HORTIN II Co Innovation Programme

Towards cost effective, high quality value chains

Effect of sowing technique, nursery and variety on transplant raising and yield of hot pepper

HORTIN-II Research Report nr. 11

Witono Adiyoga, Herman de Putter, Nikardi Gunadi and Tonny K. Moekasan

Lelystad,The Netherlands Lembang Indonesia, March 2009.

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.

On the Indonesian side the programme is carried out by the Indonesian Centre for Horticultural Research and Development (ICHORD), Jakarta, with the Indonesian Vegetable Research Institute (IVEGRI), Lembang, and the Indonesian Centre for Agricultural Postharvest Research and Development (ICAPRD) in Bogor.

In the Netherlands the Agricultural Economics Research Institute (AEI), Den Haag, the Agrotechnology and Food Sciences Group (ASFG), Wageningen, Applied Plant Research (APR), Lelystad, and WUR-Greenhouse Horticulture (WUR-GH), Bleiswijk, all partners in Wageningen University and Research centre, are involved in the programme.

Addresses:

Indonesian Centre for Horticultural Research and Development (ICHORD)
Address : Jl. Ragunan 29A, Pasarminggu, Jakarta 12520, Indonesia
Tel. : +62 21 7890990
Fax : +62 21 7805135
E-mail : pushor@rad.net.id or pushorti@yahoo.com
Internet : www.litbanghortikultura.go.id

Indonesian Vegetable Research Institute (IVEGRI)
Address : Jl. Tangkuban Perahu 517, Lembang-Bandung 40391, West Java, Indonesia
Tel. : +62 22 2786 245
Fax : +62 22 2786 416
E-mail : dir_ivegri@balits.org or balitsa@balitsa.org
Internet : www.balitsa.org

Indonesian Centre for Agricultural Postharvest Research and Development (ICAPRD)
Address : Kampus Penelitian Pertanian, Cimanggu, Bogor 16114, West Java, Indonesia
Tel. : + 62 251 321762
Fax : + 62 251 350920
E-mail : bb_pascapanen@litbang.deptan.go.id or bb_pascapanen@yahoo.com
Internet : www.pascapanen.litbang.deptan.go.id

Agricultural Economics Research Institute (AEI)
Address : Alexanderveld 5, Den Haag, The Netherlands
: PO Box 29703, 2502 LS Den Haag, The Netherlands
Tel. : +31 70 335 83 30
Fax : +31 70 361 56 24
E-mail : informatie.lei@wur.nl
Internet : www.lei.wur.nl

Agrotechnology and Food Sciences Group (ASFG)
Address : Building 118, Bornsesteeg 59, Wageningen, The Netherlands
: PO Box 17, 6700 AA, Wageningen, The Netherlands
Tel. : +31 317 480 084
Fax : +31 317 483 011
E-mail : info.asfg@wur.nl
Internet : www.asfg.wur.nl

Applied Plant Research (APR)
AGV Research Unit
Address : Edelhertweg 1, Lelystad, The Netherlands
: PO Box 430, 8200 AK Lelystad, The Netherlands
Tel. : +31 320 29 11 11
Fax : +31 320 23 04 79
E-mail : infoagv.ppo@wur.nl
Internet : www.ppo.wur.nl

WUR-Greenhouse Horticulture (WUR-GH)
Address : Violierenweg 1, Bleiswijk, The Netherlands
: PO Box 20, 2665 ZG Bleiswijk, The Netherlands
Tel. : +31 317 48 56 06
Fax : +31 10 52 25 193
E-mail : glastuinbouw@wur.nl
Internet : www.glastuinbouw.wur.nl

Programme Team

	Indonesia	The Netherlands
Programme management	Dr Yusdar Hilman, Director ICHORD Telephone +62 Fax +62 E-mail: Dr.Nikardi Gunadi, IVEGRI Telephone +62 22 2786 245 Fax +62 22 2786 416 E-mail: NGUNADI@BDG.CENTRIN.NET.ID	Dr. Arij Everaarts, APR, General management Telephone +31 320 291 671 Fax +31 320 230 479 E-mail: ARIJ.EVERAARTS@WUR.NL Dr. Andre de Jager, AEI, Supply chain management Telephone +31 70 3358 341 Fax +31 70 3615 624 E-mail: ANDRE.DEJAGER@WUR.NL
Sweet pepper pilot project	Dr.Nikardi Gunadi, IVEGRI Telephone +62 22 2786 245 Fax +62 22 2786 416 E-mail: NGUNADI@BDG.CENTRIN.NET.ID	Ruud Maaswinkel, WUR-Greenhouse Horticulture Telephone +31 317 485 537 Fax +31 105 225 193 E-mail: RUUD.MAASWINKEL@WUR.NL
Shallot pilot project	Dr. Rofik Sinung Basuki, IVEGRI Telephone +62 22 2786 245 Fax +62 22 2786 416 E-mail: ROFIK@HOTMAIL.COM	Lubbert van den Brink, APR Telephone +31 320 291 353 Fax +31 320 230 479 E-mail: LUBBERT.VANDENBRINK@WUR.NL
Hot pepper pilot project	Dr. Witono Adiyoga, IVEGRI Telephone +62 22 2786 245 Fax +62 22 2786 416 E-mail: VICIANTI@YAHOO.CO.ID	Herman de Putter, APR Telephone +31 320 291 614 Fax:+31 320 230 479 E-mail: HERMAN.DEPUTTER@WUR.NL
Supply chain management	Dr. Witono Adiyoga, IVEGRI Telephone +62 22 2786 245 Fax +62 22 2786 416 E-mail: VICIANTI@YAHOO.CO.ID	Dr. Andre de Jager, AEI Telephone +31 70 3358 341 Fax +31 70 3615 624 E-mail: ANDRE.DEJAGER@WUR.NL
Quantitative Economic Analysis	Dr. Witono Adiyoga, IVEGRI Telephone +62 22 2786 245 Fax +62 22 2786 416 E-mail: VICIANTI@YAHOO.CO.ID	Marcel van der Voort, APR Telephone +31 320 291 312 Fax +31 320 230 479 E-mail: MARCEL.VANDERVOORT@WUR.NL
Fruit supply chains	Dr. Sri Yuliani, ICAPRD Telephone +62 251 321762 Fax +62 251 350920 E-mail: S.YULIANI@GMAIL.COM	Dr. Jeroen Knol, ASFG Telephone +31 317 480177 Fax +31 317 483011 E-mail: JEROEN.KNOL@WUR.NL

CONTENTS

Executive summary

From April till September, 2008 an experiment was performed to test the effect of sowing technique, nursery construction and variety on transplant production and yield of hot pepper.
From the results of previous experiments it became clear that percentage of usable transplants raised in a nursery was quite low. Based on discussions an observations it seemed that sowing was not carried out in an optimal way. Labourers did not receive proper instructions and also the sowing depth was shallow. Results of this experiment showed that after proper instruction and with introducing a slightly deeper sowing depth the results improved. Also results were improved with the covering of seeds with rice husk.
When climatic conditions in a nursery are optimal, then between using plastic bags or trays as transplant raising container differences in emergence and usable transplants are limited.
Based on feed back of the farmers also tested was the effect of nursery construction. Farmers had the impression that the used nursery with a table construction was more expensive than a simple construction directly positioned on the soil. However, results indicated that emergence and percentage usable transplants was negatively influenced by the soil nursery.
During the cultivation pest and disease pressure was quite high. This influenced the results greatly and between direct sowing and transplants no significant differences were observed in terms of yield. Yield per plant and per square meter of Gada were higher than the yield of Tit Segitiga. With Gada a 50% lower plant density was present compared to the density used with Tit Segitiga.

Hot pepper seedling with shallot intercrop.

1 Introduction

In 2007 a project was initiated to improve the hot pepper supply chain.
A main constraint in the supply chain were the low production levels of hot pepper. The production is hampered by several factors. Presence of pests and diseases is one important reason for low production levels. Another main constraint is the cultivation technique of direct sowing. With direct sowing high amounts of seeds are required to ensure at least one plant per desired plant position, and uniformity of the crop is low. Currently hot pepper is direct seeded where per desired plant position 5 seeds are sowed. This means that only 20% of the seed is used. Since high amounts of seeds are required, only varieties of which seeds are cheap are used. Farmers rarely use hybrid varieties since seed costs will be too high. Therefore mainly low yielding open pollinated varieties are used by the farmers. At the moment the main variety is Tit Segitiga. Source of seeds is mostly from own kept seeds from the previous crop. Besides, most farmers save seeds from the preceding crop for their next crop. Seed quality is low and worsens the situation for emergence and even more seeds are required then to end with a same plant establishment as before. With the introduction of transplant use less seeds are required. Transplants are raised under protected conditions and at the time of transplanting at each plant hole only one plant is planted. Since a lower amount of seeds is required, high yielding hybrid varieties are within reach of the farmers to be cultivated. Transplants are raised in protected structures, and for the first four weeks transplants are not exposed to the field conditions where easily plants can be infected with diseases or infested with pests. Due to a better seedling quality of transplants as compared to direct sowing plants, a higher yield might be possible as compared to the yield currently present with direct sowing.
Based on these considerations it was decided to test the advantages of transplant use on yield and quality of hot pepper.
The hot pepper agronomic experiments are carried out in the vicinity of Kersana Brebes. Brebes is an important area for hot pepper cultivation. Estimated is that about 40% of the hot pepper production on Java takes place here. Hot pepper is considered as a secondary crop by the local farmers and is used to intercrop with shallot, which is considered as the main crop. Rotation takes place with rice and sugar cane. In general the climate in Brebes is suitable for hot pepper cultivation except for the months December and January when heavy rainfall is present. Hot pepper main season starts in April after the rice is harvested.
Previous experiments in 2007 and early 2008 showed that compared to direct sowing with the use of transplants the percentage of usable seedlings per used seed increased, and therefore a reduction in seed use required for hot pepper cultivation is possible. However, the percentage of usable transplants is still low with and has to be increased to a higher percentage to be economically sound. The sowing process can be optimized to ensure a higher emergence rate and a higher percentage of usable transplants.
With this test the aim was to

- Improve emergence of seeds by:
    - Slightly deeper sowing depth
    - Covering seeds with rice husk after sowing
    - Giving labourers better instructions and watch their work more closely
- Test effect of nursery type on emergence
- Test effect of variety on seedling production and yield

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. Mr. Rien Rodenburg director R&D of PT EWINDO offered valuable advice on hot pepper cultivation. PT Syngenta also assisted to 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 doing the observations.

2 Materials and methods

The experiment was performed in the area of Kersana Brebes (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. The soil can be characterized as a fluvisol with 70% clay.

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

A field at Brebes was rented from farmers for performing the experiments 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. Samples were taken from the field of the top layer of 0 – 30 cm depth. The site was divided in three equal sized blocks. Sampling was done by taking 5 sub samples along the diagonal of the three blocks.
Soil pH-H_2O is slight acid to neutral (Table 1). Phosphate content of the soil is excessive while potassium content is medium. Finally, both calcium and magnesium content is medium to high.

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

Total parcel = 12.7 x 134 m = 1702 m^2

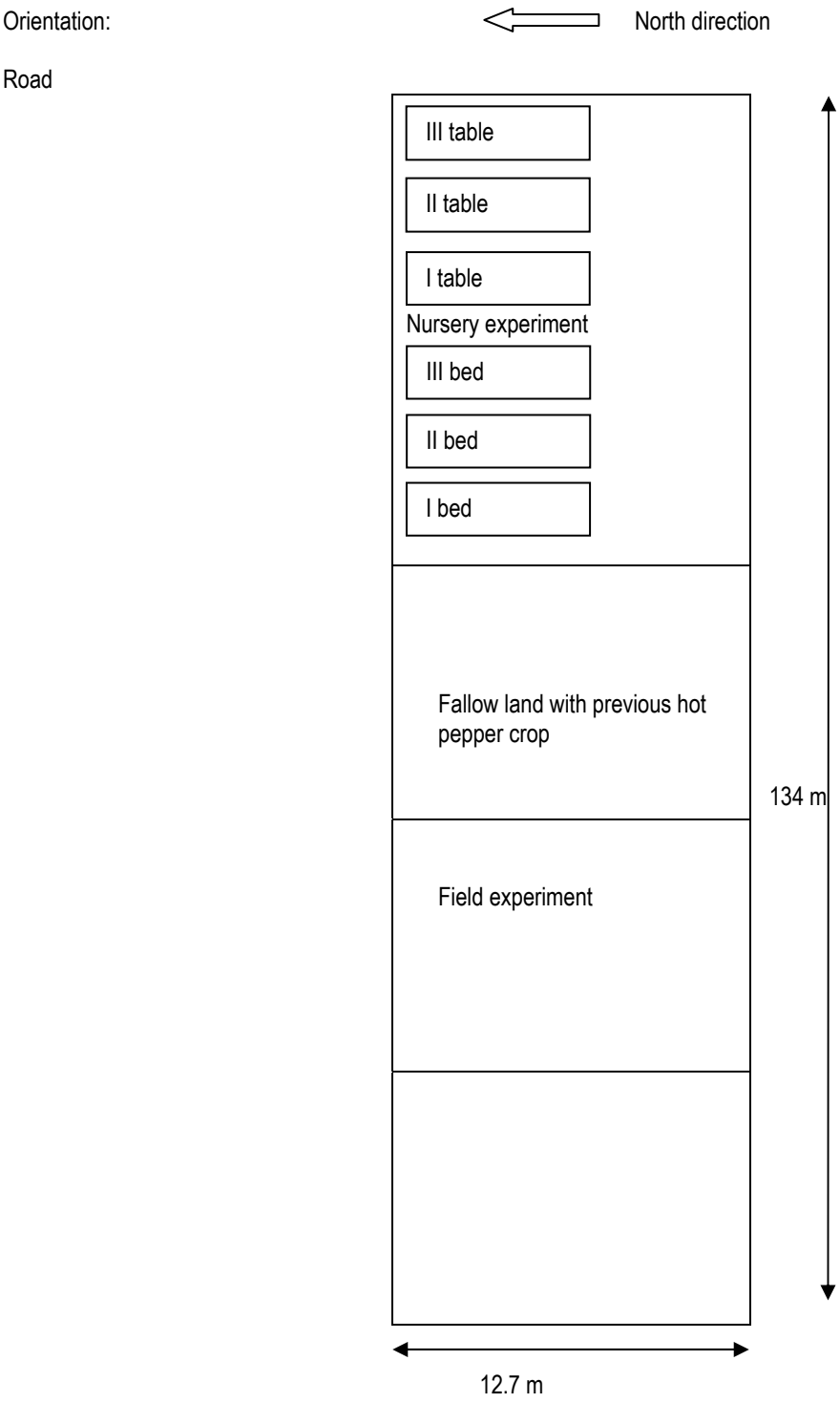


Figure 2. Orientation of the experimental field.

2.1 Nurseries for raising of seedlings

Two types of nurseries (table and soil) were tested on their effect on emergence of seedlings and seedling quality at transplanting (Figure 3, 4 and 5). The nursery placed directly on the soil showed for the raising section the same dimensions as the nursery with a table design, but lacked the table construction. The soil in the soil nursery was covered with insect net to prevent soil insects from entering the nursery and trays were placed directly on this net. Each nursery house was present threefold.

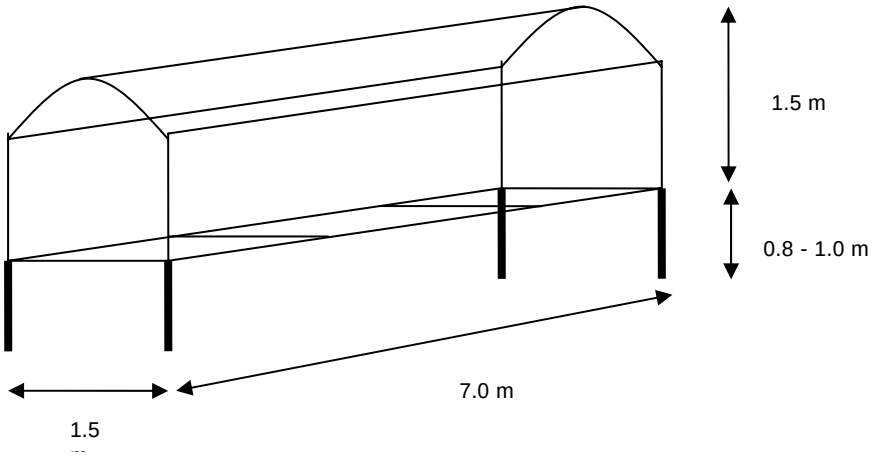


Figure 3. Schematic view of a table nursery.

Figure 4. Inside of the table nursery.

Figure 5. Bed or soil nurseries in the front and table nurseries in the back.

2.2 Hot pepper varieties used for the experiment

Two types of varieties were used in the experiments:

- Local open pollinated variety (Tit Segitiga)
- Hybrid variety (Gada F_1)

Seeds from Tit Segitiga were obtained locally from farmers while seeds from Gada F_1 were donated by PT EWINDO located at Purwakarta.

2.3 Cultivation

2.3.1 Intercropping

Cultivation took place as common practice in Brebes where hot pepper is intercropped with shallot (Figure 6). In Brebes crops are grown on suats or beds surrounded by ditches. In the experiments each plot consisted of half a suat with a plot size of 1.5 x 5.7 m. Shallots were planted one week before hot pepper seeds were sown. Population density of hot pepper for an open pollinated variety was twice the density present with the hybrid variety (Table 2). Hot pepper transplants were transplanted 3 to 4 weeks after shallot was planted. In Annex I, a lay out for the intercropping pattern used in the experiment is presented.

Table 2. 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 (OP)	100	4	25	21	30/60
Hot pepper (F_1)	50	4	13	42	30/60

Figure 6. One Suat or bed accommodating two experimental plots.

2.3.2 Cultivation practice

Sowing of hot pepper in the field and in the nurseries took place on April 18, 2008 (Table 3). Per plot 200 seeds were sown for raising transplants of both varieties while with direct sowing 250 or 500 seeds were used for respectively Gada F_1 and Tit Segitiga.

Shallot was planted in the field on April 18. Transplanting of transplants raised in the nursery into the field took place on May 17, 2008.

Table 3. General information on the cultivation.

Hot pepper sowing	:	April 18th, 2008
Hot pepper transplanting	:	May 17th, 2008
Shallot planting	:	April 11th, 2008
Shallot harvest	:	June 2008
Start hot pepper harvest	:	July 23rd, 2008
End hot pepper harvest	:	September 3rd, 2008
Used seeds	:	200 per plot
Direct sowing (5 seeds per sowing position)	:	500 seeds per plot with Tit Segitiga 250 seeds per plot with Gada F_1
Plant density	:	Tit Segitiga at 12.2 plants per m^2 Gada F_1 at 6.1 plants per m^2

Further cultivation, method of harvesting, amount of fertiliser and pest control of hot pepper took place as farmers' common practice in Kersana Brebes.

2.4 Transplant raising treatments

The media for transplant raising was a mixture containing 1 volume part well composted farm yard goat manure and 1 volume part top soil. Manure was purchased from nearby farms and top soil was collected from the field near to the nurseries.
For container two types were tested namely a modular tray with 128 modules per tray and a plastic bag (Fig. 7). Cell shape was pyramidal with a cell content of 13 cm^3. Plastic bags could hold a volume of 15 cm^3 and holes were punctured in the bottom to provide for drainage.

Figure 7. Plastic bags and modular tray used for transplant raising of hot pepper.

Direct sowing was present as standard common practice reference (Table 4).

Table 4. Treatments present in the nursery.

Variety:	A1:	Tit Segitiga
	A2:	Gada F_1
Raising	B1:	Transparent plastic bag
	B2:	Modular tray
	B3:	Direct sowing
Sowing	S1:	Common practice
	S2:	Sowing at 1 cm depth and covered with rice husk
Nursery	T:	Table nursery
	S:	Soil nursery
	F:	Direct sowing – 5 seeds per hole

At the time of transplanting, only transplants raised in the best performing nursery and of the best sowing technique were transplanted into the field (Table 5). After analysing the transplant raising results, concluded was that performance of the table nursery was better than the soil nursery and that with the improved sowing technique a higher emergence percentage was present. Therefore only transplants raised with the improved sowing technique in the table nursery were transplanted into the field (Table 3). Until ten days after transplanting, dead plants were replaced with left over plants in the nursery.

Table 5. Treatments present in the field.

	Container	Variety	Media	Nursery	Sowing technique
A1	Plastic bag	Tit Segitiga	Manure + Top soil	Table	Improved
A2	Tray	Tit Segitiga	Manure + Top soil	Table	Improved
A3	Plastic bag	Gada	Manure + Top soil	Table	Improved
A4	Tray	Gada	Manure + Top soil	Table	Improved

2.5 Observations

2.5.1 Climate

During the experiment temperature was recorded by taking readings at 14.00 p.m. each day on maximum and minimum temperature. One thermometer per nursery type was placed inside in a shaded position, and one thermometer was placed outside in the field in a shaded spot. Rainfall was measured daily at 6.30 a.m. using a simple rain gauge.
Data of these recordings are listed in Annex IV.

2.5.2 Nutrient content

From the media used for filling the trays and the plastic bags, a sample was taken for analyse on content of nitrogen, potassium, phosphate, calcium and pH level. After preparing the media, in total 1kg of media was collected for analyses on nutrient content.

2.5.3 Light intensity

During transplant raising, light intensity in Lux was measured with a handheld Lux meter (LX93 from Nieuwkoop) inside and outside the nurseries on May 4 and May 20. At two spots located in the middle inside each nursery above the transplants, light intensity was measured. Outside each nursery light intensity was measured at one spot. Percentage available light inside the nurseries was calculated based on these readings.

2.5.4 Nursery observations

Emergence was observed 10 and 20 days after sowing of the treatments. Percentage of normal and abnormal seedlings was calculated.
At transplanting number of normal, usable and abnormal transplants were observed and percentage was calculated. Also number of plants with virus symptoms and infected with thrips were observed. At

transplanting randomly per plot 15 seedlings were selected, cut off at soil level, and measured for plant length, individual plant weight and number of fully developed leaves.
Plant length was measured from the cut off point to the end tip of the leave showing the longest length of a fully stretched out plant. After drying at 70^{o}C for 24 hours the total weight of the 15 plants together was weighed. Percentage 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 factorial 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 transplant raising the maximum temperature was between 37 and 45°C (Fig. 8). Mostly the inside nursery temperature was similar to the outside temperature. In the period of April 18 till May 5, maximum temperature inside the soil nursery was quite higher as compared to the table nursery temperature. Minimum temperature for both nurseries where the same and did not differ from the outside temperature.

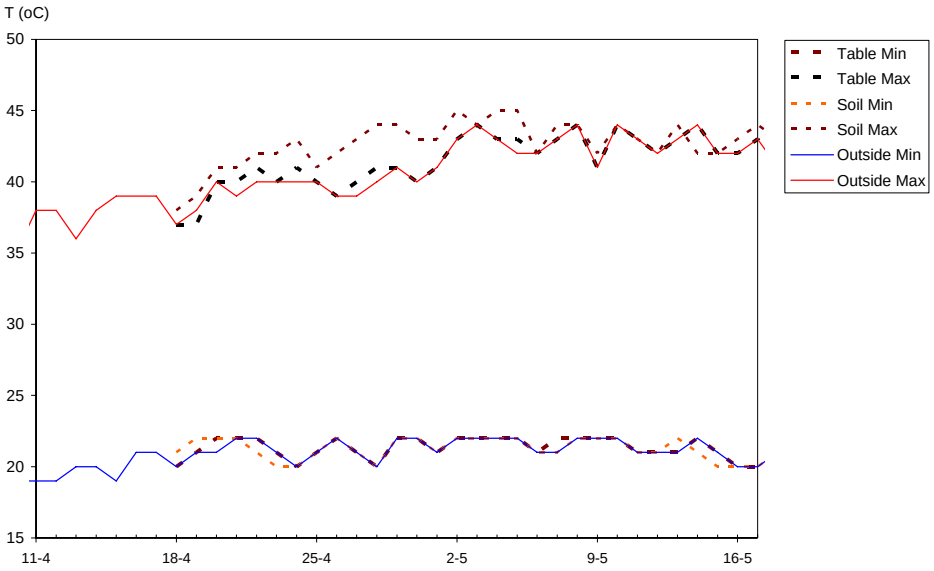


Figure 8. Inside maximum and minimum temperature of table and soil nursery and outside minimum and maximum temperature during transplant raising.

During the month April and May a rainy period was present with over 200 mm precipitation (Fig. 9). The end of August, during harvest, a wet period was noted again with 100 mm precipitation. From April onwards maximum temperature gradually increased from 35 to 45°C. Also minimum temperature increased but to a lesser extend as compared to maximum temperature.

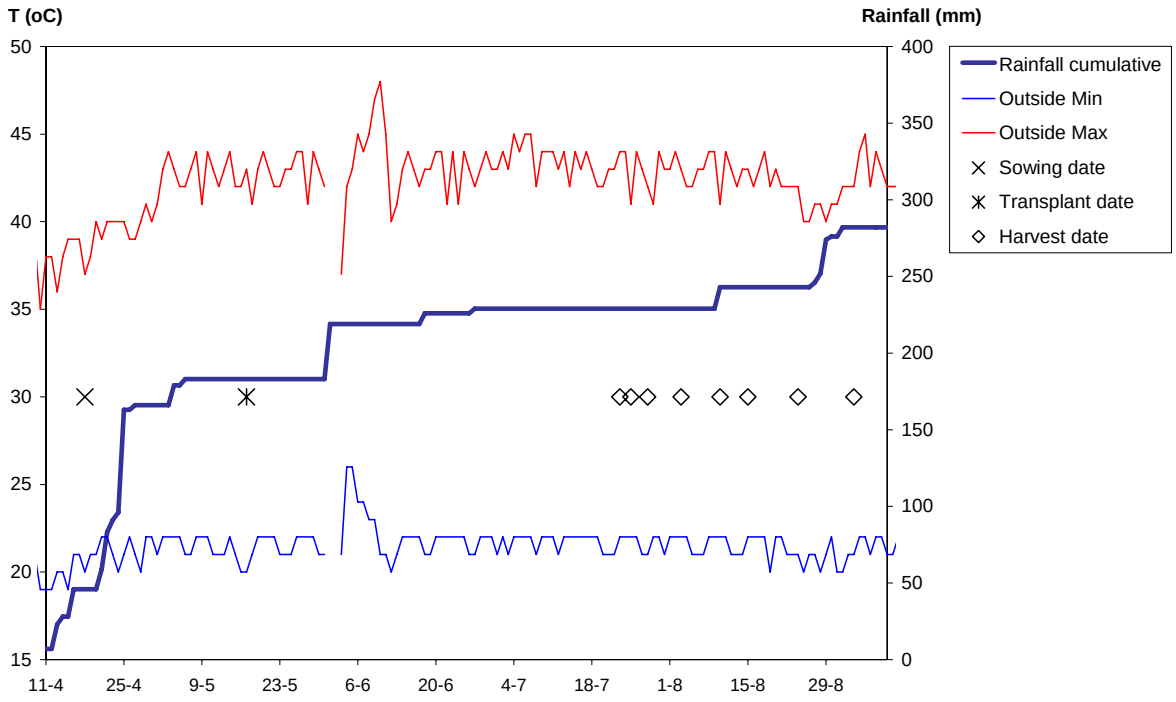


Figure 9. Rainfall and maximum and minimum temperature during the experiment.

3.2 Light levels

On May 4, light intensity in the table nursery was 59% of the out door light level. In the soil nursery the percentage was 54%. On May 20th, the percentages were respectively 70 and 69%.

3.3 Nutrient content of media and soil

The used media in this experiment was the combination of top soil with manure (TS+M) (Table 6). The pH of this media is alkaline with a pH-H_2O of 7.2. For vegetable seedling production a pH of 5.6 to 6.0 or even lower is advisable. Total nitrogen content is about 0.5 % or 500 mg per 100 gram media. Nitrate content was not measured, but content should be 6 to 7.5 mmol per litre. Too high nitrogen content might result in a too vigorous growth of the seedlings, resulting in weak seedlings, 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 Cultivation

During cultivation problems occurred with controlling pests and diseases. Observed pests and diseases during cultivation were thrips, *helicoverpa* spp. and *anthracnose.* Pesticides were applied in order to control these pests and disease. Especially the presence of *helicoverpa* spp. resulted in a significant yield reduction. As a result harvesting had to be terminated before the estimated end of the crop, and the crop had to be destroyed in order to prevent further spreading of the pest to other nearby located experiments.

3.5 Seedling raising results

3.5.1 Percentage normal seedlings

3.5.1.1 Observation after 10 days

Ten days after sowing percentage of normal Gada seedlings was with direct sowing higher compared to the percentage present with Tit Segitiga (Fig. 10). All Gada treatments in the table nursery, with the exception of raising in trays with normal sowing technique, showed a significant higher percentage compared to direct sowing. Also the plastic bag treatment with improved sowing technique in the soil nursery showed a higher percentage than with direct sowing. Tray treatments of Gada showed lower percentages than direct sowing. Nursery treatments of Tit Segitiga did not show higher percentages compared to direct sowing.

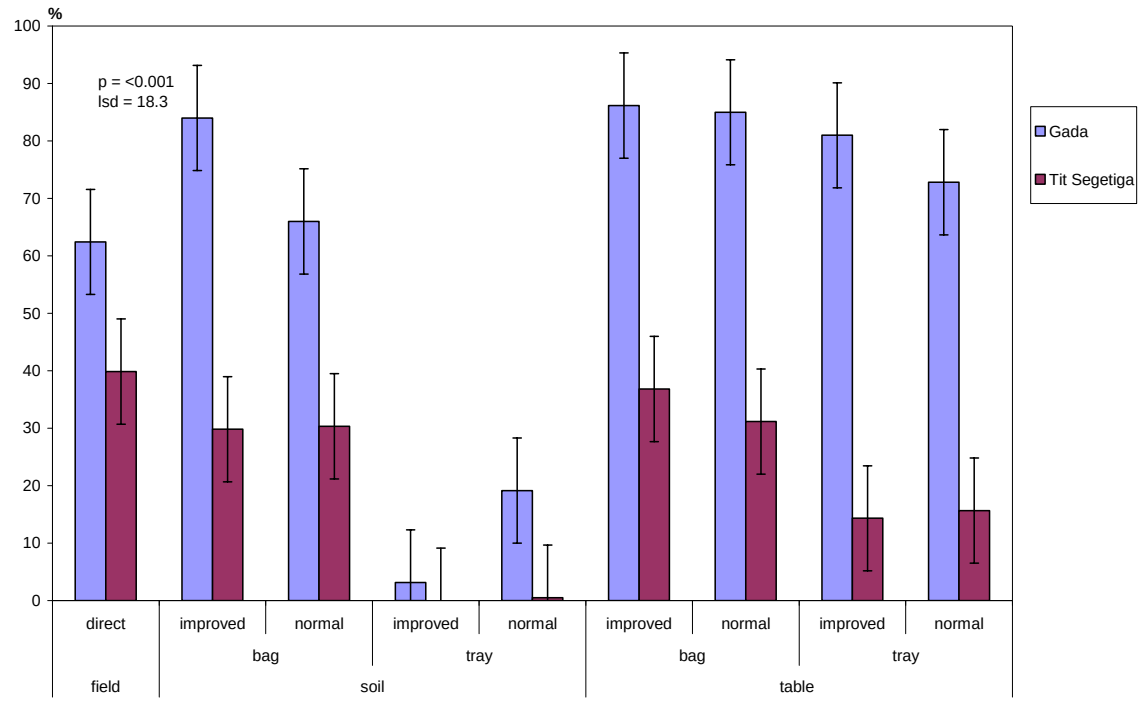


Figure 10. Percentage of normal seedlings observed 10 days after sowing.

Table 7. Effect of variety, nursery and container on percentage of normal seedlings observed 10 days after sowing.

Nursery	Variety	Plastic bag		Tray		Average
Soil	Gada	75.0	d	16.5	b	45.8
	Tit Segitiga	24.8	b c	0.2	a	12.5
Table	Gada	85.6	d	78.9	d	81.2
	Tit Segitiga	34.0	c	23.4	b c	24.5
Table average		54.6		51.2		
Soil average		36.0		22.2		
Gada average		70.2		56.8		
Tit Segitiga average		20.4		16.6		

	p	lsd
Nursery * Variety * Container	0.002	13.3
Variety*Container	< 0.001	9.43
Nursery*Variety	0.001	9.43

On average, a higher percentage of seedlings was present with the improved sowing technique as compared to normal sowing (p=<0.001). Tit Segitiga showed on average a lower percentage than Gada.

With the use of Gada, the effect of container on percentage of normal seedlings after 10 days was less present as it was with Tit Segitiga (Table 7).
The tray treatment of Tit Segitiga in the soil nursery showed the lowest percentage of seedlings compared to the result of the other treatments. Percentage of normal seedlings of the plastic bag treatment was at both nurseries the same. This while the tray treatment in the soil nursery showed a lower percentage normal seedlings compared to the tray treatment in the table nursery.
On average the percentage with the tray treatments was lower compared to the plastic bag treatments. On average treatments in the soil nursery showed lower percentages compared to the respective treatments in the table nursery.

3.5.1.2 Observation after 20 days

After 20 days the percentage of normal seedlings with direct sowing decreased with approximately 10% compared to the observation after 10 days (Fig. 11). In the table nurseries both varieties showed a higher percentage compared to the percentage with direct sowing of the respective varieties. In the soil nursery, only Gada raised in plastic bags with the improved sowing technique showed a higher percentage than direct sowing. With respective treatments, in both nurseries Gada showed a higher percentage of normal seedlings compared to Tit Segitiga.

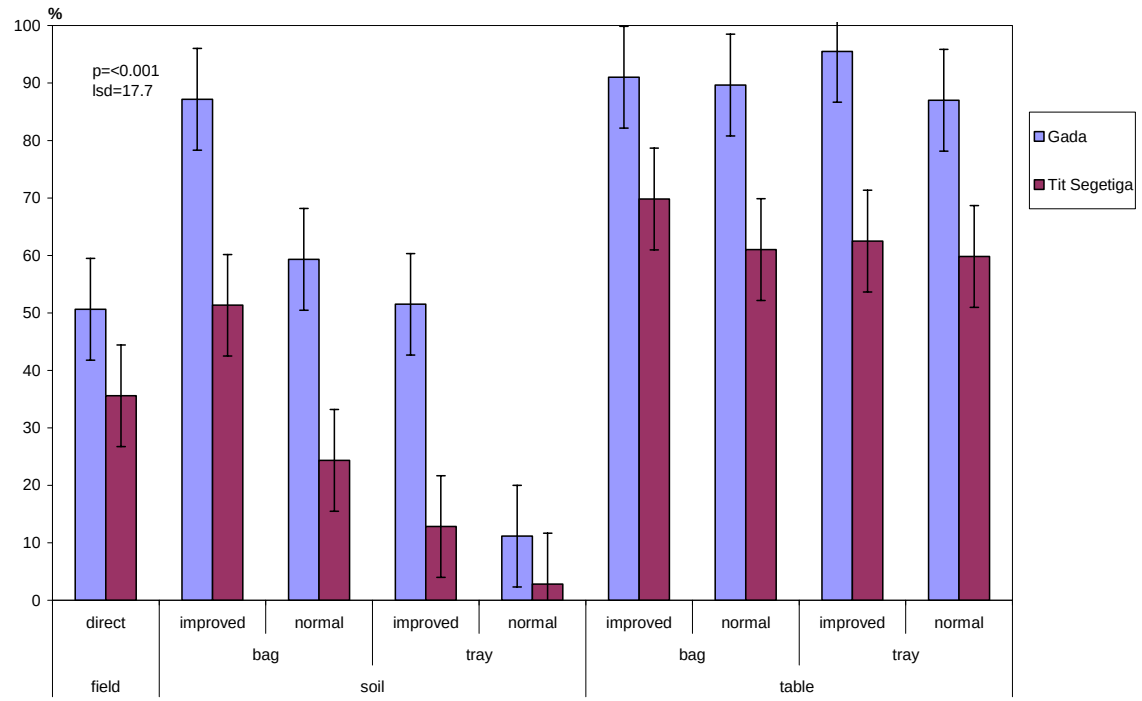


Figure 11. Percentage of normal seedlings observed 20 days after sowing.

On average a higher percentage of normal seedlings after 20 days was present in the table nursery compared to the soil nursery (Table 8). In the table nursery no differences were present in percentage of normal seedlings between raising in plastic bag or in tray. Contrasting, in the soil nursery a lower percentage was present with raising seedlings in a tray compared to raising in plastic bags.

Table 8. Effect of nursery and container on percentage of normal seedlings observed 20 days after sowing.

	Plastic bag	Tray	Average (p=<0.001)
Soil	55.5	19.6	37.6
Table	77.9	76.2	77.0
Average (p= <0.001)	66.7	47.9	
Nursery*Container	p= <0.001; lsd=9.2		

In the table nursery, the improved sowing technique showed a similar percentage as the percentage present with the normal sowing technique (Table 9). In the soil nursery a higher percentage was present with the improved technique compared to the normal sowing technique.

Table 9. Effect of nursery and sowing technique on percentage of normal seedlings observed 20 days after sowing.

	Improved	Normal	Average (p=<0.001)
Soil	50.7	24.4	37.6
Table	79.7	74.4	77.0
Average (p= <0.001)	49.4	65.2	
Nursery*Sowing	p= 0.003; lsd=9.2		

3.5.1.3 Observation at transplanting

At transplanting stage, percentage of normal seedlings with direct sowing in the field was at Gada 43% and at Tit Segitiga 38% (Fig. 12). With the exception of Tit Segitiga tray treatment with the normal sowing technique all treatments in the table nursery showed a higher percentage of normal seedlings than direct sowing for the respective variety.

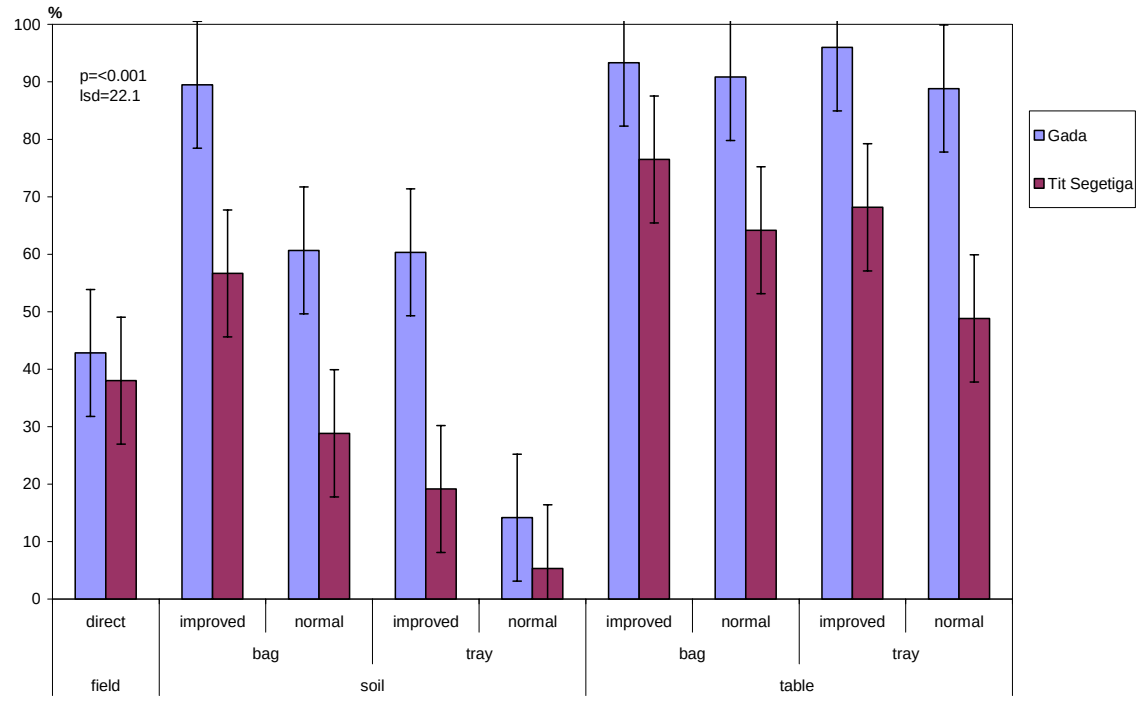


Figure 12. Percentage normal seedlings observed at transplanting.

On average, Gada showed a higher percentage of normal seedlings then Tit Segitiga (p=<0.001). At the table nursery no differences between treatments of Gada were present. At Tit Segitiga with the plastic bag and improved sowing technique a significant higher percentage was present as compared to the tray treatment with normal sowing technique at the table nursery.
At the table nursery percentage of seedlings was similar when raised in tray or in plastic bag, while at the soil nursery percentage of seedlings in trays was significant lower compared to raising in plastic bags (Table 10). On average for both plastic bag and tray the percentage of seedlings was higher in the table nursery compared to raising in the soil nursery.

Table 10. Effect of nursery and container on percentage of normal seedlings observed at transplanting.

	Plastic bag	Tray	Average (p=<0.001)
Soil	58.9	24.8	41.8
Table	81.2	75.5	78.3
Average (p= <0.001)	70.1	50.1	
Nursery*Container	p= <0.001; lsd=11.7		

In the table nursery no difference in percentage of seedlings was present between improved and normal sowing technique (Table 11). In the soil nursery a lower percentage was present with normal sowing technique compared to the improved technique.

Table 11. Effect of nursery and sowing technique on percentage of normal seedlings observed at transplanting.

	Improved	Normal	Average (p=<0.001)
Soil	56.4	27.2	41.8
Table	83.5	73.2	78.3
Average (p= <0.001)	50.2	70.0	
Nursery*Sowing	p= 0.003; lsd=11.7		

3.5.2 Fresh weight of seedlings at transplanting

Fresh weight of seedlings with direct sowing was higher compared to the fresh weight of seedlings raised in nurseries (Fig. 13). With direct sowing fresh weigh of Gada was quite higher than the fresh weight of Tit Segitiga. At the nursery treatments there was no difference in fresh weight between varieties and not between sowing technique.

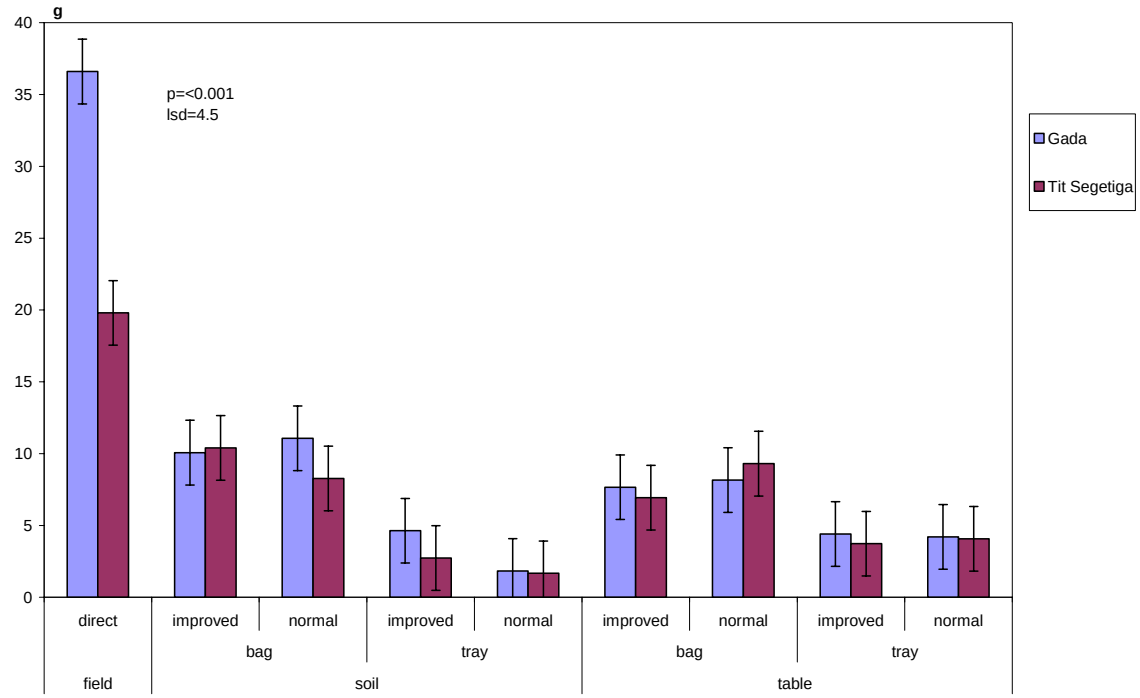


Figure 13. Seedling fresh weight observed at transplanting.

In both nurseries, fresh weight of seedlings raised in plastic bags was higher than the fresh weight of seedlings raised in trays (Table 12). Between nurseries there were no significant differences in fresh weight present.

Table 12. Effect of nursery and container on fresh weight at transplanting.

	Plastic bag	Tray	Average (p=0.7)
Soil	10.0	2.7	6.3
Table	8.0	4.1	6.1
Average (p= <0.001)	8.98	3.4	
Nursery*Container	p= 0.028; lsd=2.1		

3.5.3 Dry weight at transplanting

Dry weight of direct sowed seedlings was higher than the dry weight of seedlings raised in nurseries (Fig. 14). With direct sowing the dry weight of Gada was higher than the dry weight of Tit Segitiga. In both nurseries, dry weight of Gada was similar to the dry weight of Tit Segitiga. The dry weight of seedlings raised in plastic bags was higher compared to the dry weight of seedlings raised in trays. Sowing technique did not influence the dry weight.

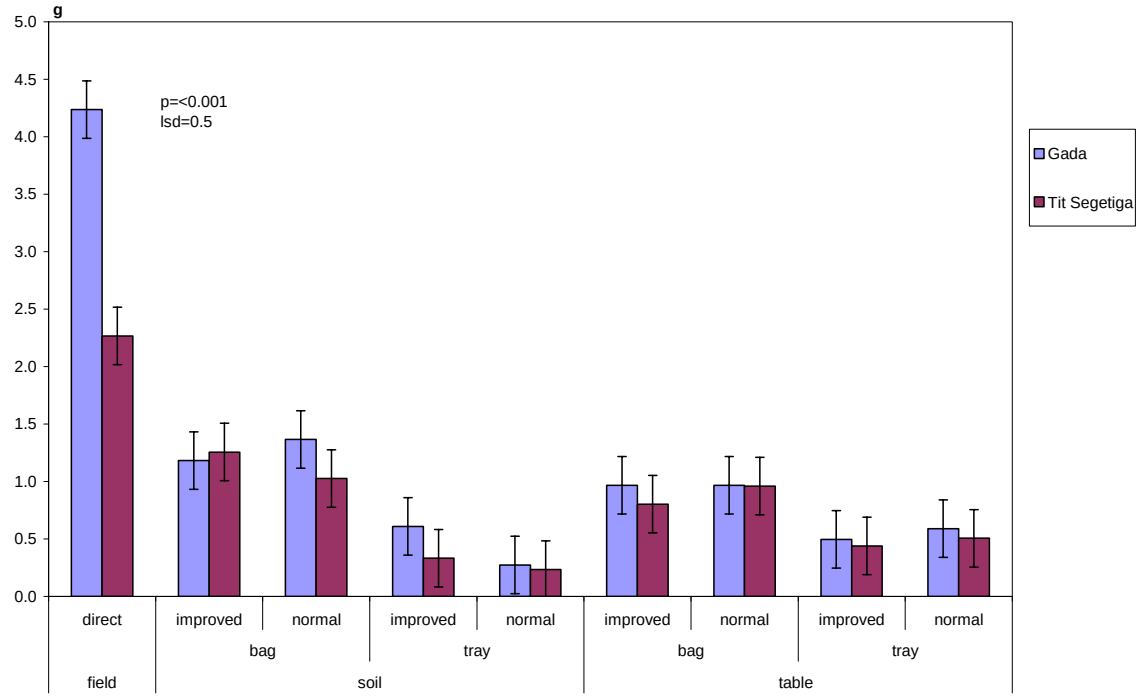


Figure 14. Seedling dry weight observed at transplanting.

Dry weight of seedlings raised in plastic bags in the soil nursery was the highest (Table 13). Dry weight of seedlings raised in plastic bags was higher in the soil nursery than the dry weight of seedlings in the table nursery. With the seedlings raised in trays no difference was present in dry weight between soil or table nursery.

Table13. Effect of nursery and container on dry weight at transplanting.

	Plastic bag	Tray	Average (p=0.5)
Soil	1.2	0.4	0.8
Table	0.9	0.5	0.7
Average (p= <0.001)	1.1	0.4	
Nursery*Container	p= 0.028; lsd=0.27		

3.5.4 Plant length at transplanting

Plant length of Gada was at all treatments higher compared to the length of in a same way raised Tit Segitiga seedlings (Fig. 15). With direct sowing, both Gada and Tit Segitiga showed longer plants compared to the nursery treatments of the respective varieties.

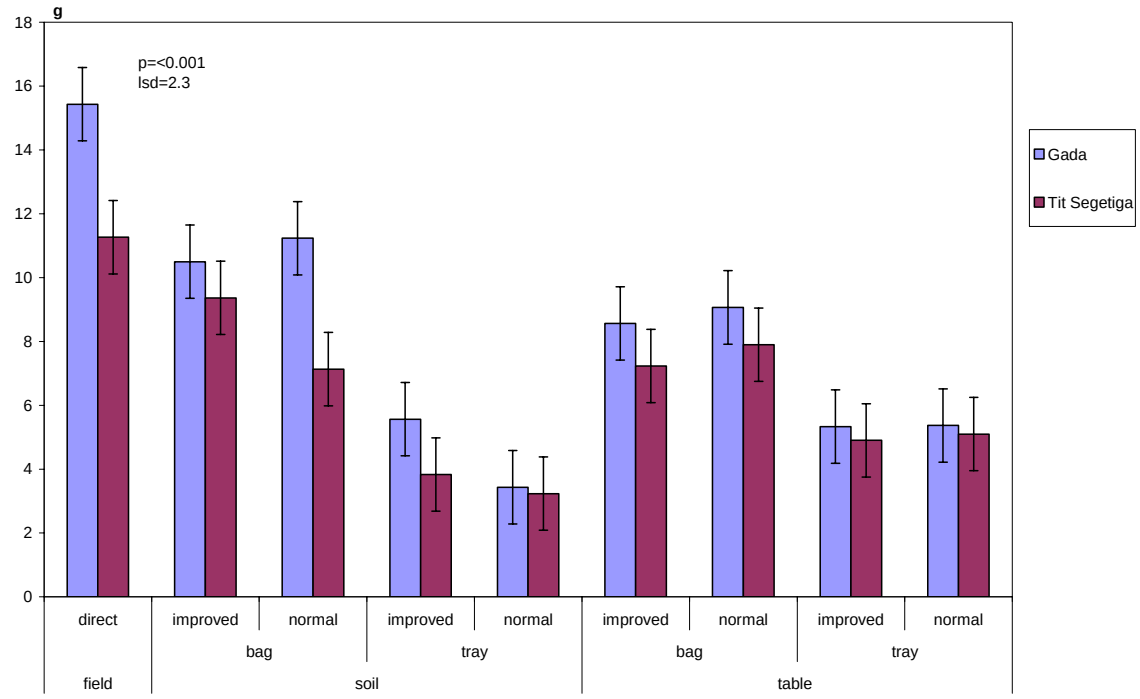


Figure 15. Seedling plant length observed at transplanting.

Length of plants raised in the soil nursery in plastic bags was longer than that of plants raised in plastic bags in the table nursery (Table 14). Plants raised in plastic bags showed a longer length than plants raised in trays. Plant length of plants raised in trays was the same in both soil and table nursery.

Table 14. Effect of nursery and container on plant length at transplanting.

	Plastic bag	Tray	Average (p=0.8)
Soil	9.6	4.0	6.8
Table	8.2	5.2	6.7
Average (p= <0.001)	8.9	4.6	
Nursery*Container	p= 0.004; lsd=1.2		

3.5.5 Number of leaves at transplanting

Number of leaves per seedlings was at direct sowing more as compared to that of seedlings raised in a nursery (Fig. 16). With direct sowing Gada showed a higher leaf number than Tit Segitiga. At the nursery treatments no differences were present between Gada and Tit Segitiga.

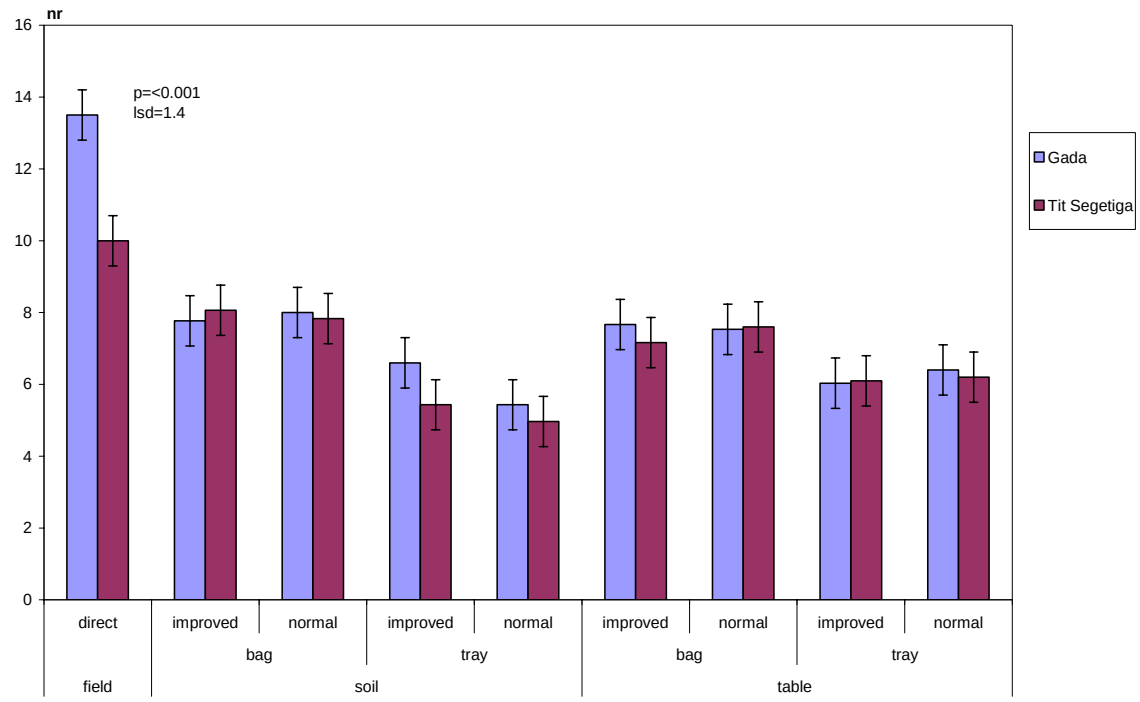


Figure 16. Number of leaves per seedling observed at transplanting.

Seedlings raised in plastic bags did not show a different leaf number between the soil and table nursery (Table 15). With raising in trays, a higher leaf number was present in the table nursery as compared to the soil nursery. On average, number of leaves was higher when seedlings were raised in plastic bags than in trays.

Table 15. Effect of nursery and container on number of leaves at transplanting.

	Plastic bag	Tray	Average (p=0.7)
Soil	7.9	5.6	6.8
Table	7.5	6.2	6.8
Average (p= <0.001)	7.7	5.9	
Nursery*Container	p= 0.034; lsd=0.7		

3.5.6 Presence of thrips and virus at transplanting

At the time of transplanting, with the nursery treatments no seedlings with thrips symptoms could be found while in the field of Tit Segitiga more than 20% and of Gada more than 40% of the plants were already infected with thrips (Fig. 17).

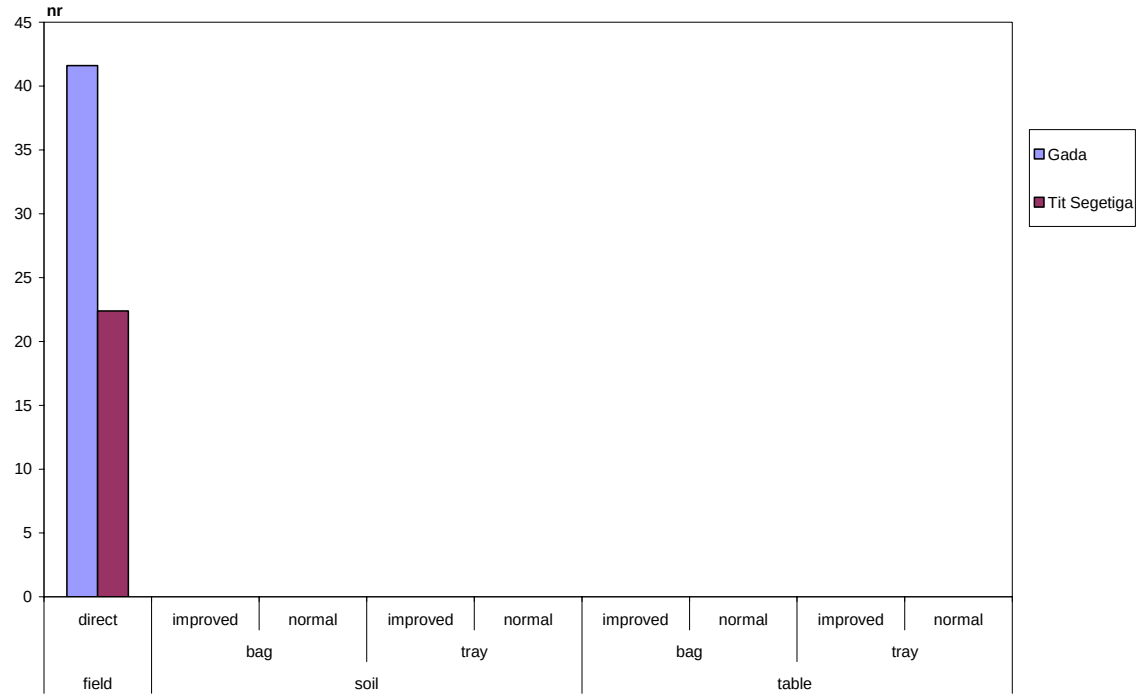
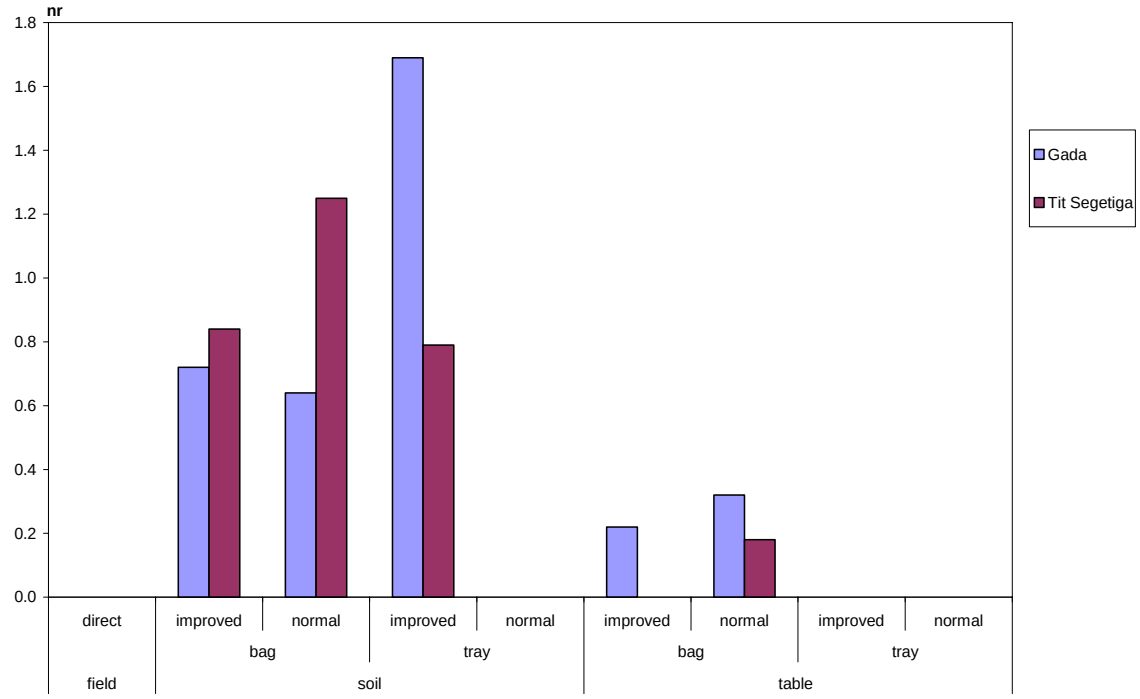


Figure 17. Percentage of seedlings with thrips symptoms at transplanting

Virus symptoms were found especially at treatments in the soil nursery (Fig. 18). Due to the high incidence of thrips symptoms and severity of these with direct sowing, virus symptoms could not be observed properly at that treatment.



.

Figure 18. Percentage of seedlings with virus symptoms

3.6 Harvest results

3.6.1 Total yield of hot pepper

Gada showed with 88 gram per plant, a higher total yield per plant with direct sowing compared to the yield of transplants raised in plastic bags or trays (Table 16). With Tit Segitiga yield of direct sowing was comparable to the yield of plastic bag transplants and higher compared to the yield of transplants raised on trays. On average yield of Gada was higher compared to the yield per plant of Tit Segitiga.

Table 16. Total yield of hot pepper in gram per plant.

	Raising			
Variety	Direct	Plastic bag	Tray	Average
Gada	88.0	65.4	68.8	74.1
Tit Segitiga	41.3	41.9	32.8	38.7
Average	64.6	53.7	50.8	56.4
	p	lsd		
Variety	<0.001	8.1		
Raising	0.038	10.0		
Variety * Raising	0.08	14.1		

Per square meter, yield of Gada was similar to that of Tit Segitiga (Table 17). No significant differences were present for effect of variety or raising.

Table 17. Total yield of hot pepper in gram per m^2.

	Raising			
Variety	Direct	Plastic bag	Tray	Average
Gada	530.4	392.4	418.7	447.2
Tit Segitiga	502.7	508.4	394.2	468.4
Average	516.6	450.4	406.4	457.8
	p	lsd		
Variety	N.S.	19.5		
Raising	N.S.	23.0		
Variety * Raising	N.S.	123.0		

Marketable yield per plant was on average 8.5 gram per plant (Table 18). Raising method had no effect on marketable yield per plant. With Gada a higher marketable yield was present compared to the yield per plant of Tit Segitiga.

Table 18. Marketable yield of hot pepper in gram per plant.

	Raising			
Variety	Direct	Plastic bag	Tray	Average
Gada	16.0	9.4	10.6	12.0
Tit Segitiga	4.4	5.9	4.9	5.1
Average	10.2	7.7	7.7	8.5
	p	lsd		
Variety	0.005	4.1		
Raising	N.S.	5.2		
Variety * Raising	N.S.	7.3		

Per square meter, on average marketable yield was 66.3 gram (Table 19). Between variety and raising no significant differences were present.

Table 19. Marketable yield of hot pepper in gram per m^2.

	Raising			
Variety	Direct	Plastic bag	Tray	Average
Gada	92.8	56.7	64.3	71.3
Tit Segitiga	53.6	72.1	58.5	61.4
Average	73.2	64.4	61.4	66.3
	p	lsd		
Variety	N.S.	23.0		
Raising	N.S.	28.2		
Variety * Raising	N.S.	39.9		

Cumulative total production per plant increased from July 23rd till August 13th (Fig. 19). Production did not increase until August 25th. Cultivation was terminated on September 3rd, and all fruits were harvested then, this resulted in a final production increase at the end.

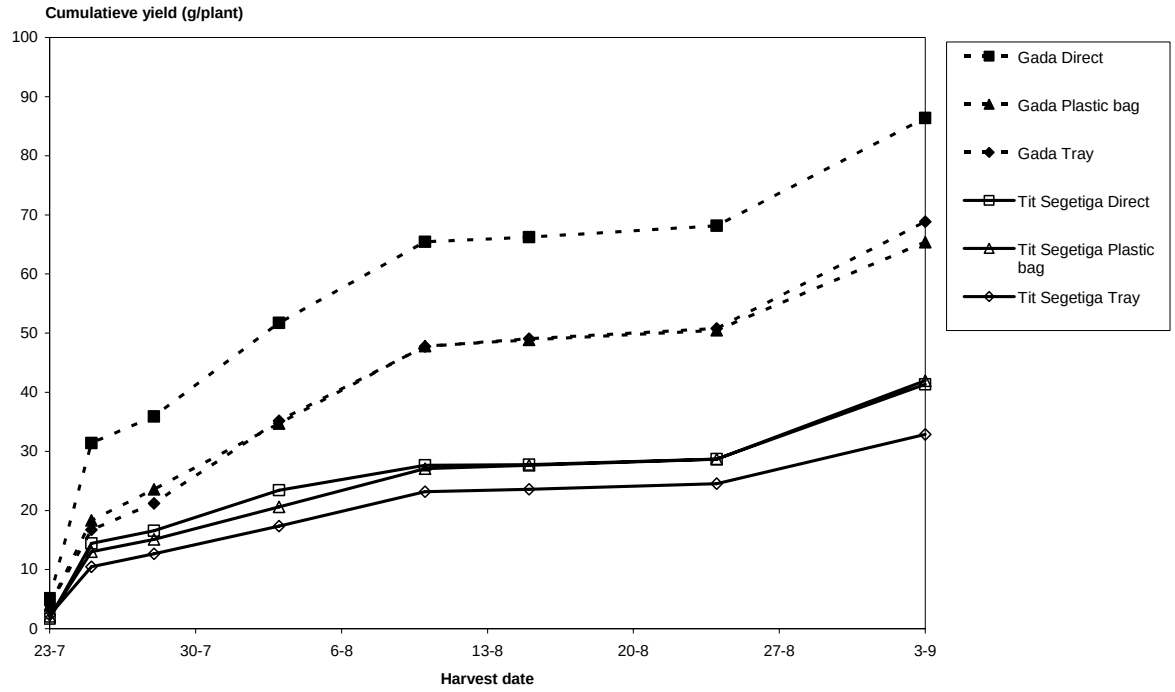


Figure 19. Cumulative total production in gram per plant.

3.6.2 Fruit number

Per plant on average in total 16.7 fruits were harvested (Table 20). No significant differences were present between the different raising techniques. On average Gada showed a higher number of harvested fruits than Tit Segitiga.

Table 20. Total fruit number per plant.

	Raising			
Variety	Direct	Plastic bag	Tray	Average
Gada	23.8	19.1	23.6	22.2
Tit Segitiga	12.3	11.5	9.8	11.2
Average	18.0	15.3	16.7	16.7
	p	lsd		
Variety	<0.001	2.4		
Raising	N.S.	2.9		
Variety * Raising	N.S.	4.0		

Also per square meter no differences were present between raising techniques (Table 21). Per variety, number of harvested fruits was the same as well.

Table 21. Total fruit number per m^2.

	Raising			
Variety	Direct	Plastic bag	Tray	Average
Gada	144.5	114.5	143.7	134.3
Tit Segitiga	149.4	139.9	117.2	135.5
Average	147.0	127.2	130.5	134.9
	p	lsd		
Variety	N.S.	19.5		
Raising	N.S.	23.0		
Variety * Raising	N.S.	24.8		

Number of marketable fruits per plant was on average 1.2 (Table 22). With direct sowing of Gada a higher number was present compared to Gada transplants raised in plastic bags and tray. WithjTit Segitiga no differences in raising technique were present. With direct sowing and transplants raised in trays Gada showed a higher marketable fruit number than Tit Segitiga.

Table 22. Marketable fruit number per plant.

	Raising			
Variety	Direct	Plastic bag	Tray	Average
Gada	2.3	1.3	1.5	1.7
Tit Segitiga	0.6	0.9	0.7	0.7
Average	1.4	1.1	1.1	1.2
	p	lsd		
Variety	<0.001	0.4		
Raising	N.S.	0.5		
Variety * Raising	0.04	0.7		

Per square meter, the number of marketable fruits was with direct sowing of Gada higher compared to raising in plastic bags but was not different from the number of fruit present at seedlings raised in a tray (Table 23). With Tit Segitiga no difference between raising techniques was present. Direct sowing of Gada showed a higher number compared to direct sowing of Tit Segitiga while between the other treatments no differences were present.

Table 23. Marketable fruit number per m^2.

	Raising			
Variety	Direct	Plastic bag	Tray	Average
Gada	13.7	7.7	9.4	10.3
Tit Segitiga	6.9	10.6	8.2	8.6
Average	10.3	9.2	8.8	9.4
	p	lsd		
Variety	N.S.	2.9		
Raising	N.S.	3.5		
Variety * Raising	0.03	5.0		

3.6.3 Share of marketable yield in total production

Percentage marketable yield was on average 33% (Table 24). with direct sowing and raising in plastic bags Gada showed a higher percentage than Tit Segitiga. With Tit Segitiga raised in plastic bags a higher percentage was present compared to direct sowing and raising in trays. With raising in plastic bags of Gada a lower percentage was present compared to direct sowing and raising in trays.

Table 24. Share of marketable yield in the total production (%).

	Raising			
Variety	Direct	Plastic bag	Tray	Average
Gada	39.5	26.6	34.6	33.6
Tit Segitiga	29.1	37.2	31.2	32.5
Average	34.3	31.9	32.9	33.0
	p	lsd		
Variety	N.S.	4.1		
Raising	N.S.	5.0		
Variety * Raising	0.003	7.1		

3.6.4 Average fruit weight

Average weight of fruits in the total yield was for all treatments the same and was on average 4.9 gram (Table 25).

Table 25. Average weight of fruits of the total production (g).

	Raising			
Variety	Direct	Plastic bag	Tray	Average
Gada	5.0	4.8	4.7	4.8
Tit Segitiga	5.0	5.2	4.8	5.0
Average	5.0	5.0	4.8	4.9
	p	lsd		
Variety	N.S.	0.4		
Raising	N.S.	0.5		
Variety * Raising	N.S.	0.6		

Average fruit weight of the marketable yield was 7.2 gram (Table 26). Between treatments no differences in average fruit weight were present.

Table 26. Average fruit weight in gram of the marketable production.

	Raising			
Variety	Direct	Plastic bag	Tray	Average
Gada	6.5	7.6	7.1	7.1
Tit Segitiga	8.0	7.2	6.9	7.3
Average	7.2	7.4	7.0	7.2
	p	lsd		
Variety	N.S.	0.9		
Raising	N.S.	1.1		
Variety * Raising	N.S.	1.5		

4 Discussion

4.1 Effect of nursery on seedling raising

In the soil nursery, percentage of normal seedlings was lower compared to the percentage present in the table nursery. Average fresh weight and dry weight of transplants was higher in the soil nursery. However, plant density in the soil nursery was lower as a result of a lower emergence. Therefore individual seedlings have more nutrients and light available for growing. Temperature in the soil nursery was for a period of two weeks higher compared to the table nursery temperature. In the soil nursery ventilation is probably less compared to the table nursery giving higher temperatures and therefore a lower emergence was present in the soil nursery. Also the poorer performance of the soil nursery can be caused due to a less optimal working condition of the labourers to take care of the seedlings. Probably watering and drainage in the table nursery is more optimal than it is in the soil nursery. Virus symptoms were more present in the soil nursery compared to the table nursery. The reason for this is not known.
Compared to direct sowing, percentage of emergence was at the table nursery higher. With direct sowing five times the amount of seeds is needed in order to accommodate the desired plant population and to have 100 seedlings 500 seeds are required then. With raising in the table nursery, where 90% of the seeds will result in a normal seedling usable for transplanting, for 100 seedlings a total seed number of 111 seeds is needed. When using hybrid seeds, a substantial reduction in seed costs is possible then.

4.2 Effect of sowing technique on seedling raising

Improved sowing technique has a positive influence on emergence and seedling establishment. When sowing was done with more care and seeds were placed at a constant depth, emergence was better. Not observed but also uniformity of the seedlings will be improved. Under harsh conditions (soil nursery) the effect of improved technique is more clear than at more optimal conditions (table nursery). With the improved sowing technique moisture level in the containers are less sensitive to climatic conditions. In the soil nursery due to a higher temperature, moisture levels are influenced to a greater extend than the moisture level in containers in the table nursery. Therefore the effect of improved sowing technique was more notable in the soil nursery..

4.3 Effect of variety on seedling raising and yield

In general the germination and emergence of Gada is better than that of Tit Segitiga. Gada seeds are produced under controlled conditions, where selection takes place on plants infested with viruses and diseases. After harvesting, also a better control on seed quality of Gada is done by EWINDO than what farmers do with own harvested Tit Segitiga seeds.
Gada is producing a higher yield per plant compared to Tit Segitiga. Per square meter where the population of Gada is 50% of the density maintained with Tit Segitiga, the production is still higher or comparable to the production of Tit Segitiga. As a result with Gada only 50% of the seed is required in order to obtain a similar yield compared to the cultivation of Tit Segitiga.
However, overall yield is low. Normally a yield of 250 gram per plant is possible. However, due to heavy attack of the fruits by helicoverpa, yield was dramatically reduced and did not exceed 16 gram per plant

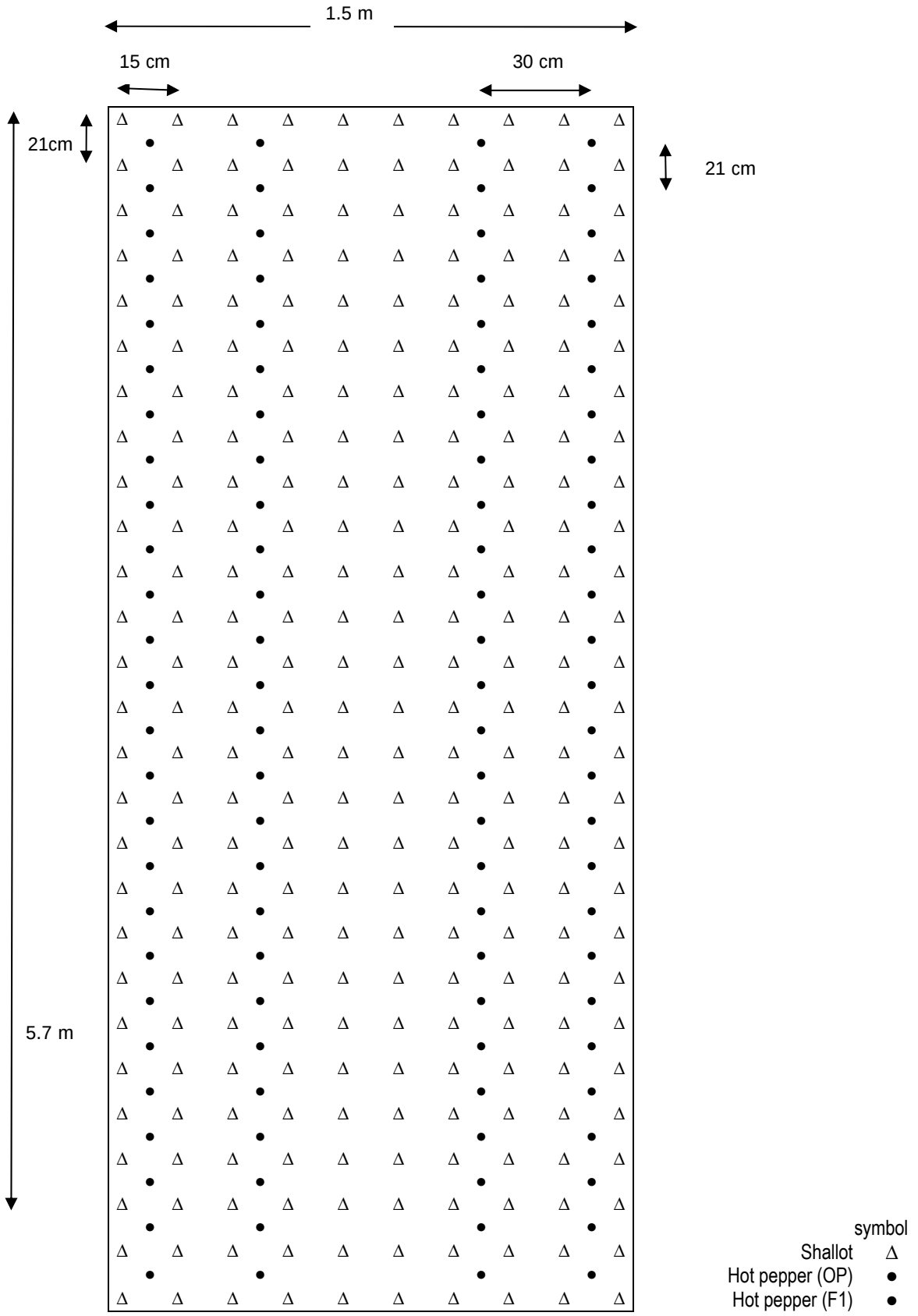
4.4 Effect of container on seedling raising and yield

Influence of container on emergence and percentage usable seedlings was present. Under more optimal conditions in the table nursery, differences in emergence were less pronoun as it was in the soil nursery. Raising in trays is more difficult than raising in plastic bags. Probably the larger plastic bags are less sensitive to environmental conditions on moisture levels than the smaller cells present in the trays. Yield of transplants was similar to direct sowing. Influence of variety in combination with raising technique was present with Gada, where transplants from trays showed a slightly higher yield compared to transplants from plastic bags.

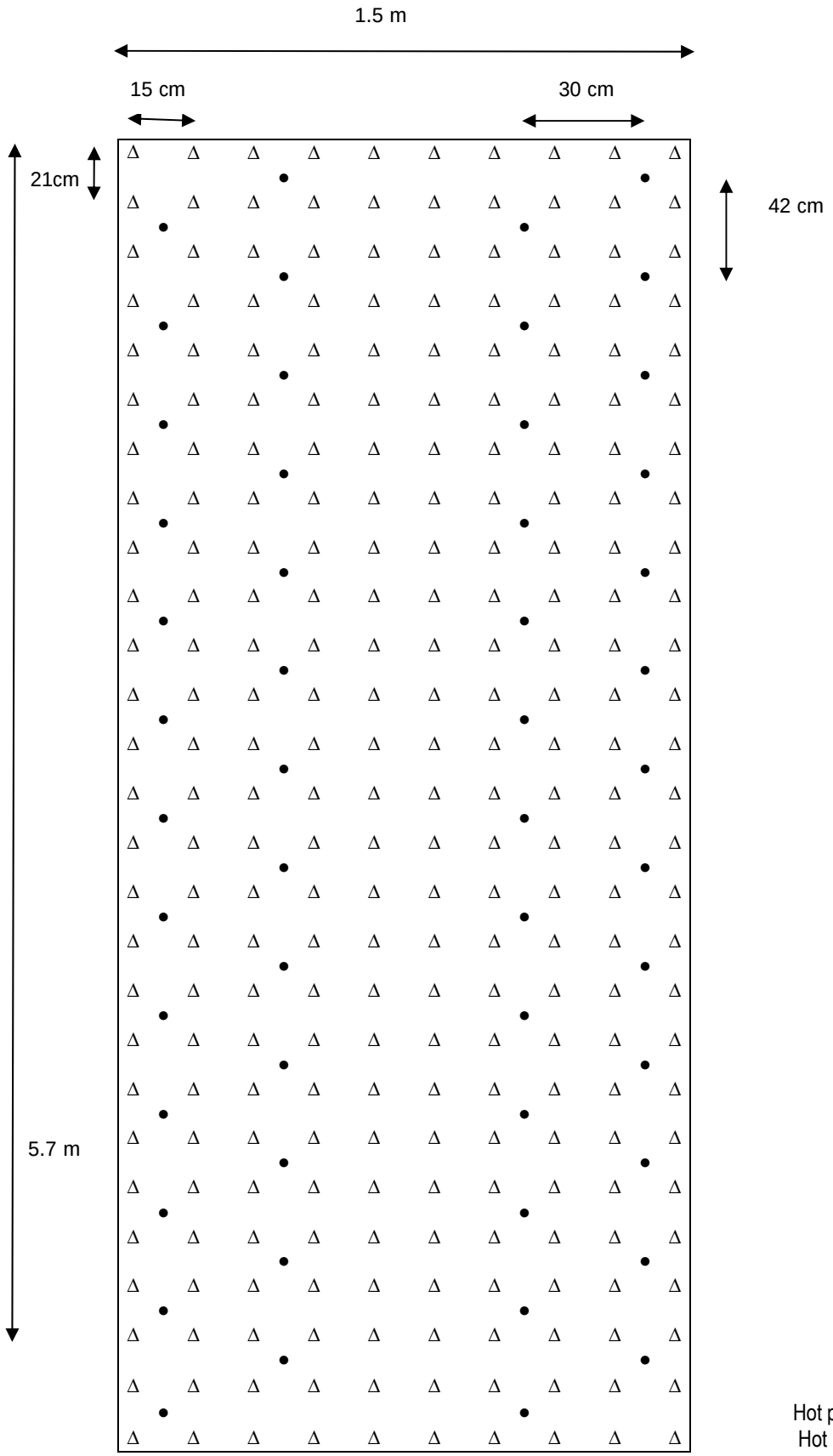
5 Conclusions

- By sowing with more care and at a constant depth with afterwards covering the seeds with rice husk the emergence is improved and results in a higher percentage of usable transplants.
- A table nursery is more preferred than a soil nursery, since it seems climatic conditions in the table nursery are better and results in a better emergence.
- When conditions are less favourable, transplant raising in plastic bags, with a higher buffer capacity for moisture and less risk on dehydration due to the plastic foil material of the bags and higher cell volume, results in a better emergence and higher percentage of usable transplants. When climatic conditions are optimal, differences between plastic bags and trays are minimal.
- Raising in a nursery results in better seedlings. Transplants shows a lower percentage of plants with thrips symptoms. However, yield is similar to direct sowing but a lower amount of seeds is required for that.
- Yield per plant of Gada is twice as much as the yield of Tit Segitiga. With only 50% of the plant population compared to the density used with tit Segitiga, a similar yield per square meter is present. Recommended then is to introduce hybrid varieties.
- Yield of seedlings raised in a nursery are equal or lower then that of direct sowing. However, the harvest had to be terminated before the expected end of the cultivation. Due to the limitating factor of pests and diseases presence the full potential of these seedlings could not be established.
- Due to pest and disease pressure at the test location yield is low. Besides paying attention to raising of seedlings also an adequate pest and disease control programme needs to be formulated. One option could be the introduction of a monocrop culture where mulch can be used. With the use of plastic mulch the incidence of both pests and diseases can be reduced.

Annex I. Plant arrangement per plot



Plant arrangement per plot for the open pollinated variety Tit Segitiga (100 plants = 11.7 pl/m2)



Plant arrangement per plot for hybrid variety Gada F1 (50 plants = 5.8 pl/m2) (recommended = 4.2)

Annex II. Layout of treatments in nurseries.

Soil nursery I

1 Plastic bag Tit Segitiga Improved sowing	2 Plastic bag Gada Normal sowing	3 Tray Tit Segitiga Normal sowing	4 Plastic bag Gada Improved sowing
5 Plastic bag Tit Segitiga Normal sowing	6 Tray Tit Segitiga Improved sowing	7 Tray Gada Normal sowing	8 Tray Gada Improved sowing

Soil nursery II

9 Plastic bag Gada Normal sowing	10 Tray Tit Segitiga Normal sowing	11 Tray Gada Improved sowing	12 Plastic bag Tit Segitiga Improved sowing
13 Plastic bag Gada Improved sowing	14 Tray Tit Segitiga Improved sowing	15 Tray Gada Normal sowing	16 Plastic bag Tit Segitiga Normal sowing

Soil nursery III

17 Plastic bag Tit Segitiga Improved sowing	18 Tray Gada Improved sowing	19 Plastic bag Tit Segitiga Normal sowing	20 Plastic bag Gada Normal sowing
21 Plastic bag Gada Improved sowing	22 Tray Gada Normal sowing	23 Tray Tit Segitiga Improved sowing	24 Tray Tit Segitiga Normal sowing

Table nursery I

25 Plastic bag Tit Segitiga Improved sowing	26 Plastic bag Gada Normal sowing	27 Tray Tit Segitiga Normal sowing	28 Plastic bag Gada Improved sowing
29 Plastic bag Tit Segitiga Normal sowing	30 Tray Tit Segitiga Improved sowing	31 Tray Gada Normal sowing	32 Tray Gada Improved sowing

Table nursery II

33 Plastic bag Gada Normal sowing	34 Tray Tit Segitiga Normal sowing	35 Tray Gada Improved sowing	36 Plastic bag Tit Segitiga Improved sowing
37 Plastic bag Gada Improved sowing	38 Tray Tit Segitiga Improved sowing	39 Tray Gada Normal sowing	40 Plastic bag Tit Segitiga Normal sowing

Table nursery III

41 Plastic bag Tit Segitiga Improved sowing	42 Tray Gada Improved sowing	43 Plastic bag Tit Segitiga Normal sowing	44 Plastic bag Gada Normal sowing
45 Plastic bag Gada Improved sowing	46 Tray Gada Normal sowing	47 Tray Tit Segitiga Improved sowing	48 Tray Tit Segitiga Normal sowing

● = Position for light intensity measurement

Overview all nursery stage treatments

Table nursery

	Variety	Raising System	
		Container	Sowing
TA1B1S1	Tit Segitiga	Transparent plastic bag	Normal
TA1B2S1	Tit Segitiga	Small module tray	Normal
TA1B1S2	Tit Segitiga	Transparent plastic bag	1 cm depth with Rice husk sprinkled on top
TA1B2S2	Tit Segitiga	Small module tray	1 cm depth with Rice husk sprinkled on top
TA2B1S1	Gada	Transparent plastic bag	Normal
TA2B2S1	Gada	Small module tray	Normal
TA2B1S2	Gada	Transparent plastic bag	1 cm depth with Rice husk sprinkled on top
TA2B2S2	Gada	Small module tray	1 cm depth with Rice husk sprinkled on top

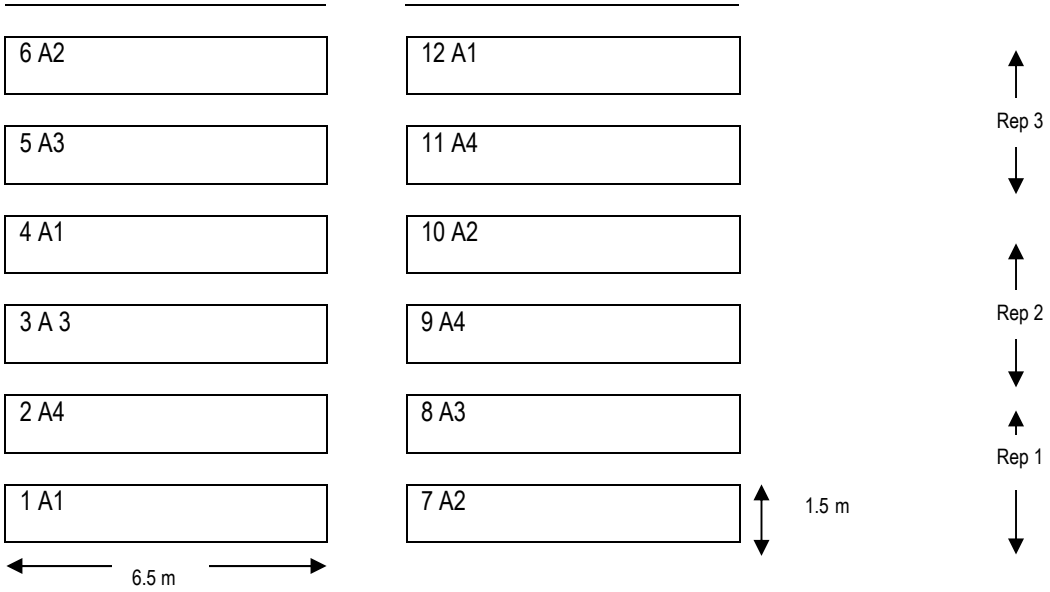
Soil nursery

	Variety	Raising System	
		Container	Sowing
SA1B1S1	Tit Segitiga	Transparent plastic bag	Normal
SA1B2S1	Tit Segitiga	Small module tray	Normal
SA1B1S2	Tit Segitiga	Transparent plastic bag	1 cm depth with Rice husk sprinkled on top
SA1B2S2	Tit Segitiga	Small module tray	1 cm depth with Rice husk sprinkled on top
SA2B1S1	Gada	Transparent plastic bag	Normal
SA2B2S1	Gada	Small module tray	Normal
SA2B1S2	Gada	Transparent plastic bag	1 cm depth with Rice husk sprinkled on top
SA2B2S2	Gada	Small module tray	1 cm depth with Rice husk sprinkled on top

Direct sowing in the field

	Variety	Raising System
FA1B3	Tit Segitiga	Direct seeding
FA2B3	Gada	Direct seeding

Annex III. Layout of treatments in the field.



Field stage treatments for sowing experiment from the table nursery with improved sowing technique.

	Container	Media	Variety
A1	Plastic bag	Manure + Top soil	Tit Segitiga
A2	Tray	Manure + Top soil	Tit Segitiga
A3	Plastic bag	Manure + Top soil	Gada
A4	Tray	Manure + Top soil	Gada

Annex IV. Temperature and rainfall during the experiment.

	Table		Soil		Outside		Rainfall
Date	Min T	Max T	Min T	Max T	Min T	Max T	
11-4-2008					19	38	7
12-4-2008					19	38	0
13-4-2008					20	36	16
14-4-2008					20	38	5
15-4-2008					19	39	0
16-4-2008					21	39	18
17-4-2008					21	39	0
18-4-2008	20	37	21	38	20	37	0
19-4-2008	21	37	22	39	21	38	0
20-4-2008	22	40	22	41	21	40	0
21-4-2008	22	40	22	41	22	39	13
22-4-2008	22	41	21	42	22	40	24
23-4-2008	21	40	20	42	21	40	8
24-4-2008	20	41	20	43	20	40	5
25-4-2008	21	40	21	41	21	40	67
26-4-2008	22	39	22	42	22	39	0
27-4-2008	21	40	21	43	21	39	3
28-4-2008	20	41	20	44	20	40	0
29-4-2008	22	41	22	44	22	41	0
30-4-2008	22	40	22	43	22	40	0
1-5-2008	21	41	21	43	21	41	0
2-5-2008	22	43	22	45	22	43	0
3-5-2008	22	44	22	44	22	44	0
4-5-2008	22	43	22	45	22	43	13
5-5-2008	22	43	22	45	22	42	0
6-5-2008	21	42	21	42	21	42	4
7-5-2008	22	43	21	44	21	43	0
8-5-2008	22	44	22	44	22	44	0
9-5-2008	22	41	22	42	22	41	0
10-5-2008	22	44	22	44	22	44	0
11-5-2008	21	43	21	43	21	43	0
12-5-2008	21	42	21	42	21	42	0
13-5-2008	21	43	22	44	21	43	0
14-5-2008	22	44	21	42	22	44	0
15-5-2008	21	42	20	42	21	42	0
16-5-2008	20	42	20	43	20	42	0
17-5-2008	20	43	20	44	20	43	0
18-5-2008	21	41	21	43	21	41	0

	Table		Soil		Outside		Rainfall
Date	Min T	Max T	Min T	Max T	Min T	Max T	
19-5-2008					22	43	0
20-5-2008					22	44	0
21-5-2008					22	43	0
22-5-2008					22	42	0
23-5-2008					21	42	0
24-5-2008					21	43	0
25-5-2008					21	43	0
26-5-2008					22	44	0
27-5-2008					22	44	0
28-5-2008					22	41	0
29-5-2008					22	44	0
30-5-2008					21	43	0
31-5-2008					21	42	0
1-6-2008							36
2-6-2008							0
3-6-2008					21	37	0
4-6-2008					26	42	0
5-6-2008					26	43	0
6-6-2008					24	45	0
7-6-2008					24	44	0
8-6-2008					23	45	0
9-6-2008					23	47	0
10-6-2008					21	48	0
11-6-2008					21	45	0
12-6-2008					20	40	0
13-6-2008					21	41	0
14-6-2008					22	43	0
15-6-2008					22	44	0
16-6-2008					22	43	0
17-6-2008					22	42	0
18-6-2008					21	43	7
19-6-2008					21	43	0
20-6-2008					22	44	0
21-6-2008					22	44	0
22-6-2008					22	41	0
23-6-2008					22	44	0
24-6-2008					22	41	0
25-6-2008					22	44	0
26-6-2008					21	43	0
27-6-2008					21	42	3
28-6-2008					22	43	0
29-6-2008					22	44	0
30-6-2008					22	43	0

	Table		Soil		Outside		Rainfall
Date	Min T	Max T	Min T	Max T	Min T	Max T	
1-7-2008					21	43	0
2-7-2008					22	44	0
3-7-2008					21	43	0
4-7-2008					22	45	0
5-7-2008					22	44	0
6-7-2008					22	45	0
7-7-2008					22	45	0
8-7-2008					21	42	0
9-7-2008					22	44	0
10-7-2008					22	44	0
11-7-2008					22	44	0
12-7-2008					21	43	0
13-7-2008					22	44	0
14-7-2008					22	42	0
15-7-2008					22	44	0
16-7-2008					22	43	0
17-7-2008					22	44	0
18-7-2008					22	43	0
19-7-2008					22	42	0
20-7-2008					21	42	0
21-7-2008					21	43	0
22-7-2008					21	43	0
23-7-2008					22	44	0
24-7-2008					22	44	0
25-7-2008					22	41	0
26-7-2008					22	44	0
27-7-2008					21	43	0
28-7-2008					21	42	0
29-7-2008					22	41	0
30-7-2008					22	44	0
31-7-2008					21	43	0
1-8-2008					22	43	0
2-8-2008					22	44	0
3-8-2008					22	43	0
4-8-2008					22	42	0
5-8-2008					21	42	0
6-8-2008					21	43	0
7-8-2008					21	43	0
8-8-2008					22	44	0
9-8-2008					22	44	0
10-8-2008					22	41	14
11-8-2008					22	44	0
12-8-2008					21	43	0
13-8-2008					21	42	0
14-8-2008					21	43	0
15-8-2008					22	43	0

	Table		Soil		Outside		Rainfall
Date	Min T	Max T	Min T	Max T	Min T	Max T	
16-8-2008					22	42	0
17-8-2008					22	43	0
18-8-2008					22	44	0
19-8-2008					20	42	0
20-8-2008					22	43	0
21-8-2008					22	42	0
22-8-2008					21	42	0
23-8-2008					21	42	0
24-8-2008					21	42	0
25-8-2008					20	40	0
26-8-2008					21	40	0
27-8-2008					21	41	3
28-8-2008					20	41	6
29-8-2008					21	40	22
30-8-2008					22	41	2
31-8-2008					20	41	0
1-9-2008					20	42	6
2-9-2008					21	42	0
3-9-2008					21	42	0

Annex V. Nursery data and results.

nursery	container	variety	system	10 days %	20 days %	at transplanting %
		Gada	Direct	62.4 f	50.6 d e	42.8 c d e
		Tit Segitiga	Direct	39.9 e	35.6 c d	38.0 c d
Soil	Bag	Gada	Improved	84.0 g h	87.2 g h	89.5 h i
Soil	Bag	Gada	Normal	66.0 f g	59.3 e f	60.7 e f g
Soil	Tray	Gada	Improved	29.8 c d e	51.5 d e	60.3 e f g
Soil	Tray	Gada	Normal	3.2 a b	11.2 a b	14.2 a b
Soil	Bag	Tit Segitiga	Improved	30.3 c d e	51.3 d e	56.7 d e f g
Soil	Bag	Tit Segitiga	normal	19.2 b c d	24.3 b c	28.8 b c
Soil	Tray	Tit Segitiga	Improved	0.0 a	12.8 a b	19.2 a b
Soil	Tray	Tit Segitiga	Normal	0.5 a	2.8 a	5.3 a
Table	Bag	Gada	Improved	86.2 h	91.0 h	93.3 i
Table	Bag	Gada	Normal	85.0 h	89.7 h	90.8 i
Table	Tray	Gada	Improved	81.0 g h	95.5 h	96.0 i
Table	Tray	Gada	Normal	72.8 f g h	87.0 g h	88.8 h i
Table	Bag	Tit Segitiga	Improved	36.8 d e	69.8 f g	76.5 g h i
Table	Bag	Tit Segitiga	Normal	31.2 c d e	61.0 e f	64.2 e f g
Table	Tray	Tit Segitiga	Improved	14.3 a b c	62.5 e f	68.2 f g h
Table	Tray	Tit Segitiga	Normal	15.7 a b c	59.8 e f	48.8 c d e f
				42.1	55.7	57.9
		p =		< 0.001	<0.001	<0.001
		lsd=		18.3	17.7	22.1

nursery	container	variety	system	fresh weight	dry weight	plant length
		Gada	Direct	36.6 f	4.2 g	15.4 h
		Tit Segitiga	Direct	19.8 e	2.3 f	11.3 g
Soil	Bag	Gada	Improved	10.1 d	1.2 d e	10.5 f g
Soil	Bag	Gada	Normal	11.1 d	1.4 e	11.2 g
Soil	Tray	Gada	Improved	4.6 a b c	0.6 a b c	5.6 b c d
Soil	Tray	Gada	Normal	1.8 a	0.3 a b	3.4 a b
Soil	Bag	Tit Segitiga	Improved	10.4 d	1.3 d e	9.4 e f g
Soil	Bag	Tit Segitiga	normal	8.3 c d	1.0 c d e	7.1 c d e
Soil	Tray	Tit Segitiga	Improved	2.7 a	0.3 a b	3.8 a b
Soil	Tray	Tit Segitiga	Normal	1.7 a	0.2 a	3.2 a
Table	Bag	Gada	Improved	7.7 b c d	1.0 c d e	8.6 e f
Table	Bag	Gada	Normal	8.2 b c d	1.0 c d e	9.1 e f g
Table	Tray	Gada	Improved	4.4 a b c	0.5 a b c	5.3 a b c
Table	Tray	Gada	Normal	4.2 a b c	0.6 a b c	5.4 a b c
Table	Bag	Tit Segitiga	Improved	6.9 b c d	0.8 b c d	7.2 c d e
Table	Bag	Tit Segitiga	Normal	9.3 d	1.0 c d e	7.9 d e
Table	Tray	Tit Segitiga	Improved	3.7 a b	0.4 a b	4.9 a b c
Table	Tray	Tit Segitiga	Normal	4.1 a b c	0.5 a b c	5.1 a b c
				8.6	1.0	7.5
		p =		<0.001	< 0.001	<0.001
		lsd=		4.5	0.5	2.3

nursery	container	variety	system	no of leaves	thrips %	Virus%
		Gada	Direct	13.5 j	41.6 c	0.0
		Tit Segitiga	Direct	10.0 i	22.4 b	0.0
Soil	Bag	Gada	Improved	7.8 f g h	0 a	0.7
Soil	Bag	Gada	Normal	8.0 g h	0 a	0.6
Soil	Tray	Gada	Improved	6.6 b c d e f g	0 a	1.7
Soil	Tray	Gada	Normal	5.4 a b	0 a	0.0
Soil	Bag	Tit Segitiga	Improved	8.1 h	0 a	0.8
Soil	Bag	Tit Segitiga	normal	7.8 f g h	0 a	1.3
Soil	Tray	Tit Segitiga	Improved	5.4 a b	0 a	0.8
Soil	Tray	Tit Segitiga	Normal	5.0 a	0 a	0.0
Table	Bag	Gada	Improved	7.7 f g h	0 a	0.2
Table	Bag	Gada	Normal	7.5 d e f g h	0 a	0.3
Table	Tray	Gada	Improved	6.0 a b c	0 a	0.0
Table	Tray	Gada	Normal	6.4 b c d e f	0 a	0.0
Table	Bag	Tit Segitiga	Improved	7.2 c d e f g h	0 a	0.0
Table	Bag	Tit Segitiga	Normal	7.6 e f g h	0 a	0.2
Table	Tray	Tit Segitiga	Improved	6.1 a b c d	0 a	0.0
Table	Tray	Tit Segitiga	Normal	6.2 a b c d e	0 a	0.0
				7.4	3.6	0.4
		p =		<0.001	<0.001	NS
		lsd=		1.4	6.9	