HORTIN II Co Innovation Programme

Towards cost effective, high quality value chains

Influence of substrate, tray choice and variety on transplant raising and yield of hot pepper

HORTIN-II Research Report nr. 6

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The purpose of the HORTIN-II programme is to contribute to the development of cost effective high quality value chains for vegetables and fruits. Among others this can be achieved when technology development takes place in close collaboration between public institutions, farmers and private companies.

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Executive summary

From August till December 2007 an experiment was carried out to test the effect of variety and transplant raising on the seedling quality and yield of hot pepper as compared to direct sowing. The location of the experiment was situated at Kersana Brebes in Central Java.
The hybrid variety Astina and the open pollinated variety Tit Segitiga were tested. Transplants were raised in simple nursery constructions either in individual plastic bags or in modular trays with 128 cells. Used media for the containers was either a mixture of top soil with manure, top soil with rice husk, manure with rice husk and top soil with both manure and rice husk. Observations took place on emergence and seedling quality defined as plant length, fresh weight, number of leaves and dry weight.
Transplants of the best performing nursery treatments were transplanted in the field. Yield was compared with the yield present at direct sowing.
Astina showed a slightly better emergence and better seedling quality as compared to Tit Segitiga.
In general the media mixture of manure with top soil resulted in better emergence and seedling quality. When using plastic bags a better emergence and better seedling quality was present. However, a higher virus incidence was observed at the seedlings raised in plastic bags.
Yield levels of transplants were not distinctive more then with direct sowing. Transplants raised in plastic bags filled with manure and top soil did tended to show higher yields. In terms of yield, transplants raised in plastic bags showed higher yields then transplants raised in plastic trays.

1 Introduction

Hot pepper is an important and essential component in the Indonesian diet. It is mainly consumed in fresh semi crushed form, locally known as “sambal”. Hot pepper could also be categorized as an important commercial crop, since it is grown year-round. Despite the importance of hot pepper and its product in the Indonesian diet and their role in generating income for farmers and other stakeholders in the food chain, the industry is still facing bottlenecks that need further attention to be solved. In general, some bottlenecks identified during an inception workshop held in 2006 were: (a) Unavailability of a less costly and low input-demanding improved open pollinated varieties that have high yield potential and desired attributes, (b) Low quality of hot pepper for processing that leads to higher dependence to imported raw materials, (c) Relatively low productivity and high production cost that lead to export prices of hot pepper remained higher than the import prices (becoming uncompetitive in the international market), (d) Considering insects and diseases as the number one constraint in hot pepper production, no appropriate, safe, and low-risk control method available yet, that can assure farmers to stop the excessive use of pesticides, (e) Lack of post-harvest and processing activities at the farm-level that reduce farmer capacity of holding output for a longer period. Hence, it reduces farmers share in the retail price of hot pepper and weaken their bargaining power, and (f) Lack of collaboration along the market chain, among different stakeholders, that hinders the effort to increase efficiency in the market chain and to enhance the value of the products and services generated along a market chain. Moreover, stakeholder group-discussion during the workshop has agreed to narrow down the bottlenecks and suggested low yield of hot pepper as the root problem. Even though some high-yielding varieties, mostly hybrids (20-30 t/ha) are already available in the market, their use in some production centers is still low. In the mean time, farmers’ preference to use their own saved-seed and the practice of direct seeding may also aggravate the problem, because they frequently use low quality planting material. Based on this identification process, experiments are carried out with the objectives of improving hot pepper planting material through nursery seedling raising and introducing alternatives hot pepper varieties and promising lines that have high yield potential and desired attributes.

1.1 Acknowledgements

The research was done in close cooperation with farmers in Brebes. PT EWINDO supplied materials for the nursery construction and seeds of the hybrid hot pepper variety Gada F_1. Besides material inputs, EWINDO offered valuable advice on hot pepper cultivation. PT Syngenta also assisted the research by supplying pesticides and advice on pest control.

Special thanks are due to Uka and Arifin. They played an important role in carrying out the field work and in performing the observations.

2 Materials and Methods

The experiment was conducted at the Kersana Village, Kersana Sub-district, Brebes District, Central Java from July 2007 until December 2007 (Fig. 1). Brebes is located on the northern coast of Java adjacent to the Java Sea at 7° S and 109° E. The climate can be classified as a humid tropical lowland climate with clear distinguished dry and wet seasons. Soil type can be characterized as a fluvisol with 70% clay.

Figure 1. Location of the hot pepper cultivation area where the experiment took place.

For the experiment a field was rented from farmers and the nurseries were constructed at the entrance of the field while the production fields were located behind the nurseries (Fig. 2). In 2007 on August 10th, three soil samples were taken from the experimental site. The site was divided in three equal sized blocks. Samples were taken from the field of the top layer of 0 – 30 cm depth. Sampling was done by taking 5 sub samples along the diagonal of the three blocks.

Soil pH-H_2O indicates a slight acid to neutral soil (Table 1). Phosphate content of the soil is present at an excessive level while potassium is present at an adequate medium level. Calcium and magnesium content are both medium to high.

Table 1. Analyse results of soil samples taken in August 2007 at experimental site.

sample	pH-H_2O	pH-KCl	N (%) Kjeldahl	P_2O_5 (ppm) Olsen	K (ppm) MV	Ca	Mg
						(meq/100g) Ammonium acetate 1N pH 7	
I	6.5	5.8	0.13	108.2	181.8	45.74	8.55
II	6.6	5.8	0.10	84.8	190.8	50.89	8.96
III	6.5	5.7	0.11	99.3	178.6	52.48	8.65

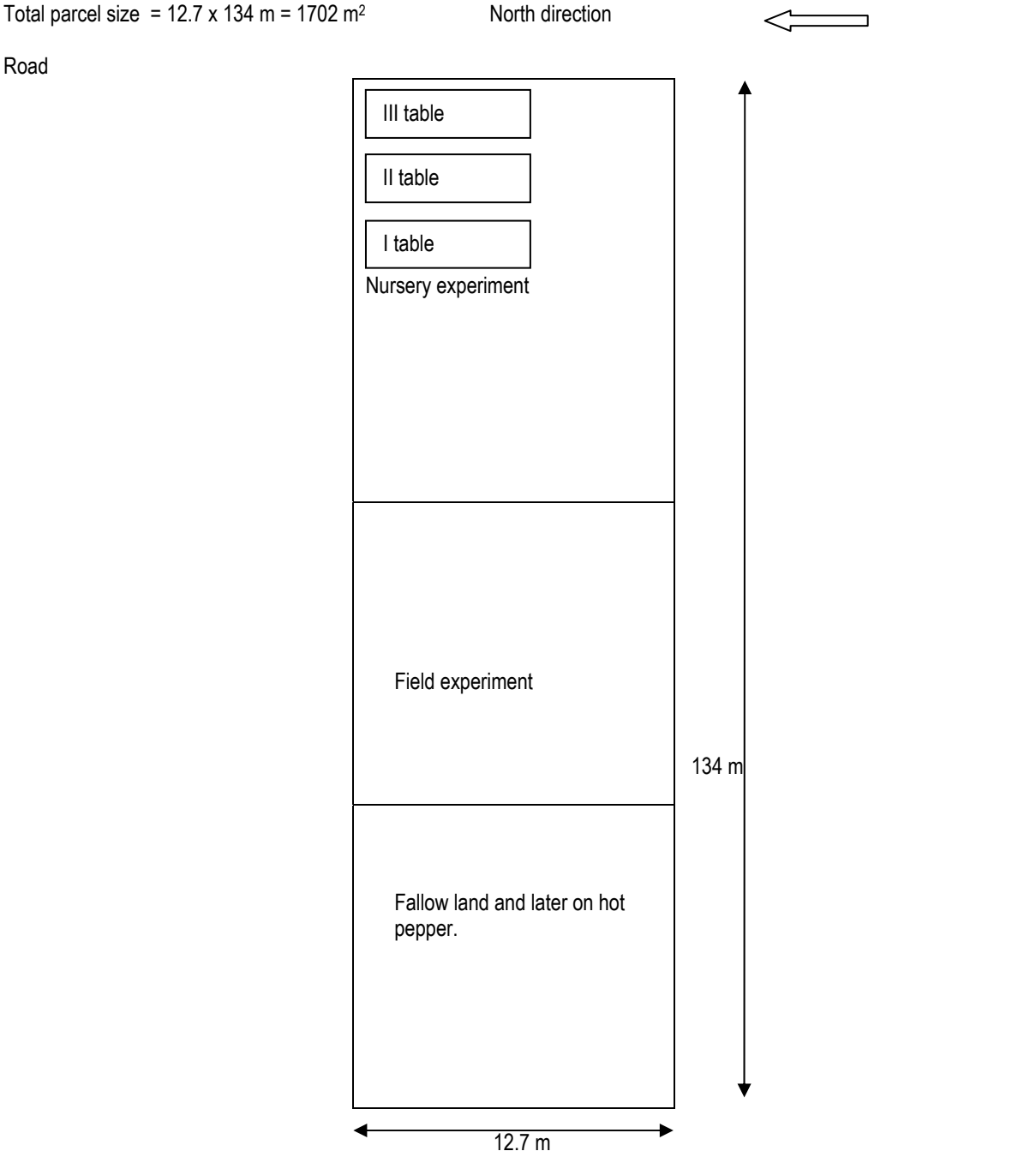


Figure 2. Layout of the experimental site

2.1 Nursery

Hot pepper seedlings were raised in a simple net house bamboo construction (Figure 3, 4 and 5). Three nursery net houses were built for conducting the nursery experiment, and for supplying seedlings for the field experiment.

- One net house was designed to accommodate a maximum of 32 trays of 128 seedlings each. Hence, a nursery can accommodate a total of 4096 seedlings.
- Some wooden crates (55 x 35 cm) were also constructed to place the individual transparent plastic bags in, which are used as a container.
- Minimum required length of the nursery table : 16 x 35 cm = 5.60 m
- Minimum required width of the nursery table: 2 x 55 cm = 1.10 m

- Taking into account necessary spacing between wooden crates or trays, the size of a nursery table is approximately 1.5 x 7.0 m

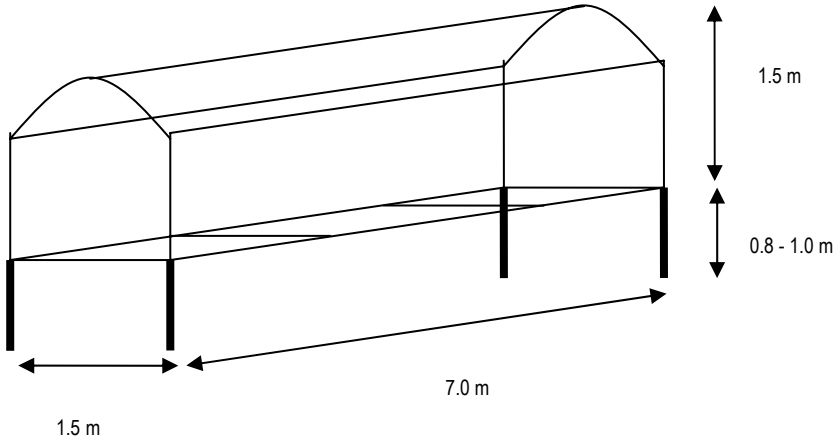


Figure 3. Schematic view of a nursery.

Figure 4. Inside details of the nursery construction.

Figure 5. Outside details of the nursery construction.

2.2 Variety

In the experiment two varieties were included for testing:

- Open Pollinated variety (Tit Segitiga) – local variety (farmer saved seed) dominantly used by farmers
- Hybrid variety (Astina F_1) – bred and commercially marketed by East West Seed Indonesia, (EWINDO), Purwakarta.

Figure 6. Open Pollinated variety (Tit Segitiga)

Figure 7. Hybrid variety (Astina F_1)

2.3 Seedling raising treatments

In this experiment, several media compositions were tested (Table 2). Those were: (a) a mixture of burned rice-husk and to soil (1:1); (b) a mixture of burned rice-husk and manure (1:1); (c) a mixture of manure and top soil

(1:1); and (d) a mixture of burned rice-husk, manure and top soil (1:1:1). Burned rice-husk and manure were bought from outside sources, while top soil was collected from the field where the experiments were carried out. The media was then sampled by taking 4 x 1 kg of the mixture for laboratory analysis on nutrient content, pH, EC and bulk density.

Two types of container were used in this experiment. Those were a modular plastic tray with 128 modules per tray (approx. volume of 13 cm^3 per module) and a transparent plastic bag (approx. volume of 15 cm^3 per module (Fig. 8). The transparent plastic bags were punctured at the bottom for drainage. Some wooden-bamboo boxes were made to place seedlings raised in transparent plastic bags.

Figure 8. Transparent plastic bags, modular plastic trays and wooden-bamboo box.

Table 2. Treatments of the nursery stage experiment.

Code	Variety	Container	Media
A1B1C1	Tit Segitiga	Transparent plastic bag 5x8 cm	Rice husk + top-soil (1:1)
A1B1C2	Tit Segitiga	Transparent plastic bag 5x8 cm	Rice husk + manure (1:1)
A1B1C3	Tit Segitiga	Transparent plastic bag 5x8 cm	Manure + top-soil (1:1)
A1B1C4	Tit Segitiga	Transparent plastic bag 5x8 cm	Rice husk + manure + top-soil (1:1:1)
A1B2C1	Tit Segitiga	Plastic tray	Rice husk + top-soil (1:1)
A1B2C2	Tit Segitiga	Plastic tray	Rice husk + manure (1:1)
A1B2C3	Tit Segitiga	Plastic tray	Manure + top-soil (1:1)
A1B2C4	Tit Segitiga	Plastic tray	Rice husk + manure + top-soil (1:1:1)
A2B1C1	Astina	Transparent plastic bag 5x8 cm	Rice husk + top-soil (1:1)
A2B1C2	Astina	Transparent plastic bag 5x8 cm	Rice husk + manure (1:1)
A2B1C3	Astina	Transparent plastic bag 5x8 cm	Manure + top-soil (1:1)
A2B1C4	Astina	Transparent plastic bag 5x8 cm	Rice husk + manure + top-soil (1:1:1)
A2B2C1	Astina	Plastic tray	Rice husk + top-soil (1:1)
A2B2C2	Astina	Plastic tray	Rice husk + manure (1:1)
A2B2C3	Astina	Plastic tray	Manure + top-soil (1:1)
A2B2C4	Astina	Plastic tray	Rice husk + manure + top-soil (1:1:1)
A1B3	Tit Segitiga	Direct sowing	-
A2B3	Astina	Direct sowing	-

From the nursery stage experiment, the best treatments per variety were selected for further testing in the field-stage experiment (Table 3). Only the four-best combinations from each variety were selected as treatments in the field experiment besides the direct seeded treatments as standard or control. Those treatments were selected based on the highest number of usable seedling criterion, providing that the fresh weight of the seedlings was not too low.

Time of transplanting was set to be mainly depending on seedling stage and not to the date. If after three to four weeks seedlings were not developed well enough, transplanting needed to be postponed. Also if transplants from one treatment were not good enough for transplanting this treatment should only be transplanted when seedlings

were at the right stage. It was therefore possible that treatments were transplanted at different dates. In this experiment, however, seedlings from all selected treatments were relatively at the right stage at a same date. Hence, those seedlings from the different selected treatments were transplanted at the same date.

Table 3. Treatments of the field – stage experiment.

Code	Variety	Container	Media
A1	Tit Segitiga	Transparent plastic bag	Manure + top soil (1:1)
A2	Tit Segitiga	Plastic tray	Manure + top soil (1:1)
A3	Tit Segitiga	Transparent plastic bag	Rice husk + manure + top soil (1:1:1)
A4	Tit Segitiga	Transparent plastic bag	Rice husk + manure (1:1)
A5	Astina	Transparent plastic bag	Rice husk + manure + top soil (1:1:1)
A6	Astina	Transparent plastic bag	Manure + top soil (1:1)
A7	Astina	Transparent plastic bag	Rice husk + manure (1:1)
A8	Astina	Plastic tray	Manure + top soil (1:1)
A9	Tit Segitiga	Direct sowing	
A10	Astina	Direct sowing	

2.4 Cultivation

2.4.1 Intercropping

Hot pepper is commonly intercropped with shallot. Those two crops are basically grown on beds that are surrounded by ditches for irrigation and drainage purposes. Each plot of the experiment is occupying one-half of bed with the size of 1.5 x 5.7 m. In common local practice, hot pepper seeds are directly planted about 7-10 days after shallot planting. In this experiment, hot pepper sowing is carried out at the same date as shallot planting. Hot pepper seedlings are transplanted 30 days after sowing. Table 4 shows the number of plants and planting distances used in the shallot-hot pepper intercropping system. A lay-out of the system as adapted in this experiment is shown in Annex 1.

Figure 9. Direct sowing.

Figure 10. Seedling transplanting.

Table 4. Number of plants and planting distances for shallot and hot pepper.

	Plants per plot	Number of rows	Plants per row	Distance within a row	Distance between rows
Shallot	260	10	26	21	15
Hot pepper	100	4	25	21	30/60

2.4.2 Cultivation practice

Adapting the local practice, shallot was planted preceding hot pepper. Hot pepper is usually directly sowed in the field after the shallot tuber seed shows some sprouts. The general information on the cultivation is shown in Table

5. Further cultural practices for both crops (weeding, fertilizing, pests and diseases controlling and harvesting) were carried out in accordance to local farmers' practices.

Table 5. General information on the cultivation.

Hot pepper sowing	:	4 August 2007
Hot pepper transplanting	:	31 August, 2007
Shallot transplanting	:	28 July, 2007
Used seeds for nursery	:	252 seeds/treatment at plastic bag container 256 seeds/treatment at plastic tray container
Direct sowing	:	3 seeds per hole for outer rows and 2 seeds per hole for inner rows (total 260 seeds per plot/treatment)
Plant density	:	Tit Segitiga and Astina F_1 at 12.2 plants per m^2

2.5 Observations

2.5.1 Climate

Maximum and minimum temperatures were recorded during the experiment by taking daily-readings at 14.00 p.m. Two simple mercury thermometers were used, one was placed inside the nursery construction and the other one was placed outside in the field. Both of them were put in the shade to avoid direct sunlight exposure. Rainfall data were gathered from Brebes Agricultural Office weather station and measured daily at 6.30 a.m. using a simple rain gauge. Data on temperature were recorded at Tegal, 20 km east of the experimental field.

2.5.2 Nutrient content

A sample from all four media (1 kg per media) used in this experiment was submitted for laboratory analysis on the content of total nitrogen, potassium, phosphate, calcium and pH level.

2.5.3 Light intensity

During the nursery-stage experiment, light intensity was measured with a handheld Lux-meter (LX93 from Nieuwkoop), both inside and outside the nurseries. Inside each nursery, light intensity was measured at two spots, while outside each nursery it was measured at one spot. The percentage of available light inside the nursery was calculated based on these readings.

2.5.4 Nursery observations

Seedling emergence of each treatment was observed 10 and 20 days after sowing. Percentage of normal and abnormal seedlings was calculated. At transplanting stage, some counts were carried out for the number of usable and unusable transplants and their percentages were also calculated. The number of plants with virus symptoms and infected by thrips were observed. At transplanting stage, 15 usable seedlings were selected and cut those off at soil level. Moreover, data were collected regarding the total fresh weight of 15 upper soil plant parts only; seedling height per plant from cutt off point to tip of the plant when fully stretched out; and the number of fully developed leaves per plant. After drying at 70^{o}C for 24 hours, the total weight of the 15 plants together was weighed. The percentage of dry weight was calculated as well.

2.5.5 Harvest observations

Fruits were harvested when mature, and harvesting took every two to five days place depending on the speed of fruit maturing.
At each harvest data per plot number and total weight of harvested fruits was observed. After this fruits were graded in marketable fruits and unmarketable fruits. The number and weight of marketable fruits was observed. At each harvest also the number of present plants per plot was observed.

Based on the observations total fruit number and weight, marketable fruit number and weight per plant and per square meter cultivation surface was calculated. Also share of marketable weight in total yield and average fruit weight was calculated.

2.6 Statistical information

The experiment was carried out as a randomized block design in three replications (Annex II and III).
Results were analysed with ANOVA (analysis of variance) by using the statistical program Genstat for Windows 11th edition.

3 Results

3.1 Climate

During the raising of transplants indoor minimum temperature was similar to the outdoor recorded temperature (Fig. 11). Indoor maximum temperature was during the first weeks the same as the outdoor temperature. The last weeks indoor maximum temperature was lower than the recorded outdoor maximum temperature. Temperature was higher than recorded at the station of Tegal (Fig. 12). This is due to the fact that thermometers in the field are more exposed to direct sun light.

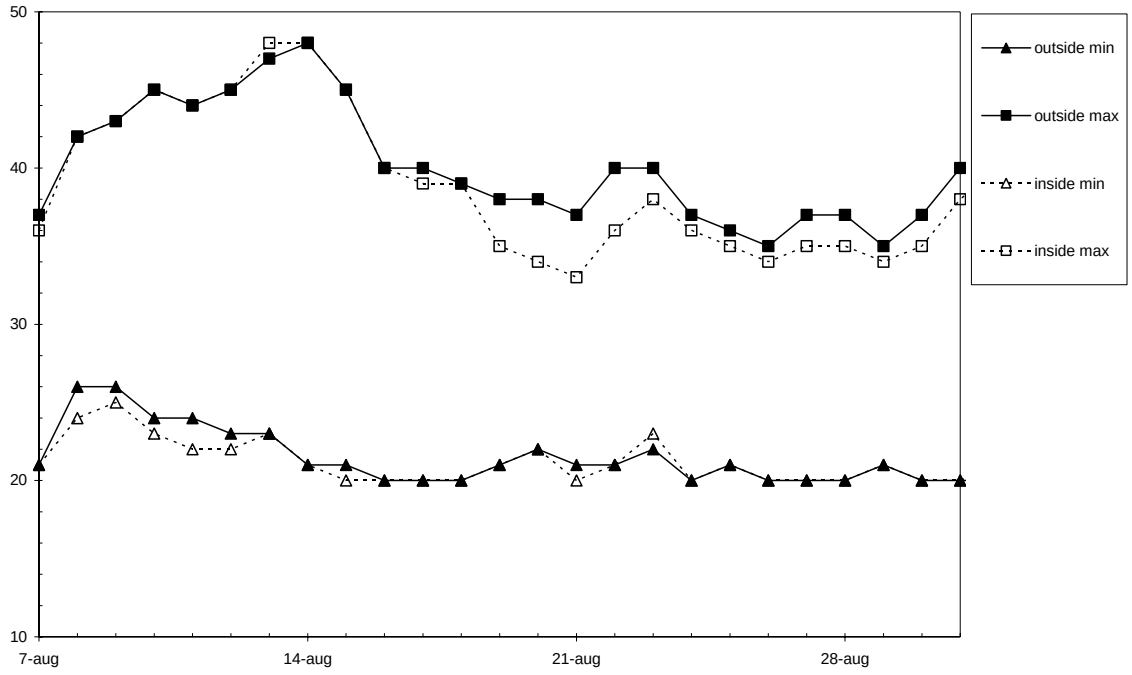


Figure 11. Indoor and outdoor maximum and minimum temperature.

Till December, maximum temperature ranges between 30 and 35°C. In December the maximum temperature declined to temperatures below 30°C. The minimum temperature increased gradually from 22°C in August to 25°C in December. Till half October no rainfall was recorded. From November onwards significant amounts of rainfall were recorded, and in total 580 mm was recorded during the experiment.

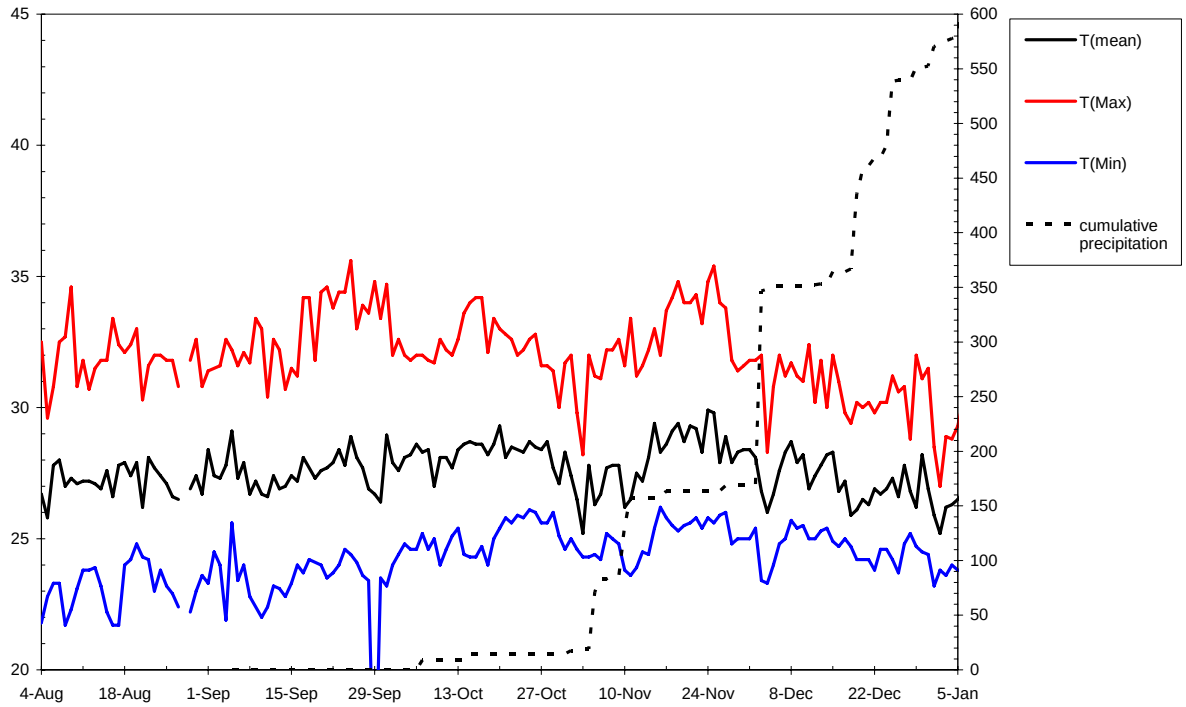


Figure 12. Mean, maximum and minimum temperature and cumulative rainfall during the experiment, Tegal 2007.

3.2 Light levels

On August 7, mean available light inside the nursery construction was 58% of the outdoor light intensity. On August 20 with shading cloth mean available light was 78% of the outdoor light intensity. Mean light level on August 31 was 64% of the available outdoor light intensity.

3.3 Nutrient content of media and soil

Transplants tested in the field were mainly raised in media containing top soil and manure (TS+M) only (Table 6). The pH of all tested media is alkaline with a pH-H_2O of 7.2 to 7.7, while for potting soils used for vegetable seedling production a pH of 5.6 to 6.0 is advised. Total nitrogen content is 0.48 % or 480 mg per 100 gram media. Nitrate content was not measured, but optimum advised content is 30 to 75 mg per litre substrate. When nitrogen content is too high, a very vigorous growth of the seedlings can occur, resulting in weak seedlings which are vulnerable to diseases and damping off.

Table 6. Nutrient content of media/substrate samples taken in August 2007.

Media	pH-H_2O	pH-KCl	N (%)	P_2O_5 (%)	K_2O (%)	CaO (%)	MgO (%)
Rice husk (RH)	7.6	7.2	0.43	0.36	0.77	0.17	0.06
Manure (M)	7.7	7.4	0.72	1.74	1.77	4.99	1.61
Top soil (TS)	6.7	5.9	0.16	0.02	0.03	1.15	0.23
RH + M	7.7	7.3	0.68	1.46	1.22	3.55	1.15
TS + M	7.2	6.8	0.48	0.78	0.89	2.24	1.54
RH + M + TS	7.4	6.9	0.48	0.87	1.00	2.48	1.30

3.4 Seedling raising results

Table 7 shows that there is no effect of variety on emergence. This indicates that both varieties do not show any difference in terms of their emergence rate. Meanwhile, Astina performs better than Tit Segitiga in fresh weight, dry weight, dry matter, plant height and number of leaves (Table 8). However, there is no difference in the percentage of seedling infected by thrips for the two varieties.

Table 7. Effect of variety on emergence, Brebes 2007.

	Emergence of normal seedlings after 10 days (%)	Total emergence after 10 days (%)	Emergence of normal seedlings after 20 days (%)	Total emergence after 20 days (%)	Emergence of normal seedlings at transplanting (%)	Total emergence at transplanting (%)	Usable seedlings (%)
Tit Segitiga	51.2	63.4	68.3	73.8	69.9	75.6	62.4
Astina	48.4	58.2	66.6	72.0	67.8	73.0	60.2
Mean	*49.8*	*60.8*	*67.5*	*72.9*	*68.8*	*74.3*	*61.3*
p=	0.529	0.202	0.631	0.582	0.46	0.344	0.516
$Lsd_{0.05}$	9.0	8.0	7.1	6.7	6.0	5.5	6.7

Table 8. Effect of variety on seedling growth, Brebes 2007.

	Fresh weight (g)	Dry weight (g)	Dry matter (%)	Plant height (cm)	Number of leaves per plant	Seedlings with thrips infection (%)	Seedlings with virus symptoms (%)
Tit Segitiga	6.1	0.86	14.1	6.3	5.5	0.1	1.8
Astina	7.2	0.91	12.8	7.9	5.8	0.4	1.9
Mean	*6.7*	*0.89*	*13.5*	*7.1*	*5.6*	*0.2*	*1.8*
p=	0.004	0.291	<0.001	<0.001	0.002	0.046	0.804
$Lsd_{0.05}$	0.7	0.10	0.5	0.5	0.2	0.3	0.8

The media of manure + top soil performs the best in the percentage of normal emergence after 10 days; percentage of total emergence after 10 days; percentage of normal emergence at transplanting; percentage of total emergence at transplanting and percentage of usable seedlings. However, in some cases the effects are not statistically significant, especially for the media of husk + manure + top soil (Table 9). Manure + top soil also performs better in some parameters of seedling growth (fresh weight, dry weight, plant height and number of leaves). Figures obtained by this media are consistently higher, even though they are not statistically different to figures obtained by the media of husk + manure + top soil (Table 10).

Table 9. Effect of media on emergence, Brebes 2007.

	Emergence of normal seedlings after 10 days (%)	Total emergence after 10 days (%)	Emergence of normal seedlings after 20 days (%)	Total emergence after 20 days (%)	Emergence of normal seedlings at transplanting (%)	Total emergence at transplanting (%)	Usable seedlings (%)
Husk+manure (H+M)	49.1 a b	57.2 a	62.5	67.4	61.8 a	67.6 a	55.9 a
Husk+top soil (H+T)	39.2 a	53.5 a	68.9	74.6	70.6 b	77.2 b	57.1 a
Manure+top soil (M+T)	59.0 b	70.6 b	71.4	77.0	73.8 b	78.2 b	68.7 b
Husk+manure+top soil (H+M+T)	51.8 a b	61.9 a b	67.1	72.4	69.1 a b	74.3 b	63.5 a b
Mean	*49.8*	*60.8*	*67.5*	*72.9*	*68.8*	*74.3*	*61.3*
p=	0.028	0.027	0.340	0.22	0.044	0.037	0.035
Lsd $_{0.05}$	12.7	11.4	10.0	9.4	8.4	7.8	9.5

Table 10. Effect of media on seedling growth, Brebes 2007.

	Fresh weight (g)	Dry weight (g)	Dry matter (%)	Plant height (cm)	Number of leaves per plant	Seedlings with thrips infection (%)	Seedlings with virus symptoms (%)
H+M	3.9 a	0.50 a	13.0 a	5.4 a	4.7 a	0.1	0.0 a
H+T	7.6 b	0.97 b c	13.0 a	7.2 b	5.9 b	0.2	6.6 b
M+T	8.2 b	1.09 c	13.5 a b	8.2 c	6.0 b	0.5	0.2 a
H+M+T	7.0 b	0.99 b c	14.3 b	7.5 b c	5.8 b	0.1	0.4 a
Mean	*6.7*	*0.89*	*13.5*	*7.1*	*5.6*	*0.2*	*1.8*
p=	<0.001	<0.001	0.005	<0.001	<0.001	0.099	<0.001
Lsd $_{0.05}$	0.97	0.14	0.8	0.7	0.3	0.4	0.2

Table 11 and 12 are indicating that the transparent plastic bag container performs significant better than the plastic tray container in emergence and seedling growth parameters. However, it should be noted that the percentage of seedlings from transparent plastic bag container infected by thrips is higher than that of plastic tray container.

Table 11. Effect of container on emergence, Brebes 2007.

	Emergence of normal seedlings after 10 days (%)	Total emergence after 10 days (%)	Emergence of normal seedlings after 20 days (%)	Total emergence after 20 days (%)	Emergence of normal seedlings at transplanting (%)	Total emergence at transplanting (%)	Usable seedlings (%)
Plastic bag	66.9	77.9	80.1	84.9	80.7	86.6	72.0
Plastic tray	32.6	43.7	54.8	60.8	57.0	62.1	50.6
Mean	*49.8*	*60.8*	*67.8*	*72.9*	*68.8*	*74.3*	*61.3*
p=	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lsd $_{0.05}$	9.0	8.0	7.1	6.7	6.0	5.5	6.7

Table 12. Effect of container on seedling growth, Brebes 2007.

	Fresh weight (g)	Dry weight (g)	Dry matter (%)	Plant height (cm)	Number of leaves per plant	Seedlings with thrips infection (%)	Seedlings with virus symptoms (%)
Plastic bag	8.1	1.04	12.84	8.1	5.9	0.3	2.6
Plastic tray	5.2	0.74	14.05	6.0	5.4	0.2	1.1
Mean	*6.7*	*0.89*	*13.45*	*7.1*	*5.6*	*0.2*	*1.8*
p=	<0.001	<0.001	<0.001	<0.001	<0.001	0.903	<0.001
$Lsd_{0.05}$	0.7	0.10	0.544	0.5	0.2	0.3	0.8

Statistically significant Interactions among treatments (variety, media and container) are shown on two parameters of emergence and four parameters of seedling growth. Table 13 and 14 reveal that interactions are dominantly occurred between media and and container.

Table 13. Interaction of variety, media and container on emergence, Brebes 2007.

	Emergence of normal seedlings after 10 days (%)	Total emergence after 10 days (%)	Emergence of normal seedlings after 20 days (%)	Total emergence after 20 days (%)	Emergence of normal seedlings at transplanting (%)	Total emergence at transplanting (%)	Usable seedlings (%)
				p=			
var*media	0.439	0.548	0.633	0.563	0.366	0.416	0.371
var*container	0.056	0.053	0.252	0.269	0.098	0.075	0.185
media*container	0.737	0.373	0.417	0.331	0.061	0.034	0.025
var*media*container	0.741	0.704	0.885	0.946	0.951	0.913	0.936

Table 14. Interaction of variety, media and container on seedling growth, Brebes 2007.

	Fresh weight (g)	Dry weight (g)	Dry matter (%)	Plant height (cm)	Number of leaves per plant	Seedlings with thrips infection (%)	Seedlings with virus symptoms (%)
				p=			
var*media	0.867	0.615	0.760	0.964	0.052	0.456	0.839
var*container	0.247	0.438	0.622	0.015	0.222	0.280	0.325
media*container	0.006	0.044	0.546	0.011	0.115	0.587	<0.001
var*media*container	0.287	0.352	0.963	0.146	0.299	0.637	0.355

As compared to other combinations, manure + top soil is performing the best in the percentage of total emergence at transplanting; percentage of usable seedlings; and fresh weight (Table 15). In the mean time, transparent plastic bag container also shows higher percentage of total emergence at transplanting; percentage of usable seedlings; and fresh weight compared to plastic tray container. This may indicate that interaction between the media of manure + top soil and the container of transparent plastic bag is the best treatment combination.

Table 15. Effect of media and container on total and usable seedlings and fresh weight, Brebes 2007.

	Total seedlings at transplanting (%)			Usable seedlings at transplanting (%)			Fresh weight (g)		
	Plastic bag	Plastic tray	*Mean*	Plastic bag	Plastic tray	*Mean*	Plastic bag	Plastic tray	*Mean*
Husk + manure	86.7	48.4	*67.6*	73.1	38.7	*55.9*	4.38	3.32	*3.85*
Husk + top soil	85.1	69.3	*77.2*	59.3	54.9	*57.1*	9.15	6.05	*7.60*
Manure + top soil	88.5	67.9	*78.2*	80.2	57.2	*68.7*	10.55	5.80	*8.17*
Husk + manure + top soil	85.9	62.6	*74.3*	75.2	51.7	*63.5*	8.38	5.65	*7.02*
Mean	*86.6*	*62.1*		*72.0*	*50.6*		*8.12*	*5.20*	
Media*Container Lsd $_{0.05}$=		11.0			13.5			1.37	
Media *Container p=		0.034			0.025			0.006	

Table 16 reveals that manure + top soil can be considered as the best media as reflected by higher plant height and higher dry weight, but also higher percentage of seedlings infected by virus. Meanwhile, transparent plastic bag container provides higher plant height and higher dry weight, but also higher percentage of seedlings infected by virus. This means that the interaction between the media of manure + top soil and the container of transparent plastic bag provides better emergence and seedling growth. However, its effect on the percentage of seedlings infected by virus should be cautiously considered.

Table 16. Effect of media and container on plant height, dry weigh and seedlings with virus symptoms. Brebes 2007.

	Plant height (cm)			Dry weight (g)			Seedlings with virus symptoms (%)		
	Plastic bag	Plastic tray	*Mean*	Plastic bag	Plastic tray	*Mean*	Plastic bag	Plastic tray	*Mean*
Husk + manure	6.06	4.82	*5.44*	0.55	0.45	*0.50*	0.00	0.07	*0.04*
Husk + top soil	8.06	6.40	*7.23*	1.11	0.84	*0.97*	9.20	4.07	*6.64*
Manure + top soil	9.89	6.44	*8.16*	1.35	0.83	*1.09*	0.40	0.00	*0.20*
Husk + manure + top soil	8.56	6.44	*7.50*	1.14	0.84	*0.99*	0.60	0.20	*0.40*
Mean	*8.14*	*6.03*		*1.04*	*0.74*		*2.55*	*1.09*	
Media*Container Lsd $_{0.05}$=		0.94			0.20			1.63	
Media *Container p=		0.011			0.044			<0.001	

The interaction between variety and container shows a significant effect only on one parameter of seedling growth, i.e., plant height. Table 17 shows that the interaction between Astina hybrid variety and transparent plastic container results in a higher plant height.

Table 17. Effect of variety and container interaction on plant height, Brebes 2007.

Plant height			
	Plastic bag	Plastic tray	*Mean*
Tit segitiga	7.06	5.53	*6.29*
Astina	9.23	6.52	*7.88*
Mean	*8.14*	*6.03*	
Variety*Container Lsd $_{0.05}$=		0.66	
Variety *Container p=		0.015	

3.5 Harvest results

The field experiment was basically intended to test the performance of some selected seedlings (treatments) from the previous nursery experiment. Four best seedling treatments from each variety, Tit Segitiga and Astina, were selected and their performance was compared to the direct sowing/planting practice.

Crop condition in the field was not as expected because of high pest and disease infestation. Efforts to control pests and diseases have been done but the results were not satisfying. In consequence, the crop could only be harvested six times. Evaluation together with farmers suggested that the non-optimal crop condition may be caused by the late planting as compared to the neighboring farmers.

The following tables indicate that the statistical analysis for total number of fruit per plant; total production per plant; total number of healthy fruits per plant; total healthy production per plant; fruit weight average; healthy fruit weight average; and the percentage of healthy production suggests no interaction between treatments (nursery system) and variety. As shown below (Table 18, 19, 20 and 21), Tit Segitiga produces a higher total number of fruit per plant; total production per plant; total number of healthy fruits per plant; total healthy production per plant than those of Astina. However, even the best nursery treatment (transparent plastic bag and manure + top soil) is not statistically different to the direct sowing/planting treatment.

Table 18. Total number of fruits per plant, Brebes 2007.

	Variety		
Treatment	Astina	Tit Segitiga	*Mean*
Direct sowing	6.7	11.0	*8.8*
Plastic bag; manure + top soil	6.2	11.6	*8.9*
Plastic bag; husk + manure	6.6	9.5	*8.1*
Plastic bag; husk + manure + top soil	6.1	8.7	*7.4*
Plastic tray; manure + top soil	3.3	9.3	*6.3*
Mean	*5.8*	*10.0*	*7.9*
	p =	$Lsd_{0.05}$	
Treatment	0.036	1.83	
Variety	<.001	1.16	
Treatment x variety	0.249	2.58	

Table 19. Total production per plant (g), Brebes 2007.

	Variety		
Treatment	Astina	Tit Segitiga	*Mean*
Direct sowing	31.2	55.4	*43.3*
Plastic bag; manure + top soil	31.0	58.1	*44.5*
Plastic bag; husk + manure	31.6	44.8	*38.2*
Plastic bag; husk + manure + top soil	27.4	38.5	*32.9*
Plastic tray; manure + top soil	16.7	41.7	*29.2*
Mean	*27.6*	*47.7*	*37.6*
	p=	$Lsd_{0.05}$	
Treatment	<0.001	7.20	
Variety	0.048	11.3	
Treatment x variety	0.463	16.0	

Table 20. Number of marketable fruits per plant. Brebes 2007.

	Variety		
Treatment	Astina	Tit Segitiga	*Mean*
Direct sowing	4.2	5.9	*5.0*
Plastic bag; manure + top soil	3.9	6.6	*5.3*
Plastic bag; husk + manure	4.1	4.3	*4.2*
Plastic bag; husk + manure + top soil	3.2	3.6	*3.4*
Plastic tray; manure + top soil	1.6	4.3	*3.0*
Mean	*3.4*	*5.0*	*4.2*
	p=	$Lsd_{0.05}$	
Treatment	0.02	1.52	
Variety	0.003	0.96	
Treatment x variety	0.295	2.15	

Table 21. Marketable production per plant (g), Brebes 2007.

	Variety		
Treatment	Astina	Tit Segitiga	*Mean*
Direct sowing	22.6	34.8	*28.7*
Plastic bag; manure + top soil	22.3	39.4	*30.8*
Plastic bag; husk + manure	22.8	26.6	*24.7*
Plastic bag; husk + manure + top soil	18.5	20.3	*19.4*
Plastic tray; manure + top soil	10.4	24.3	*17.4*
Mean	*19.3*	*29.1*	*24.2*
	p=	$Lsd_{0.05}$	
Treatment	0.04	9.70	
Variety	0.004	6.13	
Treatment x variety	0.415	13.71	

Table 22, 23 and 24 indicate that there is no significant difference between varieties and among nursery treatments in terms of fruit weight average, healthy fruit weight average. Percentage of marketable production was at direct sowing and plastic bag with manure and top soil higher then at plastic bag with rice husk, manure and top soil and plastic tray.

Table 22. Average fruit weight of the total production (g), Brebes 2007.

	Variety		
Treatment	Astina	Tit Segitiga	*Mean*
Direct sowing	4.4	4.7	*4.6*
Plastic bag; manure + top soil	4.5	4.6	*4.6*
Plastic bag; husk + manure	4.6	4.3	*4.5*
Plastic bag; husk + manure + top soil	4.2	4.1	*4.2*
Plastic tray; manure + top soil	4.7	4.4	*4.5*
Mean	*4.5*	*4.4*	*4.5*
	p=	$Lsd_{0.05}$	
Treatment	0.104	0.345	
Variety	0.555	0.21	
Treatment x variety	0.394	0.49	

Table 23. Average fruit weight of the marketable production (g), Brebes 2007.

	Variety		
Treatment	Astina	Tit Segitiga	*Mean*
Direct sowing	5.7	5.6	*5.7*
Plastic bag; manure + top soil	5.7	5.4	*5.6*
Plastic bag; husk + manure	5.6	6.2	*5.9*
Plastic bag; husk + manure + top soil	5.7	5.4	*5.5*
Plastic tray; manure + top soil	6.1	5.7	*5.9*
Mean	*5.8*	*5.6*	*5.7*
	p=	Lsd $_{0.05}$	
Treatment	0.691	0.69	
Variety	0.628	0.44	
Treatment x variety	0.617	0.98	

Table 24. Percentage (%) of marketable production, Brebes 2007.

	Variety		
Treatment	Astina	Tit Segitiga	*Mean*
Direct sowing	62.5	58.5	*60.5*
Plastic bag; manure + top soil	58.3	57.2	*57.8*
Plastic bag; husk + manure	62.7	57.2	*59.9*
Plastic bag; husk + manure + top soil	55.7	48.3	*52.0*
Plastic tray; manure + top soil	48.4	56.4	*52.4*
Mean	*57.5*	*55.5*	*56.5*
	p=	Lsd $_{0.05}$	
Treatment	0.018	6.12	
Variety	0.288	3.87	
Treatment x variety	0.117	8.66	

The following graph depicts the production of each tested treatment from six harvests cumulatively (Fig. 13).

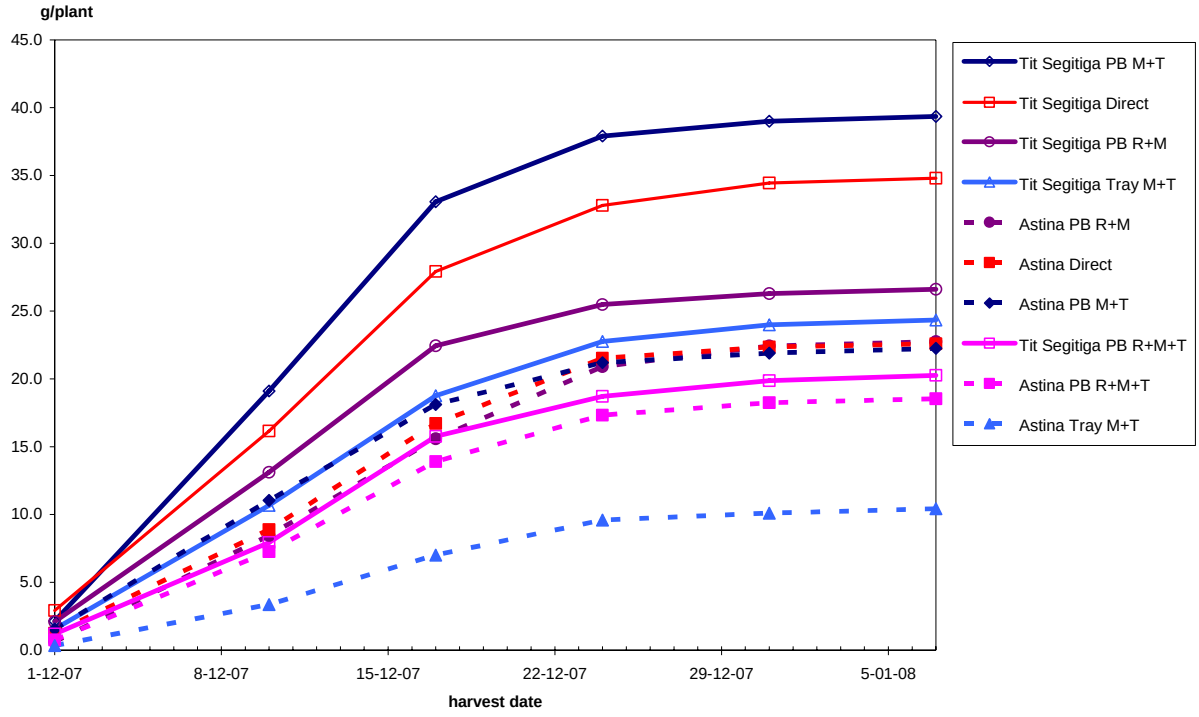


Figure 13. Cumulative marketable yield (g/plant) of the treatments.

The curves show that Tit segitiga transplants raised in plastic bags with manure and top soil performs the best and subsequently followed by direct sowing of Tit Segitiga. Astina treatments showed lower yields than respective Tit Segitiga treatments.

4 Conclusions

Nursery Experiment

i) Both Tit Segitiga local variety and Astina hybrid variety do not show signiicant effects to the seedling emergence parameters. Meanwhile, Astina performs better than Tit Segitiga in some seedling growth parameters. However, both varieties indicate similar vulnerability to thrips.

ii) The media of manure + top soil performs the best in both seedling emergence and seedling growth parameters. However, in some cases, the performance of manure + top soil media is not statistically or rice husk + manure + top soil media.

iii) Transparent plastic bag container is statistically better than plastic tray in affecting seedling emergence and seedling growth. However, the seedlings from transparent plastic bag container are more vurnerable to virus than those from plastic tray container.

iv) Interaction between manure + top soil media and transparent plastic bag container provides the best effects to seedling emergence and seedling growth. However. One should be cautious to its effect on the percentage of virus infestation. Meanwhile, the interaction between Astina hybrid variety and transparent plastic bag container shows the best effect on seedling/plant height.

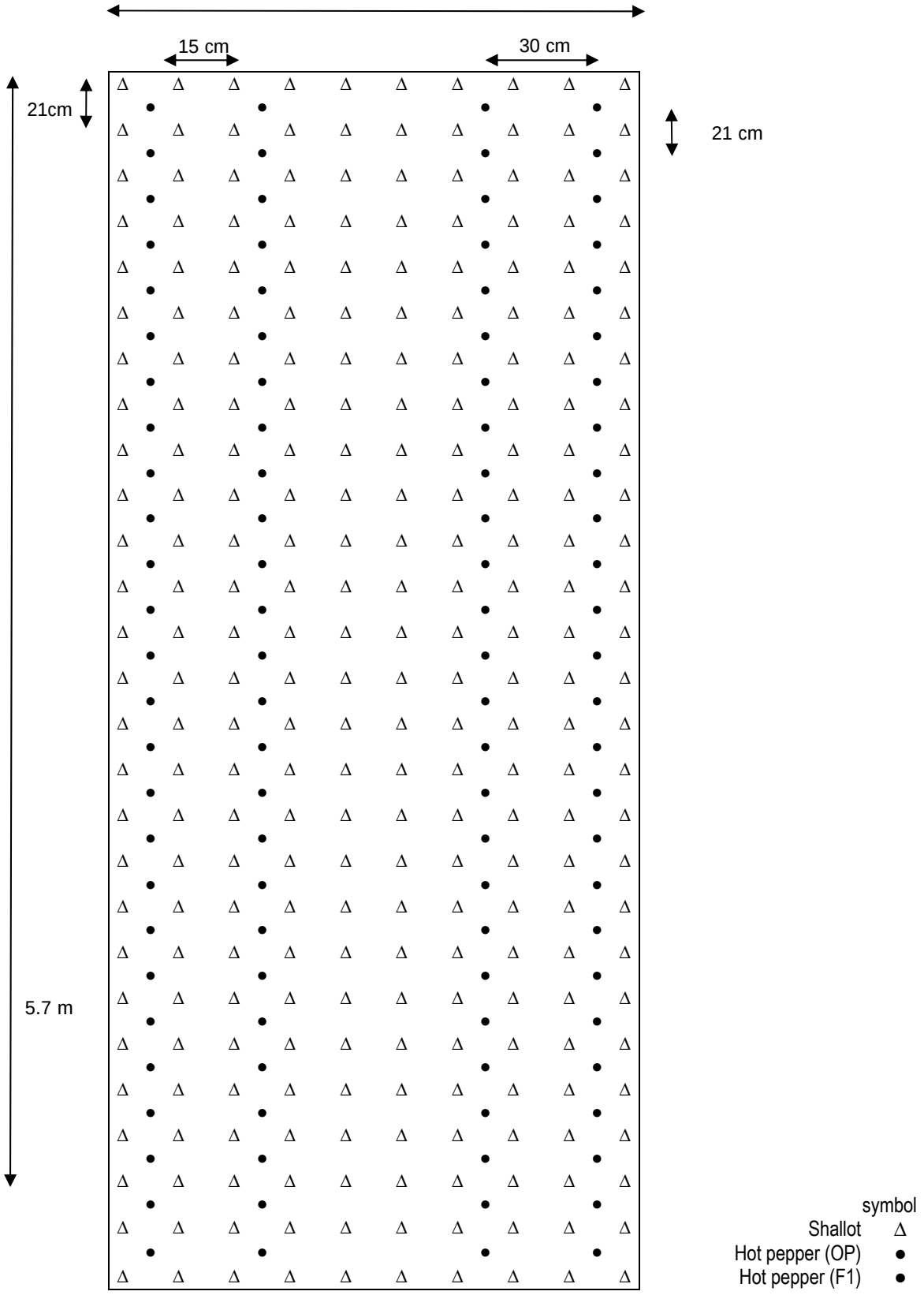
Field Experiment

(i) In general, Tit Segitiga local variety performs better than Astina hybrid variety, especially for the total number of fruit per plant; total production per plant; total number of healthy fruits per plant; and total healthy production per plant.

(ii) Even though it is not statistically significant, the only treatment that tends to perform better than direct sowing/planting, is the treatment of transparent plastic bag and manure + top soil (e.g., A1 vs. A9).

(iii) Especially for Astina hybrid variety, the use of transparent plastic bag container is consistently better than the use of plastic tray.

Annex I. Plant arrangement per plot.



Plant arrangement per plot (100 plants = 11.7 pl/m2)

Annex II. Layout of nursery treatments.

See for explanation of the treatment codes table 2.

Trays for experiment 1were arranged as follow: ← North

Replication 3: Nursery III

41	A1 B2 C4	42	A1 B1 C1	43 *L5*	A2 B1 C4	44	A1 B2 C2	45	A1 B1 C4	46	A2 B1 C3	47 *L6*	A2 B2 C2	48	A1 B1 C3
33	A2 B2 C4	34	A2 B1 C1	35	A1 B2 C3	36	A2 B1 C2	37	A1 B1 C2	38	A2 B2 C3	39	A2 B2 C1	40	A1 B2 C1

III

Replication 2: Nursery II

25	A1 B2 C2	26	A2 B2 C4	27 *L3*	A1 B1 C2	28	A1 B2 C3	29	A2 B1 C3	30	A2 B2 C1	31 *L4*	A1 B1 C1	32	A2 B1 C2
17	A2 B2 C2	18	A1 B1 C4	19	A2 B1 C1	20	A1 B1 C3	21	A1 B2 C1	22	A2 B2 C3	23	A1 B2 C4	24	A2 B1 C4

II

Replication 1: Nursery I

9	A2 B1 C4	10	A1 B2 C1	11 *L1*	A1 B1 C1	12	A2 B1 C1	13	A2 B2 C4	14	A1 B1 C3	15 *L2*	A2 B1 C2	16	A1 B2 C3
1	A1 B1 C4	2	A2 B2 C1	3	A1 B2 C2	4	A2 B2 C2	5	A1 B1 C2	6	A1 B2 C4	7	A2 B2 C3	8	A2 B1 C3

I

L1 till *L6* = light measurement position inside nursery

I, II, III = outdoor light measurement position

Annex III. Layout of treatments in the field.

Field experiment lay-out: (see for treatment codes table 3)