating hydroponic solutions that are appropriate for some leaf vegetables

- CT1 (Control experiment): The nutrient solution of Agricultural Biology Institute, Hanoi University of Agriculture.
- CT2: The nutrient solution of Fruits and Vegetables Institute, Gia Lam, Hanoi (VRQ 1).
- CT3: The nutrient solution of Fruits and Vegetables Institute, Gia Lam, Hanoi (VRQ 2).

Experiment 6: Determine the appropriate platform to hold broccoli.

Experiment 7: Determine the appropriate platform to hold lettuce.

Experiment 8: Determine the appropriate platform to hold celery.

Experiment 6, Experiment 7, Experiment 8 are implemented to compare 7 types of the platforms:

CT1: The platform of Soils and Fertilizers, (call the original platform).

CT2: fumigated husk chip platform.

CT3: coir powder platfrom.

CT4: 50% of the original platform+50% of fumigated husk.

CT5: 50% of the original platform + 50% of coir powder.

CT6: 50% of fumigated husk + 50% of coir powder.

CT7: 1/3 of the original platform + 1/3 of fumigated husk + 1/3 of coir powder.

Experiment 9: Determine the types of solution pipes that are suitable for lettuce.

Experiment 10: Determine the types of solution pipes that are suitable for broccoli.

Experiment 9, Experiment 10 are implemented to compare 3 types of the solution pipes as follow:

CT1: Rectangular plastic pipe, size 110mm x 70mm

CT2: Heat resistant round plastic pipe, Φ 110mm

CT3: PVC round plastic pipe, Φ 110mm

Model 1: Produce trially at Ba Chu Cooperative, Van Noi commune, Dong Anh, Hanoi. This model is implemented with 4 variety including broccoli, lettuce, "mo" cabbage, "chip" cabbage; the experiments conducted in a greenhouse, plastic roof; experimental period July-August, 2008.

Model 2: Produce at Fruits and Vegetable Research Institute, Gia Lam, Hanoi. This model is made with three varieties: broccoli, lettuce, celery, from May-October, 2010.

2.4.2. Norms and monitoring methods

Research and monitor the following norm groups: norm of growth and development, norms of quality vegetables, monitoring pests and diseases; all experiments have done in the greenhouse, fields; we sample, analyse in the laboratory and account economicaly.

2.4.3 Method of data processing: The data were statistically processed by IRRISTAT, Excel softwares and compared to Duncan.

Chapter III

RESULTS AND DISCUSSIONs

3.1. DETERMINATION OF APPROPRIATE THE LEAF VEGETABLES FOR PLANTING IN OFF-SEASON BY THE CIRCULATING HYDROPONIC TECHNOLOGY

3.1.1. Determine the lettuce variety that is suitable for planting in off-season by the circulating hydroponic technology

Table 3.2 shows: There are 7 similar good growth, large leaf size (Da Lat, China curly Variety, Rx 08834067, Sweet GRM, Facestyle, Flardria R2, Krintine Kz).

Table 3.2. Some norms of growth and yield of lettuce varieties grown in off-season by the circulating hydroponic technology

No.	Variety	Height of tree (cm)	Number of leaves/ Tree (leaf)	Canopy diameter (cm)	Length of leaf (cm)	Weight of trees (g)	Theorical Yield (quintal/1000m^2)
1	Da Lat	15.73 bc	13.82 e	19.80 f	16.12 b	78.82 c	17.02 e
2	Thailand	14.82 d	13.25 e	21.85 e	15.25 c	71.42 f	16.59 ef
3	China curly Variety	15.25 c	16.00 c	21.65 e	16.85 b	72.97 e	18.36 cd
4	Rx08834067	12.45 i	16.53 c	26.51 a	16.50 b	71.07 f	20.20 c
5	Lubsson	12.9 f	13.78 e	21.61 e	11.63 f	72.19 e	19.01 d
6	Sweet GRM	22.68 a	17.33 b	17.79 g	20.20 a	86.86 b	23.15 b
7	Vulcania	13.48 e	16.44 c	25.63 b	15.43 c	79.38 c	21.53 c
8	Facestyle	15.40 c	15.41 d	22.68 d	16.03 bc	77.05 d	21.71 c
9	Flardria R_2	14.63 d	19.53 a	25.29 b	16.03 bc	179.86 a	48.64 a
10	Krintine Kz	15.85 b	13.73 e	22.75 c	16.06 bc	76.81 de	24.26 b
11	Muzai R_2	12.13 k	12.53 f	22.71cd	15.63 c	56.05 i	17.22 e
	CV%	1.0	1.5	1.2	2.3	0.8	0.8
	LSD					0.89	0.89

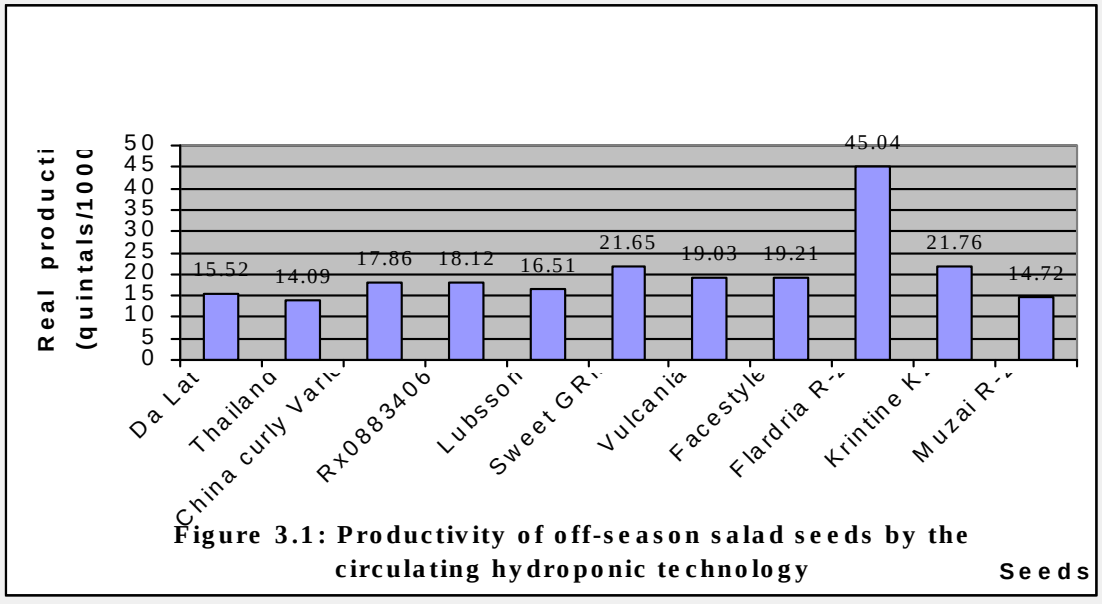

Figure 3.1: Productivity of off-season salad seeds by the circulating hydroponic technology

Figure 3.1 shows: There are six lettuce varieties for high yield from 17.86 quintal/1000m^2 to 21.65 quintal/1000m^2 (China curly vảiety, Rx 08,834,067, Sweet GRM, Vulcania, Krintine Facestyle and KZ). Particularly, Flardria R2 has 45.04 quintal/1000m^2 yield.

3.1.2. Determine the broccoli variety that is suitable for planting in off-season by the circulating hydroponic technology

Bảng 3.4. Some norms of growth and yield of broccoli varieties grown in off-season by the circulating hydroponic technology

No.	Variety	Height of tree (cm)	Number of leaves/ Tree (leaf)	Weight of trees (g)	Theorical Yield (quintal/1000 m^2)
1	BM	31,50 b	11,33 a	157,66 a	27,95 a
2	CX1	29,67 c	9,67 b	128,67 c	23,04 c
3	Tosakan	32,83 a	11,06 a	138,67 b	25,91 b
	F test	36,40**	11,76**	104,40**	28,04**
	CV%	1,6	4,7	2,9	1,6

Table 3.4 and Figure 3.2 shows: Toosakan variety has height of tree of 32.83 cm, higher than CX1 and BM, but BM is the equivalent of more varieties and CX1. The actual capacity of BM and Tosakan are similar (24.40 and 23.84 quintal/1000m^2), they are higher than that CX1 can be achieved (18.75 quintal/1000m^2).

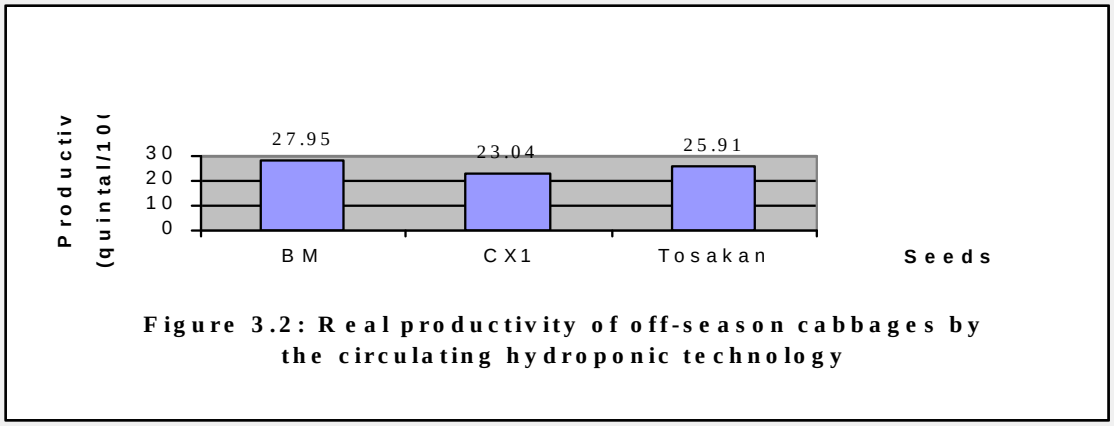

Figure 3.2: Real productivity of off-season cabbages by the circulating hydroponic technology

3.1.3. Determine the Celery variety that is suitable for planting in off-season by the circulating hydroponic technology

Table 3.6 and Figure 3.3 shows that: Tropic and BM701: at harvested time, the height of tree reached 42.6 cm, the height of BM701tree reached 42.5 cm, number of leaves/plant of it reached 9.7 leaves (same Tropic) and 9.5 leaves (BM701); the yield reached 46.24 quintal/1000m^2 (Tropic) and 46.46 quintal/1000m^2(BM701), and their yield is higher Kyo yield according to statistic data.

Table 3.6. Some norms of growth and yield of celery varieties grown in off-season by the circulating hydroponic technology

Variety	Growth				Yield	
	15 days after putting in the hydroponic system		30 days after putting in the hydroponic system		Weight of trees (g)	Theorical Yield (quintal/1000 m^2)
	Height of tree (cm)	Number of leaves/ Tree (leaf)	Height of tree (cm)	Number of leaves/ Tree (leaf)		
Tropic	25,5	6,4	42,6	9,7	81,4	64,53
Kyo	23,7	6,2	40,4	8,5	77,5	59,66
BM 701	25,8	6,5	42,5	9,5	80,8	64,07

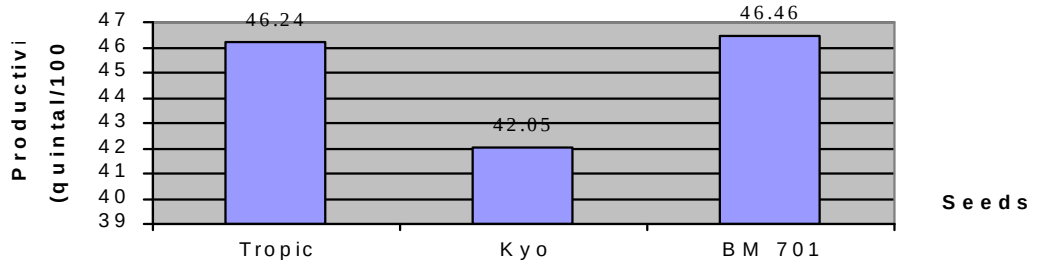

Figure 3.3: Productivity of off-season celery seeds by the circulating hydroponic system

3.1.4. Determine the Ipomoea aquatica variety that is suitable for planting in off-season by the circulating hydroponic technology.

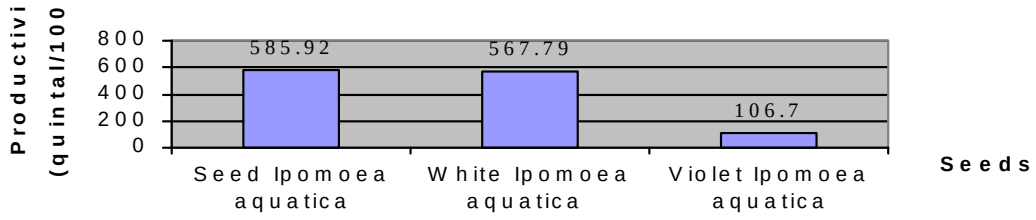

Figure 3.4: Total productivity of off-season Ipomoea aquatica varieties by the circulating hydroponic technology

Figure 3.4 shows: The highest total yield of seed Ipomoea aquatica is 585.92 quintal/1000m2 after that the total yield of the white Ipomoea aquatica is middle and total the total yield of violet Ipomoea aquatica is lowest with 106.7 quintal/1000m^2 only.

3.1.5. The quality and level of food hygiene and safety of lettuce and broccoli varieties that grown off-season in circulating hydroponic system.

Table 3.10 shows that for lettuces, the dry matter content is from 5.2% to 7.81%. total sugar content is from 0.9% to 1.44%. The highest VTMC is 2.58 mg/100g and the lowest VTMC is 1.62 mg/100g. For broccoli, dry matter content is from 7.75% to 8.22%. Total highest sugar content is Tosakan with 3.53%, total lowest sugar content is CX1 with 3.24%. The highest VTMC is Tosakan with 3.98 mg/100g and the lowest VTMC is CX1 with 3.86 mg/100g.

Table 3.10. Some norms of quality of lettuce and green vegetabe varieties grown in the circulating hydroponic system

Vegetables	**Name of varieties**	**Dry matters (%)**	**VTM C (Mg/100g)**	**Total sugar content (%)**
Lettuces	RX 08834067	5.2	2.26	1.44
	Lubsson	5.8	1.62	1.12
	Sweet GRM	5.95	2.00	1.13
	Vulcania	6.74	1.94	1.25
	Facestyle	5.6	1.67	1.02
	Flardria R_2	5.08	2.58	0.9
	Krintine Kz	***7.81***	***2.26***	***1.43***
	Muzai R_2	6.85	2.58	1.24
Broccoli	BM	7.75	3.88	3.43
	CX1	**8.22**	**3.86**	**3.24**
	Tosakan	8.12	3.98	3.53

Table 3.11. Contents of NO_3 and some heavy metals in lettuce and green vegetable varieties grown in the circulating hydroponic system

Type	Name of sample	NO_3 (mg/kg)		Pb (mg/kg)		Cd (mg/kg)	
		In vegetable	Maximum allowed Limit	In vegetable	Maximum allowed Limit	In vegetable	Maximum allowed Limit
Lettuce	RX 08834067	250	1500	0.041	1,0	0.003	0,1
	Lubsson	272		0.035		0.002	
	Sweet GRM	389		0.019		0.006	
	Vulcania	298		0.05		0.007	
	Facestyle	356		0.046		0.008	
	Flardria R_2	320		0.018		0.009	
	Krintine Kz	265		0.044		0.004	
	Muzai R_2	243		0.044		0.008	
Broccoli	CX1	392	1500	0.0485	1,0	0.004	0,2
	BM	357		0.0485		0.005	
	Tosakan	277		0.0484		0.005	

The results in the table 3.11 shows that residue of nitrate, lead and cadmium is very far below Maximum allowed Limit.

3.2. DETERMINE THE TYPE OF NUTRIENT SOLUTIONS THAT ARE SUITABLE FOR GROWING SOME LEAF VEGETABLES IN THE HYDROPONIC SYSTEM.

3.2.1. Effects of type of nutrient solutions to the growth of off-season vegetables grown in the circulating hydroponic technology

Table 3.12. Effect of the nutrient solution to height and number of leaves of off- season vegetables grown by the circulating hydroponic technology

Farming season	Type of nutrient solutions	10 (15) days after putting in the hydroponic system						20 (30) days after putting in the hydroponic system					
		Height of tree (cm)			Number of leaves/ Tree (leaf)			Height of tree (cm)			Number of leaves /Tree (leaf)		
		Lettuce	Broccoli	calery	Lettuce	Broccoli	calery	Lettuce	Broccoli	calery	Lettuce	Broccoli	calery
8-9/ 2007	CT1(đ/c)	13.5	16.5	23.5	7.5	7.7	6.4	24.1	36.2	43.7	15.0	13.9	8.6
	CT2	13.5	16.3	22.5	7.8	8.0	5.9	24.5	36.0	44.4	15.4	13.5	8.8
	CT3	11.5	14.5	21.0	6.5	6.8	5.3	21.4	31.5	40.2	13.9	12.7	7.7

Table 3.12, 3.13 shows that: for CT2, lettuce, broccoli and celery are well grown equivalent to control (CT1) and higher than CT3. For CT3, Ipomoea aquatica growth is better than in CT1 and CT2 at all of monitoring case.

Table 3.13. Effect of the nutrient solution to height of off- season Ipomoea aquatica grown by the circulating hydroponic technology (cm)

Nutrient solution	After putting in Nutrient solution							
	7 days	14 days	21 days	28 days	35 days	43 days	50 days	57 days
CT1 (Đ/c)	25.6	24.7	23.7	22.8	23.6	24.7	25.7	20.7
CT2	25.5	26.8	26.0	26.5	27.4	25.3	24.8	22.0
CT3	28.8	29.5	28.6	28.5	30.7	36.2	36.5	30.4

3.2.2. Effect of the nutrient solution to yield of off- season Ipomoea aquatica grown by the circulating hydroponic technology.

The results in the table 3.14 and the table 3.15 show that: for CT2, lettuce, broccoli and celery harvest equivalent to control (CT1) and higher in CT 3. For CT 3, the yield of Ipomoea aquatica reached 40.06 to 63.52 quintal/1000m2 – it is higher than in the control and in CT 1, CT 2 (at all harvests).

Table 3.14. Effect of the nutrient solution to yield of off- season vegetables grown by the circulating hydroponic technology

Farming season	Type of nutrient solutions	Weight of tree (g)			Theorical yield (quintal/1000m^2)			Actual yield (quintal/1000m^2)		
		Lettuce	Broccoli	calery	Lettuce	Broccoli	calery	Lettuce	Broccoli	calery
2007	CT1 (Đ/c)	55.3	59.5	71.5	39.82	42.84	51.48	35.46 a	38.52 a	46.25 a
	CT2	57.8	58.7	71.7	41.62	42.26	51.62	35.28 a	38.94 a	46.06 a
	CT3	52.5	49.5	58.2	37.80	35.64	49.10	30.16 b	31.06 b	43.53 b
	Ftest	-	-	-	-	-	-	21.21**	54.17**	31.90**
	CV%	-	-	-	-	-	-	1.2	1.1	1.2

Table 3.15. Effect of the nutrient solution to yield
of off- season Ipomoea aquatica grown by the circulating hydroponic technology

Studied time	Type of nutrient solutions	Litter 1		Litter 2		Litter 3		Litter 4	
		Weight of tree (g)	Actual yield (quintal /1000m^2)	Weight of tree (g)	Actual yield (quintal /1000m^2)	Weight of tree (g)	Actual yield (quintal /1000m^2)	Weight of tree (g)	Actual yield (quintal /1000m^2)
10/07-3/08	CT1 (đ/c)	82.6	28.75 c	84.6	29.46 c	87.5	30.78 c	82.7	27.79 c
	CT2	110.6	37.78 b	116.5	35.56 b	126.2	36.33 b	136.5	38.38 b
	CT3	144.8	48.58 a	175.2	61.25 a	182.3	62.04 a	193.9	62.58 a
	Ftest	-	***	-	***	-	***	-	***
	CV%	-	0.9	-	1.0	-	1.0	-	1.1
Studied time	**Type of nutrient solutions**	**Litter 5**		**Litter 6**		**Litter 7**		**Litter 8**	
		Weight of tree (g)	Actual yield (quintal /1000m^2)	Weight of tree (g)	Actual yield (quintal /1000m^2)	Weight of tree (g)	Actual yield (quintal /1000m^2)	Weight of tree (g)	Actual yield (quintal /1000m^2)
10/07-3/08	CT1 (đ/c)	89.6	32.78 c	88.7	28.75 c	88.5	29.46 c	82.0	25.73 c
	CT2	126.5	34.33 b	136.5	39.34 b	130.8	38.58 b	123.6	30.78 b
	CT3	192.1	62.84 a	200.5	63.52 a	171.7	50.06 a	164.8	44.56 a
	Ftest	-	***	-	***	-	***	-	***
	CV%	-	1.0	-	0.9	-	1.2	-	1.4

3.2.3. Effects of type of nutrient solutions to the nitrate and heavy metal contents in lettuce, broccoli grown in the circulating hydroponic technology

Table 3.16 shows: three types of nutrient solutions into trials give us the vegetable products that meet food safety due to contents of nitrates and heavy metals are far below the allowed threshold.

Table 3.16. Effects of type of nutrient solutions to the nitrate and heavy metal contents in lettuce, broccoli grown in the circulating hydroponic technolog

Type of vegetable	Type of nutrient solutions	NO_3 (mg/kg fresh)		Pb (mg/kg fresh)		Cd (mg/kg fresh)	
		In vegetable	Maximum allowed Limit (TCVN)	In vegetable	Maximum allowed Limit (TCVN)	In vegetable	Maximum allowed Limit (TCVN)
Lettuce	CT1(ĐHNNI)	292	**1500**	0.051	**1,0**	0.007	**0,1**
	CT2 (VRQ1)	343		0.053		0.005	
	CT3 (VRQ2)	268		0.028		0.009	
Broccoli	CT1(ĐHNNI)	323	**1500**	0.058	**1,0**	0.008	**0,2**
	CT2 (VRQ1)	285		0.048		0.005	
	CT3 (VRQ2)	286		0.045		0.004	

3.3. DETERMINE THE TYPE OF PLATFORM THAT ARE SUITABLE FOR GROWING SOME LEAF VEGETABLES IN THE HYDROPONIC SYSTEM

3.3.1. Effects of the type of platform to growth, development, productivity and quality of off-season green cabbage by the circulating hydroponic technology

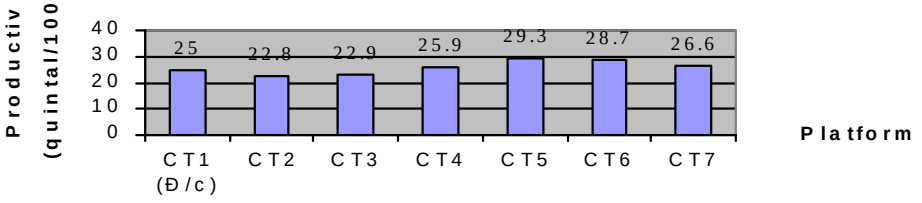

Figure 3.5: Effects of the type of platform to productivity of off-season green cabbage by the circulating hydroponic technology

Figure 3.5 shows: in formula 5 and formula 6, the vegetables grow and develop well. Productivity of the green cabbage in experiment formulas is clearly different. Formula 5 shows highest productivity as 29.3 quintals/1000m2, equivalent to the formula 6 with 28.7 quintals/1000m2. The lowest as formula 2 (22.8 quintals/1000m^2 equivalent to formula 3 (22.9 quintals/1000m^2).

Table 3.18: Accumulation ability of dry substance in formula 5 (50% original platform +50% coconut fiber) gains 12.09% as highest, total sugar contents reach 2.35% and Vitamin C content achieves 2.45mg/100g). NO_3 content and heavy metal are all under the permitted limit.

Table 3.18: Effects of the type of platform to quality of off-season green cabbage by the circulating hydroponic technology

Indicator / Type of platform	Total sugar (%)	Dry substance (%)	VTMC (mg/100g)	NO_3^- (mg/100g)	Pb (mg/100g)	Cd (mg/100g)
CT1 (Đ/c)	2.00	10.51	2.00	456	0.044	0.006
CT2	1.53	9.37	1.53	444	0.047	0.008
CT3	1.75	11.82	1.75	432	0.044	0.007
CT4	1.85	11.44	1.85	420	0.053	0.009
CT5	2.35	12.09	2.45	425	0.06	0.006
CT6	1.74	11.61	1.79	384	0.063	0.004
CT7	2.45	11.69	2.35	432	0.060	0.007

3.3.2. Effects of the type of platform to growth, development, productivity and quality of off-season salad by the circulating hydroponic technology

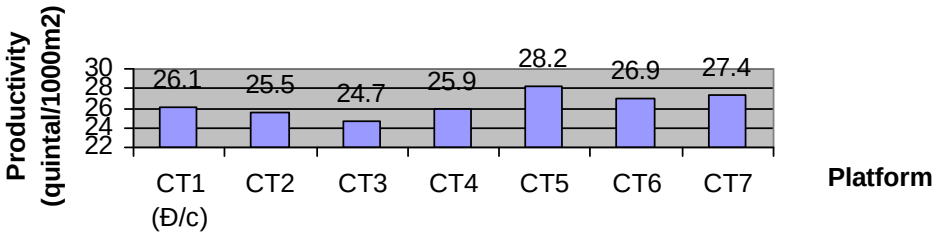

Figure 3.6: Effects of the type of platform to productivity off-season salad by the circulating hydroponic technology

Figure 3.6 shows: formula 5, highest productivity of salad reaches 28,2 quintals/1000m^2. The lowest is formula 3, 24.7 quintals/1000m^2.

Table 3.20: Effects of the type of platform to quality indicators of off-season salad by the circulating hydroponic technology

Indicator / Type of platform	Total sugar (%)	Dry substance (%)	VTMC (mg/100g)	NO_3- (mg/100g)	Pb (mg/100g)	Cd (mg/100g)
CT1 (Đ/c)	2.20	7.71	2.42	316	0.046	0.006
CT2	2.75	7.62	3.23	312	0.057	0.008
CT3	2.70	8.07	2.70	427	0.070	0.060
CT4	2.41	7.23	2.41	416	0.043	0.050
CT5	2.13	8.84	2.65	412	0.042	0.009
CT6	2.05	7.33	2.05	420	0.067	0.030
CT7	2.65	7.99	2.13	414	0.005	0.040

Table 3.20: Formula 2, salad has total sugar content of highest (2.75%), next formula 3, 2.70% and formula 7, 2.65%. Total Vitamin C content in formula 2 reaches the highest content as 3.23mg/100g, second as formula 3, 2.70mg/100g, third as formula 5, 2.65 mg/100g. Rate of dry substance in formula 5 reaches the highest content as 8.84% , next formula 3, 8.07%. Redundance of Nitrat and heavy metal in formulas engaged in the experiment are much under the permitted limit.

3.3.3. ***Effects of the type of platform to growth, development, productivity and quality of off-season celery by the circulating hydroponic technology***

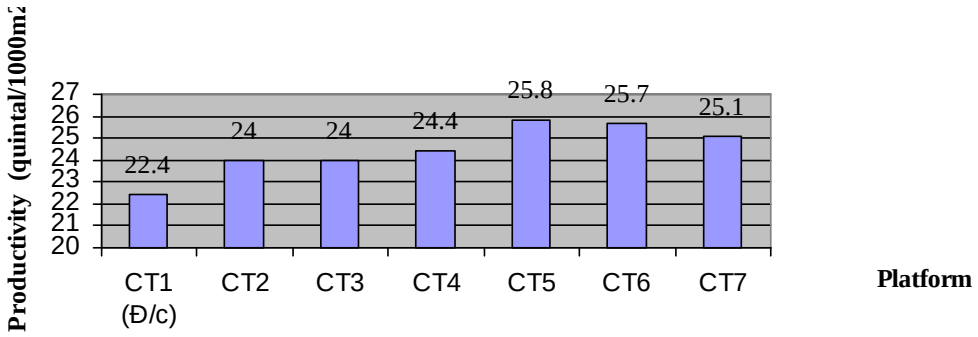

Figure 3.7 : Effects of the type of platform to productivity of off-season celery by the circulating hydroponic technology

Figure 3.7 shows: productivity in formula 5 reaches the highest as 25.8 quintals/1000m^2 , next as formula 6, 25.7 quintals/ 1000m^2, the lowest as formula 1 (đ/c), 22.4 quintals/1000m^2.

Table 3.22: Effects of the type of platform to quality of off-season celery by the circulating hydroponic technology

Indicator / Type of platform	Total sugar (%)	Dry substance (%)	VTMC (mg/100g)	NO_3^- (mg/100g)	Pb (mg/100g)	Cd (mg/100g)
CT1 (Đ/c)	0.9	7.5	132	430	0.060	0.005
CT2	0.8	7.5	124	315	0.062	0.065
CT3	0.6	5.7	135	421	0.005	0.045
CT4	0.9	7.2	120	453	0.054	0.067
CT5	1.0	7.5	142	376	0.050	0.078
CT6	0.9	7.1	136	428	0.040	0.062
CT7	0.6	5.3	122	432	0.005	0.056

Vitamin C contents in celery is relatively high and there is differences among experimental formulas; highest as formula 5 reaches 142mg/100g, then formula 6, 136 mg/100g and lowest as formula 4, 120mg/100g. Redundance of Nitrat and heavy metal in formulas engaged in the experiment are much under the permitted limit.

3.4. SELECTION OF SUITABLE TYPE OF SOLUTION CONDUIT FOR GROWING VEGETABLES BY THE CIRCULATING HYDROPONIC TECHNOLOGY

3.4.1. Effects of type of solution conduits to growth, development and productivity of salad

Table 3.23: Effects of type of solution conduits to productivity of salad

No.	Formula	Weight (g)		Theorical productivity (quintal/1000m^2)		Real productivity (quintal/1000m^2)	
		Season 1	Season 2	**Season 1**	Season 2	**Season 1**	Season 2
1	CT1	**61.5**	53.6	**41.84**	38.68	**34.88 a**	29.79 a
2	CT2	**63.2**	51.2	**43.02**	36.93	**34.34 a**	28.06 b
3	CT3	**58.6**	51.6	**39.87**	37.25	**33.41 b**	28.13 b
	Ftest	-	-	-	-	17.45**	19.58**
	CV%	-	-	-	-	**8.5**	1.5

Table 3.23 shows: Season 1: Formula 1 and formula 2 five productivity of 34.3 quintals. Productivity in formula 3 reaches 33.4 quintals- not much lower than formula 1 and formula 2 (0.9 quintals). Season 2: Productivity in formula 1 gains 29.7 quintals – higher than formula 2 (1.7 quintals) and formula 3 (1.6 quintals). Formula 2 and formula 3 give equivalent productivity.

3.4.1.3. Economic efficiency of salad grown in solution conduits

Table 3.24. Economic efficiency of salad grown in solution conduits

Reseached season	Type of solution conduits	Productivity / quintals /1000m2 /season	Selling price (thousand dong/kg)	Total receipts /1000 m2/season (thousand dong)	Tool depreciation /1000m2/season (thousand dong)	Expenses for sedes, solution, workman labor/1000m2 /veason (thousand dong)	Profit/ season (thousand dong /1000m2)
Season 1	CT1	34.88	7	24.010	8.250	4.120	11.640
	CT2	34.34	7	24.010	5.500	4.120	14.390
	CT3	33.41	7	23.380	4.250	4.120	15.010
Season 2	CT1	29.79	7	20.790	8.250	4.120	8.420
	CT2	28.06	7	19.600	5.500	4.120	9.980
	CT3	28.13	7	19.670	4.250	4.120	11.300

Table 3.24 shows : Formula 1 gives high productivity, but because of costly expenses for conduits, so economic efficiency is the lowest among conduit formulas in two trial seasons : profit 11640,000 dong (Season 1) and 8,420,000 dong (Season 2). Productivity in formula 3 is lower, but cheaper price of plastic pipes, so economic efficiency is higher than formula 1 and formula 2. In both two trial seasons : 15,010,000 dong (Season 1) and 11,300,000 dong (season 2).

3.4.2. Effects of type of solution conduits to growth, development and productivity of green cabbage

Bảng 3.26. Effects of type of solution conduits to quanity and productivity of green cabbage

Type of solution conduits	**Weight (g)**		**Theorical productivity (quintal/1000m^2)**		**Real productivity (quintal/1000m^2)**	
	Season 1	Season 2	**Season 1**	Season 2	**Season 1**	Season 2
Regtangle	**45.5**	44.6	**32.86**	32.15	**29.75 a**	25.97 a
Heatproof round	**46.0**	43.5	**33.13**	30.34	**29.58 a**	23.86 b
Normal round	**40.2**	39.0	**28.95**	28.17	**26.13 b**	22.44 bc
Ftest	-	-	-	-	66.7**	62.5**
CV%	-	-	-	-	1.8	1.9

Table 3.26 shows: Season 1: Formula 1 and formula 2 give equivalent productivity: 29.7 quintals and 29.5 quintals. Productivity in formula 3 is lower than formula 1 and 2, but not much 3.6 quintals and 3.4 quintals. Season 2: Formula 1 gives the highest productivity, higher than formula 2 and 3: 2.1 quintals and 3.5 quintals. Formula 3 gives the lowest productivity, lower than formula 2.

Table 3.27. Economic efficiency of green cabbage grown in solution consuits.

Resea-ched season	**Type of solution conduits**	**Productivity/ quintals /1000m2 /season**	**Selling price (thousand dong/kg)**	**Total receipts /1000m2 /season (thousand dong)**	**Tool depreciation /1000m2 /season (thousand dong)**	**Expenses for sedes, solution, workman labor/1000m2 /veason (thousand dong)**	**Profit/ season (thousand dong /1000m2)**
Season 1	CT1	29.7	5	14.850	6.600	4.120	4.230
	CT2	29.5	5	14.750	4.400	4.120	6.330
	CT3	26.1	5	13.050	3.400	4.120	5.630
Season 2	CT1	25.9	5	12.950	6.600	4.120	2.330
	CT2	23.8	5	11.900	4.400	4.120	3.480
	CT3	22.4	5	11.200	3.400	4.120	3.780

Table 3.27 shows : Formula 1 gives high productivity in both two seasons, but costly expenses for conduits, so economic efficiency is low. Formula 3 with cheap plastic pipes, so economic efficiency is higher than formula 1 and equivalent to formula 2 : profit 5,630,000 dong (season 1) and 3,780,000 dong (season 2). Formula 2 gives economic efficiency equivalent to formula 3, but heatproof plastic pipes is not available in the market.

3.5. BUILD TRIAL PRODUCTION MODEL OF SOME TYPE OF OFF-SEASON LEAF VEGETABLE BY THE CIRCULATING HYDROPONIC TECHNOLOGY

3.5.1. The results of trial modeling to produce off-season leaf vegetables by the circulating hydroponic technology at Ba Chu Cooperative, Van Noi commune, Dong Anh, Hanoi.

Table 29.3 shows: the yield of lettuce reached 17.90 quintal/1000m^2; the yield of vegetables reached 22.80 to 24.20 quintal/1000m^2, it is higher from 1.3 to 1.4 times than it planted on soil in greenhouse. Economic efficiency is not much difference compared to produce on soil: lettuce, broccoli and “Mo” cabbage give profit higher 420,000 - 980,000 VND/1000m2/harvest than when they planted on soil. “Chip” cabbage grown in the circulating hydroponic system give us the profit equivalent to when it grown on soil.

Table 3.29. The results of trial modeling to produce off-season leaf vegetables by the circulating hydroponic technology at Ba Chu Cooperative, Van Noi commune, Dong Anh, Hanoi

Vegetables	Yield (quintal /harvest/1000m^2)		Price (1000VND/kg)	Total (VND/harvest /1000m^2)		Cost (VND/harvest /1000m^2)		Lãi (VND/harvest /1000m^2)		Diffe-rence
	Hydroponics	On soil		Hydroponics	On soil	Hydroponics	On soil	Hydroponics	On soil	
Lettuce	**17.90**	14.20	12	**21.480**	17.040	**7.970**	3.950	**13.510**	13.090	**420**
Broccoli	**24.20**	17.70	7	**16.940**	12.390	**7.520**	3.950	**9.420**	8.440	**980**
"Mo" cabbage	**22.90**	16.80	7	**16.030**	11.760	**7.520**	3.950	**8.510**	7.810	**700**
"Chip" cabbage	**22.80**	17.80	7	**15.960**	12.460	**7.520**	3.950	**8.440**	8.510	**-70**
Total	**87.80**	**66.50**		**70.410**	**53.650**	**30.530**	**15.800**	**39.880**	**37.850**	**2.030**

3.5.2. The results of modeling to produce off-season leaf vegetable by the circulating hydroponic technology at Fruits and Vegetables Research Institute, Gia Lam, Hanoi

Table 3.31. The components of the yield and the yield of vegetables in a production model used the circulating hydroponic technology in Fruits and Vegetables Research Institute

Norms / Vegetable	Height of tree (cm)	Number of leaves (leaf)	Canopy diameter (cm)	Weight of tree (g/tree)	Theorical yield (quintal /1000m^2)	Actual yield (quintal /1000m^2)
Broccoli	32.5	11.2	27.5	82.4	32.9	28.2
lettuce	28.6	11.5	28.3	80.5	28.2	26.3
celery	30.2	12.4	25.7	90.3	31.6	27.7

Table 3.31: the actual yield of broccoli reached 28.2 quintals; the actual yield of lettuce reached 26.3 quintals; the actual yield of celery reached 27.7 quintals.

Table 3.33. Economic efficiency of the vegetables in a production model with the circulating hydroponic technology at Fruits and Vegetables Research Institute

Norms / Vegetable	Yield (quintal /1000m^2)	Cost (1000 VND)					Price (1000 VND /kg)	Total (1000 VND /kg)	Profit (1000 VND)
		Plat-form	Solu-tion	Deprec-iation	Seed	Ele-ctric			
Broccoli	28.2	5000	2000	5000	100	450	6	16.920	4.370
lettuce	26.3	5000	2000	5000	200	450	8	21.040	8.390
celery	27.7	5000	2000	5000	750	450	10	27.700	14.500

Table 3:33. The profit of Broccoli is 4.37 million VND /harvest; The profit of lettuce is 8.39 million VND/ harvest; The profit of celery is 14.5 million VND/harvest

3.5.3. Pest situation of off-season leaf vegetables grown in the circulating hydroponic system

Vegetables grown in the circulating hydroponic system in a greenhouse are isolated with insect, the rate of disease and pests on the crops are 0. ***Thus it can be stated that the off-season vegetables in the circulating hydroponic technology are isolated with insect pests to ensure clean, not to use pesticides.***

3.6. The process of the off-season leaf vegetable production in the circulating hydroponic technology

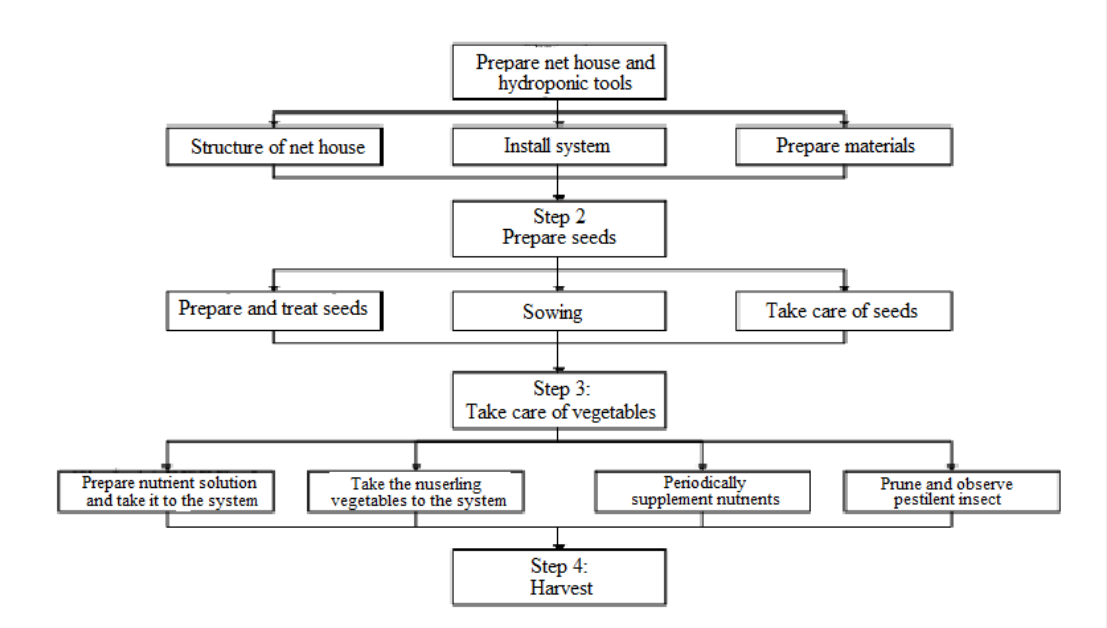

Figure 3.7. Flow chart of leaf vegetables production by using the circulating hydroponic technology

CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

1.1. Vegetable variety that are suitable to plant in off-season by the circulating hydroponic solutions including: six lettuce variety: curly lettuce, China, Rx08834067, Sweet GRM, Vulcania, Facestyle and Krintine KZ. Two broccoli variety: BM and Tosakan. Two variety of celery: BM 701 and Tropic. The two Ipomoea aquatica variety: seed Ipomoea aquatica, white Ipomoea aquatica. The leaf vegetables are grown in off-season by the circulating hydroponic technology that meets the standards of food hygiene and safety.

1.2. Nutrient solution made by Hanoi University of Agriculture, VRQ1 nutrient solution made by Fruit and Vegetable Research Institute, these solutions are suitable for production of lettuces, vegetables. VRQ2 nutrient solution is suitable for production of Ipomoea aquatica. All three of the nutrient solutions are suitable for production of celery and they ensure all levels of lead, cadmium and nitrate away from the permitted threshold.

1.3. The type of solution pipe used in the circulating hydroponic system is suitable to conditions in Vietnam, diameter of normal plastic pipe is 11cm.

1.4. The platform in producing the leaf vegetables by the circulating hydroponic technology in the off-season conditions, the used platforms are the mixed platforms including 50% coir chips + 50% orignal platform and 50% fumigated husk chips + 50% coir chips.

1.5. The model of safe off-season vegetable production used the circulating hydroponic technology with the capacity increased by 20% compared with the production on soil in a greenhouse, the leaf vegetables meet the requirements of food safety.

2. Recommendations

2.1. Deploy the model and apply the research results in production facilities; areas where there are not enough soil to culture or polluted soil areas.

2.2. We need to research on the contents of nutrient solutions, adjustments of pH and EC of the nutrient solutions in each stage of growth and development of each vegetable. At the same time, we apply the study in the production of other vegetables that meet the requirements of food hygiene and safety.