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vegIMPACTNL

Improving vegetable production and strengthening private sector development in Indonesia

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vegIMPACT Report 10 – Performance of True Shallot Seed (TSS) production using different production systems

Performance of True Shallot Seed (TSS) production using different productions systems

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Contents

1. Summary

True Shallot Seed (TSS) has a high potential in terms of productivity compared to the standard traditional production of shallots from vegetative bulbs of the Bima variety. Since TSS starts from seeds it is produced differently from the traditional shallot. Within TSS production more or less three different types of starting material are present: direct sowing, minibulb or transplant. Each of them had benefits and disadvantages in terms of raising first and in final yield in relation to location and climate. In 2019 experiments were implemented to test the performance of the TSS using the three different starting materials in relation to the performance of the standard Bima shallot.

The varieties tested where Sanren F1 from PT EWINDO and Maserati F1 from De Groot en Slot. Both varieties showed higher yields than the standard Bima used in the tests.

Results showed that location and climate have a big impact on the performance of TSS in relation to the used starting material. Overall transplants performed at both locations and all seasons good. Direct sowing did not perform well in the first season where climatic conditions are still slightly wet with showers from time to time. Minibulb production in the rainy season is possible but with the use of a nursery with rain covers. In the open field the production failed due to too moist soil conditions that resulted in presence of soil borne diseases that attacked the bulbs. Since TSS seeds are expensive it is important to end with a high emergence in the nursery or field and also with the use of transplants or minibulbs with a good plant establishment. For this seed quality of the variety should be high.

The tests were done in close cooperation between PT Sumbawang (Sumbawa, Indonesia), PT East West Seed (Purwakarta, Java, Indonesia), the Indonesian Vegetable research Institute (Lembang, Java, Indonesia), Wageningen University and Research (The Netherlands) and Yayasan Bina Tani Sejahtera (YBTS) (Jakarta, Indonesia).

2. Introduction

In Indonesia shallot is an important vegetable crop mainly grown in lowland areas of Java. Traditionally farmers grow shallots from vegetative bulbs which they have kept from a previous crop or bought from a neighbour. Degeneration of bulbs and diseases affecting the bulb quality result in relatively low yields of 5 to 10 t/ha. The last decades True Shallot Seed (TSS) is being promoted as an alternative to the current system. Instead of vegetative bulbs as starting material for a crop seeds are used. However, different paths can followed to produce shallots for consumption from this. A farmer can use direct sowing where seeds are directly place at the final spot where the bulbs will be produced. However, this method is laborious with hand sowing and with machine sowing it is only possible on light loam-sandy soils. Secondly the field period is extended with a month due to the longer growing period from seed to final bulb as compared to plant bulb to consumption bulbs. Other methods are to produce, either by the farmers him/herself or by a specialised commercial business, first a transplant or minibulb in a nursery and plant or transplant these later on in the field. The field period will be similar to the traditional production method. With minibulbs a storage period is needed to break dormancy of the bulbs. Besides the production of minibulbs takes 2-3 months. Experience of TSS promotors showed also that since the minibulb is similar to the consumption bulb farmers tend to sell them for consumption when market prices are high and thus availability of starting material will be limited. A third option is the use of transplants where in a nursery within 3 to 4 weeks seedlings are grown and after transplanted into the production field.

Field and climatic conditions can have an effect on the performance of the TSS production in relation to the selected starting material. Therefore in 2019 experiments were done to investigate the best way of producing minibulbs and transplants, testing the three different methods (direct sowing, minibulb and transplant) at two different locations in three different seasons.

3. Part I: Minibulb production

In 2018 two tests were implemented to determine the effect of sowing density on minibulb production. One test was done at a farmers field in the regency of Indramayu (north west of Cirebon on Java). The second test was done at IVEGRI in Lembang.

3.1 Production in the lowland of Indramayu

The experiment was conducted at a farmers field in the lowland of West-Java (Table 1). The variety used in this test was Sanren F1 from EWINDO PT. For vegetable production like shallots farmers prepare beds after rice production. Soil is earthen up to beds of approximately 10 – 15 m long and 1 to 1.5 m wide surrounded by a ditch of about 50 cm deep and 50 cm wide filled with water.

Table 1 General information of the experimental site.

Location	:	Sumuradem, Sukra, Indramayu, West Java
GPS coordinates	:	-6.314105, 107.961865
Altitude	:	9 m A.S.L.
Soil type	:	Clay (fluvisol)
Variety	:	Sanren F1
TKW	:	3.8 g per 1,000 seeds

On the beds constructed by the farmer plots of 1 by 2 meter were marked for direct sowing of shallot seeds (Table 2). Perpendicular on the bed direction every 10 cm shallow furrows of about 1 cm deep were pressed in the soil using a bamboo stick. Seeds were manually sown in those furrows at two different distances in the furrow. After the seeds were placed in the furrows these were covered with soil. After this the soil was covered with rice husk and a plastic sheet to favourite germination and emergence.

Table 2 Experimental data for direct sowing production method.

Design	:	Complete Randomized Block Design
Blocks	:	4
Plot size	:	1 x 2 m
Sowing date	:	18 October 2018
Harvest date	:	17 January 2019

Two sowing densities were tested, D1 with a density of approximately 750 seeds per square meter and D2 with a density of approximately 1000 seeds/m^2.

Table 3 Treatments Direct sowing.

Treatment	Density	Density	Distance between lines	Number of seeds per line of 1	Average distance within lines (cm)

	(sds/m2)	(g/m2)	(cm)	meter	
D1	750	2.9	10	75	1.3
D2	1000	3.8	10	100	1.0

For the experiments plots were randomized according to a complete randomized block structure set up (Fig. 1)

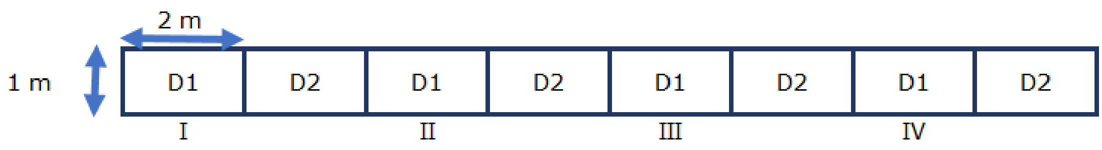

Figure 1 *Layout of the experiment.*

The experiment with transplants was done on beds next to the test with direct sowing (Table 4). Sowing took place in two nurseries similar to the method described for direct sowing. After seedlings were large enough they were transplanted into the field.

Table 4 *Experimental data for transplant production method.*

Transplant phase		
Blocks	:	1
Plot size nursery transplant	:	1.5 x 10 m (1 nursery per per density)
Field phase		
Blocks	:	6
Plot size	:	1.5 x 10 m
Planting distance transplants	:	5 x 10 cm
Sowing date	:	18 October 2018
Transplant date	:	19 November 2018
Harvest date	:	17 January 2019

Transplants were raised using different sowing densities at sowing (Table 5). For this only one nursery per sowing density was used (Fig. 2).

Table 5 Treatments Transplant raising.

Treatment	Nursery density (sds/m2)	Density (g/m2)	Distance between lines (cm)	Number of seeds per line of 1 meter	Average distance within lines (cm)
T1	1316	5	10	132	0.75
T2	2632	10	10	263	0.38

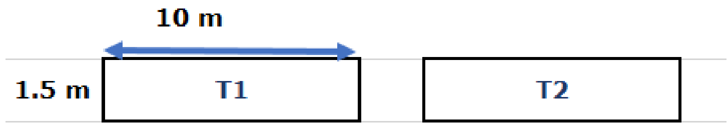

Figure 2 Layout of the nursery with 2 densities (T1 = 5 g/m² and T2 = 10 g/m²).

In the field only one planting density was applied for transplants from both sowing densities and randomized according to a complete randomized block design (Fig. 3).

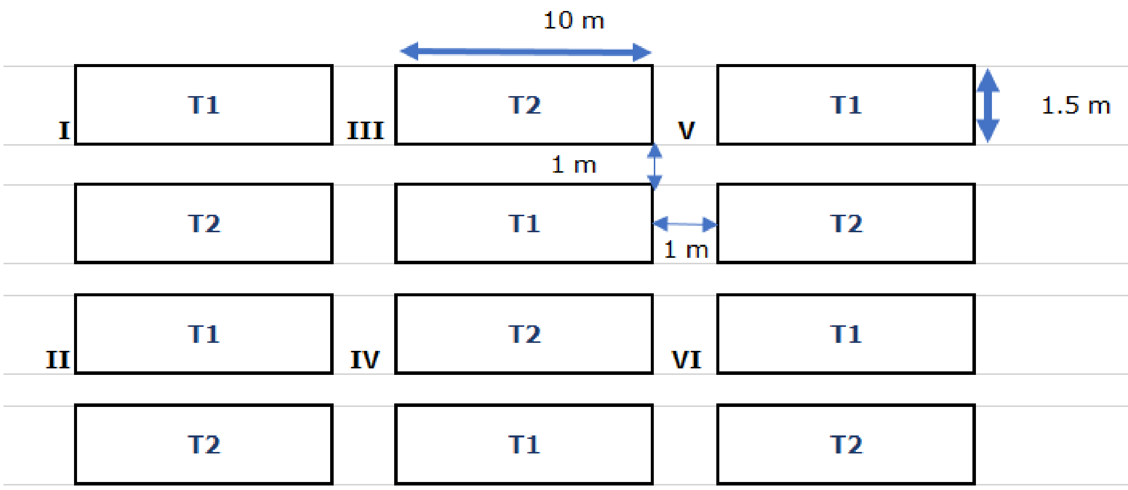

Figure 3 Layout of the field with transplants from two different sowing densities (T1 from D1 planted at 5 x 10 cm and T2 from D2 planted at 5 x 1).

Seeds were sown manually by placing the calculated amount of seeds per meter in a pre drawn sowing furrow in the beds. Beds were made a week before sowing using manual labour. One day before sowing lime and compost were incorporated in the top soil.

Immediately after sowing beds were lightly watered and covered with silver coloured plastic mulch. The mulch was removed three days after sowing. Simultaneously plastic covers were constructed to protect later on the beds against heavy rain.

Fertilization and crop protection was according to good agricultural practices. In the direct sowing experiment, fertilization was done before planting with 200 kg/ha Superphosphate (0-36-0), and two top dressings on October 29 and on November 9 with 80 kg/ha NPK 16-16-16 and 350 kg/ha KNO3 per application date. To control soil borne pests Regent 3G was applied and the insecticides Besfast and Buldok were applied to control mainly Spodoptera. Previcur N was sprayed to control fungal diseases. Once fusarium was observed the fungicides Trivia and Delsene and also Bactocyn were applied to prevent further spreading of the disease. When necessary irrigation was done twice a day, in the morning and in the afternoon. Weeding was done twice manually during the field period, the first time on October 28 and the second time on November 8.

Harvest of both production systems took place on January 17. Due to the fusarium infection it was decided to harvest the crop prematurely.

3.1.2 Observations

At the direct sowing plots emergence and establishment was observed at 7, 13, 40 and 85 days after sowing. Per plot the number of emerged plants was observed at 7 and 13 days by counting the number of plants at 4 sowing rows of 1 meter length per plot. At 40 and 85 days the number of established plant clusters per plot was observed per four original sowing lines plot. For the transplant treatment only the number of established transplants after 20 and 55 days after planting was observed per 1 m2 per plot.

After noticing in the second week of December the presence of the disease fusarium in the field observations were done on number of affected plants per plot. Affected plants were removed on a daily base and the number of removed plants was recorded per plot. Samples of the plants with disease symptoms were send to the R&D laboratory of PT EWINDO to confirm the visual observation of fusarium infection.

At harvest total marketable yield per plot was recorded immediately as fresh yield. After that the shallots were air dried in a covered place for three days after which the weight was determined again per plot. Subsequently bulbs were graded intro three classes according to bulb size diameter: A (> 2.5 c,m), B (1.5 – 2.5 cm) and C (< 1.5 cm). Per class total weight was recorded and the number of bulbs was counted.

During the experiments a log book was kept and activities, used materials, spend labour in hours and costs were recorded daily.

Climatic data was obtained from the weather station located at Kerjati (-6.73440, 108.26300; Alt. 85 m A.S.L.) via the website from the Meteorological, Climatological, and Geophysical Agency (BMKG): http://dataonline.bmkg.go.id/data_iklim. (Fig. 4).

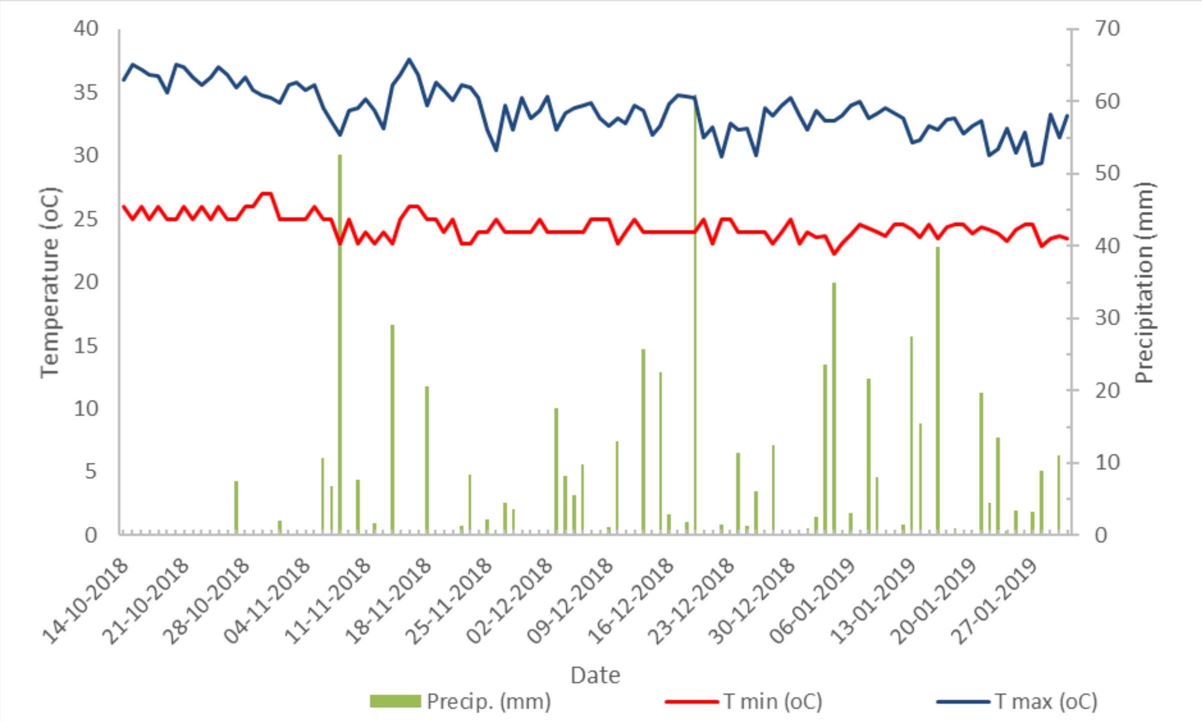

Figure 4 Temperature and precipitation recorded at Kerjati between 14 Octobre 2018 and 31 January 2019.

3.1.3 Results and discussion

Direct sowing method

Emergence after 7, 13, 40 and 85 days was for both treatments the same (Table 6). Number of established seedlings increased to a maximum of 59 % at about two weeks after sowing. During the cultivation of shallot minibulbs the final established clusters at harvest was reduced to 26%. This was mainly due to plant loss caused by soil borne diseases.

Table 6 Emergence percentage of shallot seeds at 700 sds/m2 (D1) and 1,000 sds/m2 (D2) at 7 and 13 days after sowing (DAS) and established plant clusters as a percentage of number of sowed seeds at 40 and 85 DAS.

Treatment	7 DAS	13 DAS	40 DAS	85 DAS
D1 (700 s/m2)	47	58	53	26
D2 (1,000 s/m2)	45	59	53	27
Mean	46	59	53	26
P =	0.7	0.3	1	0.7

Minibulb yield did not differ per sowing density (Fig. 5). On average 3.2 kg per square meter was produced. Compared to current shallot cultivation for consumption purpose using the variety Bima Curut the yield is three times higher still in spite of the soil borne diseases reducing plant density.

Figure 5 Fresh yield (p = 0.5) and dried yield (p = 0.6) of minibulb produced at different sowing densities.

Sowing density seemed also not having an effect on grading of the produced minibulbs (Fig. 6). No significant differences in number of bulbs per grade was present.

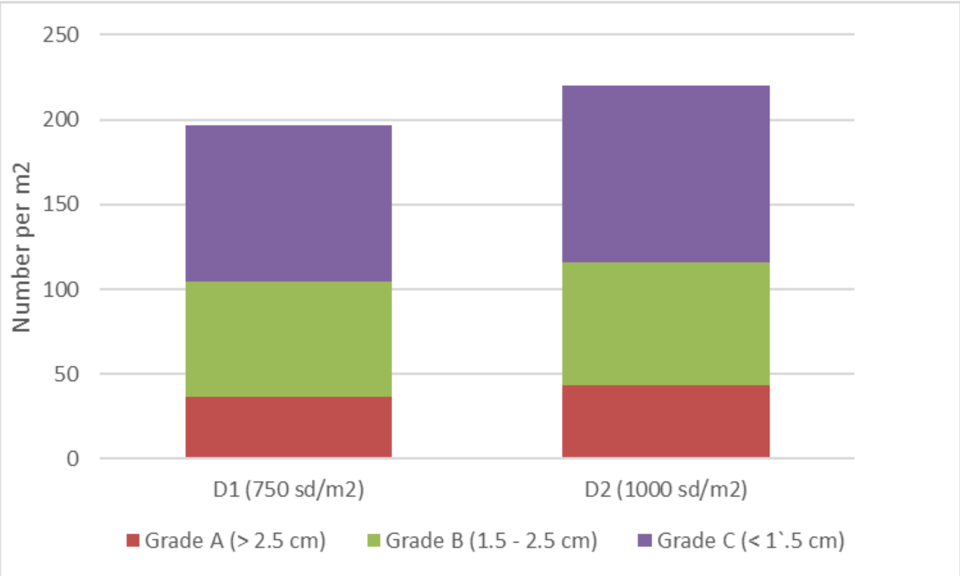

Figure 6 Grading of minibulbs in the three classes harvest.

For direct sowing the production costs at the density of 750 seeds/m^2 were 212,414 IDR per square meter while for 1000 seeds per m2 this was 215,359 IDR (Table 7). Considering the production of minibulbs this resutls in a cost price of approximately 135,000 to 165,000 IDR per kilogram or about 1,000 IDR per bulb.

Table 7 Production costs of minibulbs with direct sowing (cost in IDR/m^2 based on 16 m^{2}area)

Sowing density	750	1000	sd/m2
	2.9	3.8	g/m2
Seeds	8,835	11,780	IDR/m2
Seedbed cover	22,703	22,703	
Fertilization	13,756	13,756	
Crop protection	12,119	12,119	
Labour costs (excl. Harvest)	155,000	155,000	
Total costs	212,414	215,359	
yield	1.3	1.6	kg/m2
number	197	220	#/m2
cost price	163,395	134,599	IDR/kg
	1078	979	IDR /bulb

16,000 IDR = 1 euro

Results Transplant method

No significant differences in fresh yield (p = 0.8) or dried yield (p = 0.9) were present at harvest between transplants raised at different sowing densities (Fig. 7). Fresh yield was between 1.2 and 1.7 kg/m2, which was quite lower than the yield level with direct sowing.

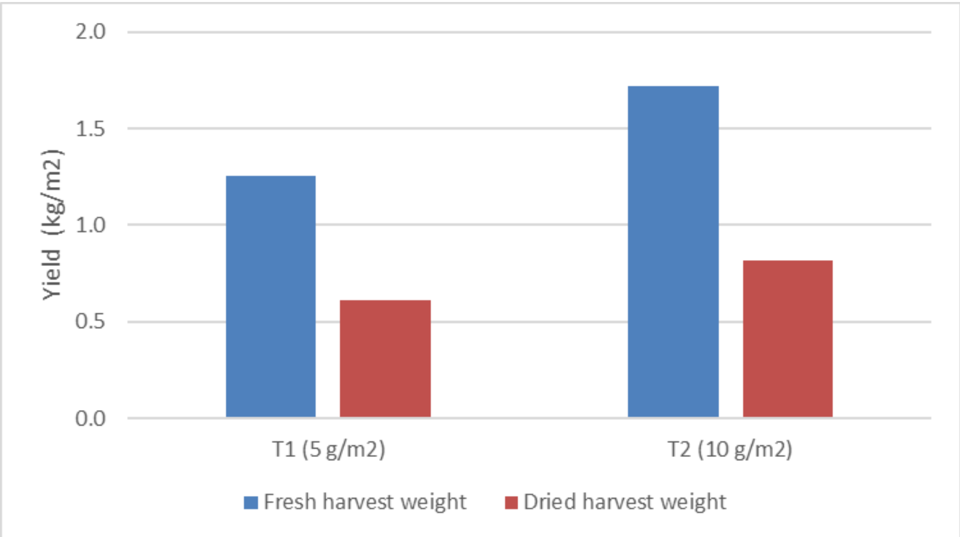

Figure 7 Yield of minibulbs from transplants raised at different sowing densities.

Per grade no significant differences were found in number of bulbs per grade (Fig. 8). The total number of bulbs at transplants raised in a nursery with high density was significant higher (p = 0.05). Although plants in the field were all planted at a same distance the plants raised at a high density gave more bulbs. Perhaps the high density in the nursery induced the plants to split more in the field.

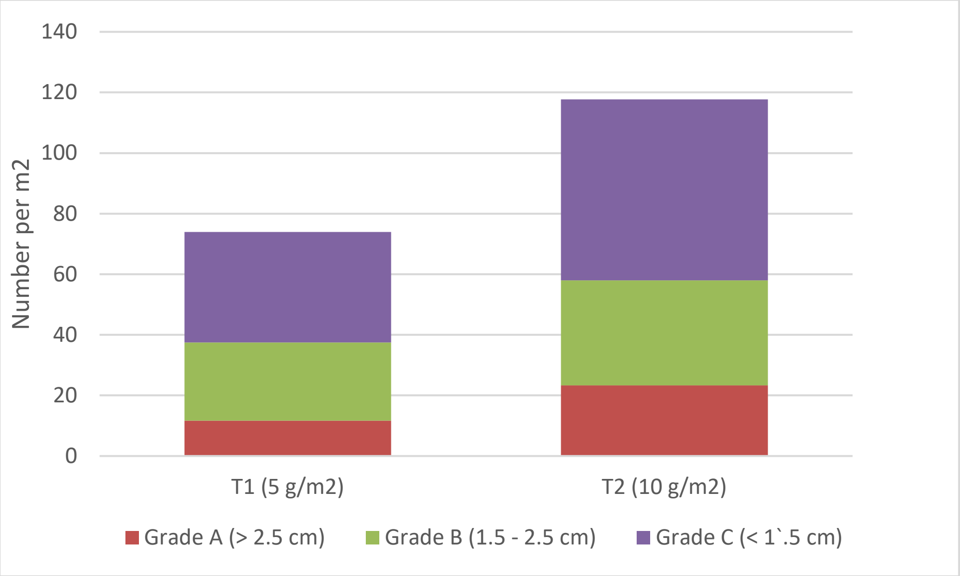

Figure 8 Grading of minibulbs at harvest in three size classes.

Cost price of minibulbs using the transplant method contains the raising costs in the nursery (Table 8) and the costs of production in the field (Table 9). The transplant raised in a nursery costs about 75 to 125 IDR per piece depending on the sowing density. The assumption of 55% survival rate of transplants related to seed use is based on the emergence observation done at direct sowing where at 40 days after sowing 53% was present.

Table 8 Production costs of minibulbs with direct sowing (costs in IDR/m² based on 16 m² area).

Nursery density	1316	2632	sd/m2
	5	10	g/m2
Seeds	15,500	31,000	IDR/m2
Seedbed cover	10,684	10,684	
Fertilization	7,337	7,337	
Crop protection	5,763	5,763	
Labour costs	51,618	51,618	
Total	90,901	106,401	
Estimated number of transplants	724	1,447	# plants
(55% of sowed seeds)			
cost price per transplant	126	74	IDR/plant

Given the transplant costs and further costs during production in the field, the cost price of minibulbs is 442 to 846 IDR per bulb or 65,000 to 105,000 IDR per kilogram. In spite of the lower yield the cost price of a bulb when using transplants compared to direct sowing is lower. This is mainly related to the lower seed use since loss of transplants in the field is lower than the loss present with direct sowing where more seeds were needed.

Table 9 Costs of minibulb production from transplants raised at two different nursery densities with 200 pl/m² in the field (5 x 10 cm) (based on 120 m²).

Nursery density	1316	2632	sd/m2
Plant costs	25,122	14,703	IDR/m2
Fertilization	625	625	
Crop protection	695	695	
Labour costs (excl. Harvest)	36,167	36,167	
Total	62,608	52,189	
yield	0.6	0.8	kg/m2
number	74	118	#/m2
cost price	104,347	65,236	IDR/kg
	846	442	IDR /bulb

3.2 Production of minibulbs in the highland of Lembang

At IVEGRI in Lembang minibulbs from three varieties were produced (Table 10).

Table 10 General information of the experimental site.

Location	:	IVEGRI, Lembang, Bandung, West Java.
GPS coordinates	:	-6.80246,107.64861
Altitude	:	1225 m A.S.L.
Soil type	:	Loamy Clay (Andosol)
Variety	:	Sanren F1 (TKW 3.8); Maserati F1 (TKW 3.2); Trisula (TKW 2.65)
Design	:	Complete Randomized Block Design
Blocks	:	5
Sowing date	:	23 October 2018
Harvest date	:	20 February 2019
Plot size	:	10 m2

Per variety two different sowing densities were used (Table 11).

Table 11 Treatments in the experiment.

Variety	Density (sds/m^2)	Density (g/m^2)	Distance between lines (cm)	Number of seeds per line of 1 meter	Average distance within lines (cm)
Trisula	750	1.99	10	75	1.3
	1000	2.65	10	100	1.0
Sanren	750	2.9	10	75	1.3
	1000	3.8	10	100	1.0
Maserati	750	2.4	10	75	1.3
	1000	3.2	10	100	1.0

3.2.1 Materials and methods

Raised beds of 1.2 x 10 m were prepared at IVEGRI Lembang and covers were placed over the beds (see picture). Plots of 1 m2 were used to sow the treatments for which sowing furrows were drawn at 10 cm distance between rows. In the rows the required total number of seeds per meter were placed manually after which te furrows were covered with soil and lightly irrigated.

Raising of the shallot minibulbs took place according to good agricultural practices.

3.2.2 Observations

Emergence and plant establishment was observed at 10, 40, 85 and 117 days after sowing. Per plot out of the 10 lines five lines were randomly selected. Per one meter line the total emerged seeds or established plants was counted and percentage was calculated based on the total number of sowed seeds per meter line.

Harvest took place at maturity stage of the crop 119 days after sowing on February 20. To determine average bulb weight, per plot the fresh yield and number of harvested bulbs of 5 randomly selected lines was observed Total fresh weight was observed per plot.

Climatic data was obtained from the weather station located at Bandung (-6.88356, 107.59733; Alt. 791 m A.S.L.) via the website from the Meteorological, Climatological, and Geophysical Agency (BMKG): http://dataonline.bmkg.go.id/data_iklim (Fig. 9).

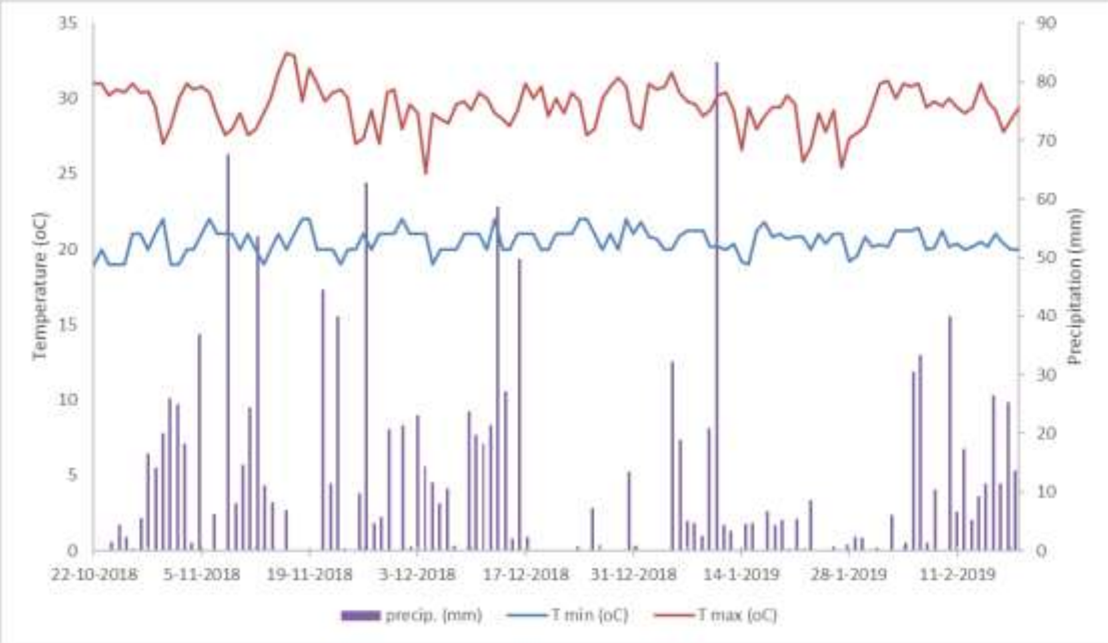

Figure 9 *Temperature and precipitation recorded at Bandung between 22 October 2018 and 24 February 2019.*

Temperature during the experiment was around 20°C during the night and 30°C during the day. Rainfall was present frequently throughout the whole period.

3.2.3 Results

Ten days after sowing Trisula showed the lowest emergence with 28% on average (Table 12). Maserati and Sanren both showed for the two sowing densities an emergence on approximately 71 %. With the lower density of 75 seeds per meter a slightly higher emergence was observed on average.

Table 12 *Emergence of plants 10 days after sowing (DAS) as percentage of total number of sowed seeds.*

Variety	100 seeds/m	75 seeds/m	mean
Maserati	70	74	72
Sanren	70	69	70
Trisula	23	34	28
mean	54	59	57
	Fprob	LSD 0.05	Fprob Logit
Variety (V)	< 0.01	6.4	<0.01
Seeds/m (S)	0.06	5.2	0.045
V x S	0.15		0145

At 40 days after sowing the overall emergence was with 40% lower than after 10 days (Table 13). Between sowing distance no significant differences were observed. Both Maserati and Sanren showed a similar emergence while the emergence of Trisula was significant lower.

Table 13 Establishment of plants 40 days after sowing (DAS) as percentage of total number of sowed seeds.

Variety	100 seeds/m	75 seeds/m	mean
Maserati	52	55	54
Sanren	53	52	52
Trisula	12	18	15
mean	39	42	40

	Fprob	LSD 0.05
Variety (V)	<0.001	5.6
Seeds/m (S)	0.2	
V x S	0.4	

At 85 days after sowing a similar pattern as with emergence is still present at final plant establishment (Table 14). A higher percentage with Maserati and Sanren while the percentage at Trisula is low with only 10% of the sowed seeds resulting in a plant that can be harvested.

Table 14 Establishment of plants 85 days after sowing (DAS) as percentage of total number of sowed seeds.

Variety	100 seeds/m	75 seeds/m	mean
Maserati	40	40	40
Sanren	41	43	42
Trisula	9	12	10
mean	30	32	31

	Fprob	LSD 0.05
Variety (V)	<0.001	4.1
Seeds/m (S)	0.3	
V x S	0.8	

At harvest, 117 days after sowing, the number of established plants was on average 21% (Table 15). Especially Trisula showed a very low percentage with only 5% of the plants present per seed sowed. Between sowing density a slightly lower percentage of established plants was present with 100 seeds per square meter.

Table 15 Establishment of plants 117 days after sowing (DAS) as percentage of total number of sowed seeds.

Variety	100 seeds/m	75 seeds/m	mean
Maserati	27	29	28
Sanren	27	31	29
Trisula	4	7	5
mean	19	22	21
	Fprob	LSD 0.05	
Variety (V)	< 0.001	2.59	
Seeds/m (S)	0.01	2.12	
V x S	0.9		

Yield of Sanren and Maserati was in spite of the low plant establishment still high with 24 to 25 t/ha (Table 16). Maserati showed with 100 seeds per line a significant higher yield than with 75 seeds. The other varieties did not show different yield per sowing density.

Table 16 Fresh weight of minibulbs (ton/ha)

	100 seeds	75 seeds	Mean (p < 0.001) LSD 0.05 = 1.11
Maserati	25.1 a	21.9 b	23.5 B
Sanren	24.1 a	25.2 a	24.7 A
Trisula	6.1 c	6.9 c	6.5 C
Mean	18.4	18.0	
Fprob (T x Sds) = 0.001			
LSD 0.05 = 1.57			

Average bulb weight was for Maserati the highest with 6.9 gram (Table 17). Sanren showed with 4.1 g per bulb the lowest weight.

Table 17 Average bulb weight of harvested minibulbs (g).

	100 seeds	75 seeds	Mean (p < 0.001) LSD 0.05 = 0.77
Maserati	6.5	7.4	6.9 A
Sanren	3.9	4.4	4.1 C
Trisula	5.9	6.2	6.1 B
Mean	5.4	6.0	
Fprob (T x Sds) = 0.7 Fprob (T) = 0.056 LSD 0.05 = 0.63			

4. Part II: Transplant production

To evaluate the effect of production systems on the yield of shallot grown from TSS three experiments were carried out at PT EWINDO and two at PT Sumbawang. Tested systems were direct sowing, transplants and minibulbs and the performance was compared to the traditional production system with the variety Bima. For the different tests transplants were raised to be planted out in the field.

4.1 Transplant raising in Purwakarta PT Ewindo

4.1.1 Materials and methods

At Purwakarta seedlings of the variety Sanren were raised (Table 18). The location was at the research plot of PT Ewindo.

Table 18 General data of experiment.

Location	:	PT Ewindo, Purwakarta, West Java.
GPS coordinates	:	-6.513305, 107.495856
Altitude	:	65 m A.S.L.
Soil type	:	Clay Loam
Variety	:	Sanren F1 (TKW 3.8)
Design	:	Complete Randomized Block Design
Plot size	:	1 x 0.8 m
Sowing distance	:	2 cm x 12.5 cm

To compare systems with different starting materials, seeds, transplants or minibulbs, transplants were raised for the 3 experiments (I, II and III). For this sowing took place at different dates (Table 19).

Transplants were raised at different dates whereas transplant early were sowed at a date to have transplants ready at the intended start of the field with planting Bima bulbs. Transplant late were intended to be sown at a same date as the Bima bulbs were planted in the production field. These transplants were planted later next to the Bima in the same field.

Table 19 Transplant raising test treatments.

Treatment	Sowing date	Uprooting date	Number of plots
Transplant early (I)	8-3-2019	11-4-2019	30
Transplant late (I)	15-4-2019	16-5-2019	30
Transplant early (II)	15-4-2019	24-5-2019	30
Transplant late (II)	24-5-2019	28-6-2019	20
Transplant early (III)	7-8-2019	13-9-2019	8

Cultivation

Raised beds were prepared by using a hand hoe. Sowing lines were made using a stick that was pressed perpendicular to the bed in the soil every 12.5 cm along the length. Per line 37 to 38 seeds were as much as possible equally distributed in an uniform way to obtain a sowing distance of 2 cm. After sowing beds were covered with rice husk to accommodate germination and emergence.

Fertilization and crop protection was done according good agricultural practices.

Observations

Emergence was observed two times per sowing treatment (Table 20). The first observation took place between 10 and 18 days after sowing and the second one took place between 21 and 30 days after sowing. Except for Transplant late (II) two sowing lines per plot were randomly selected at the first observation date and number of emerged seeds was counted in the same lines for all dates after. A same method was used for Transplant Late (II), but instead of two lines per plot three lines were selected for the counts.

Table 20 Emergence observation dates.

Treatment	Sowing date	First emergence observation	Days after sowing	Second emergence observation	Days after sowing
Transplant early (I)	8-3-2019	22-3-2019	14	29-3-2019	21
Transplant late (I)	15-4-2019	25-4-2019	10	9-5-2019	24
Transplant early (II)	15-4-2019	25-4-2019	10	9-5-2019	24
Transplant late (II)	24-5-2019	11-6-2019	18	20-6-2019	27
Transplant early (III)	7-8-2019	23-8-2019	16	6-9-2019	30

4.1.2 Results

Emergence of seeds was on average 44% at the first observation and 38 % at the second observation (Table 21). The lowest emergence was observed at Transplant late sowed for the first experiment with sowing date at 15 April and also the emergence of Transplant early for the second experiment sowed at the same date was low with 28% at the second observation. In the weeks after sowing significant precipitation volumes were recorded at the weather station located at Citeko (Fig. 10). The lower emergence might be caused due to intensive rain which can flush away the seeds, destroy the young transplants or cause losses due to rotting of seeds due to high moisture content in the soil.

Table 21 Emergence observed at two dates after sowing.

Transplant	1st Observation	2nd Observation
Transplant early (I)	53.3 c	48.4 c
Transplant late (I)	26.5 a	20.1 a
Transplant early (II)	36.6 b	28.2 b
Transplant late (II)	57.4 cd	53.6 cd
Transplant early (III)	67.0 d	61.5 d
mean	43.9	37.9

figures in the same column followed by a same letter are not significant different at 5% from each other.

4.2 Transplant raising in Sumbawa, PT Sumbawang.

4.2.1 Materials and methods

To compare systems with different starting materials, seeds, transplants or minibulbs, transplants were raised for two experiments (I and II). For this sowing was done at different dates.

The experiment was carried out at PT Sumbawang with the variety Maserati F1 (Table 22).

Table 22 General data.

Location	:	PT Sumbawang, Rhee, Sumbawa, West-Nusa Tenggara.
GPS coordinates	:	-8.405685, 117.233802
Altitude	:	10 m A.S.L.
Soil type	:	Sandy Loam
Variety	:	Maserati F1 (TKW 3.2)
Design	:	Complete Randomized Block Design
Blocks	:	15
Plot size	:	1 x 1 m
Sowing distance	:	1.4 cm x 10 cm

The treatments for transplant early were sowed at a date to have transplants ready at the intended start of the field with planting Bima bulbs (Table 23). Transplant late treatments were intended to be sown at a same date as the Bima bulbs were planted in the production field. These transplants were planted later next to the Bima in the same field.

Table 23 Transplant raising tests.

Treatment	Sowing date	Uproot date
Transplant early (I)	29-3-2019	10-5-2019
Transplant late (I)	29-4-2019	7-6-2019
Transplant early (II)	29-4-2019	3-6-2019
Transplant late (II)	29-5-2019	9-7-2019

Treatment	Sowing date	First emergence observation	Days after sowing	Second emergence observation	Days after sowing
Transplant early (I)	29-3-2019	8-4-2019	10	19-4-2019	21
Transplant late (I)	29-4-2019				
Transplant early (II)	29-4-2019	9-5-2019	10	20-5-2019	21
Transplant late (II)	29-5-2019				

Only for the early sown transplants emergence observations were done in a same way as described at section 4.1.

4.2.2 Results

Emergence of Maserati at Sumbawa was on average 81% after 10 days and 75% after 21 days (Table 24). This is quite higher than the emergence of Sanren at Purwakarta where only 38% of the seeds emerged at the second observation. The difference is mainly caused by climatic and soil conditions and not so much by variety since the germination percentage of both varieties is good. Also at the experiment at Lembang were both varieties were raised under the same conditions emergence figures did not differ significantly (Table 12 till 15).

Table 24 Emergence observed at two days after sowing.

Transplant	1st Observation	2nd Observation
Transplant early (I)	82.2	72.7
Transplant early (II)	80.5	76.4
mean	81.3	74.5
Fprob	n.s.	n.s.

4.2.3 Conclusions

Emergence of shallot seeds depends greatly on climate and on soil conditions. At Purwakarta a great deal of seeds sowed at April 15 did not emerge due to rain. Also when comparing results of shallot sowed at Sumbawa or at Purwakarta on average the emergence at Sumbawa was much higher. Still also at Sumbawa about 25% of the seeds sowed is lost.

5. Part III: Production systems

Experiments were carried out to compare different TSS systems with the traditional system where Bima vegetative bulbs were used. The tested TSS systems comprised of direct sowing, transplants of a more or less similar age planted at different moments in the field and minibulbs.

Tests were performed at the premises of PT Ewindo located in Purwakarta, west Java and at PT Sumbawang on the island of Sumbawa. At both locations the bulbs of the reference crop Bima Curut was purchased from the same source. At Purwakarta the Bima needed 5 to 6 more days to harvest than the Bima on Sumbawa (Table 25). Plant loss at Purwakarta was higher than at Sumbawa and also yield of Bima was lower at Purwakarta than on Sumbawa for the early season. Purwakarta is a location with a more clayey soil and also rainfall was much higher during this season. As a result more plants were lost which already resulted in a lower yield. Also indirect effects of rain, soil compaction, less light and possible soil saturation with water could have an effect on yield.

Table 25 Performance of Birma Curut.

season	location	Crop Age at harvest (DAP)	Plant loss %		Fresh weight (t/ha)		Dried weight (t/ha)	
early	Purwakarta	61	53	b c	19	a b	14	a b
	Sumbawa	56	39	b	29	c	22	c
mid	Purwakarta	62	56	c	25	b c	21	b c
	Sumbawa	56	40	b c	26	c	19	b c
late	Purwakarta	55	20	a	16	a	11	a
Mean		58	42		23		17	
Fprob			<0.001		0.009		0.03	
LSD 0.05			18.0		6.9		7.1	

5.1 Experiments at PT Ewindo

5.1.1 Materials and methods

Experiments were implemented at PT Ewindo located at Purwakarta (Table 26).

Table 26 General data of the experimental location.

Location	:	PT Ewindo, Purwakarta, West Java.
GPS coordinates	:	-6.513305, 107.495856
Altitude	:	65 m A.S.L.
Soil type	:	Clay Loam
Variety	:	Sanren F1 (TKW 3.8)
Design	:	Complete Randomized Block Design
Blocks	:	4

Plot size	:	Variable (3 to 6 m2)

For the TSS variety Sanren F1 from PT Ewindo was used. The reference treatment was Bima Curut, a variety widely used by farmers.

Three experiments were implemented, where at each experiment the planting date of Bima Curut was the marking point to start the other treatments. At experiment I and II transplants were planted and direct sowing took place at the same date as Bima was planted. At experiment II and III also minibulbs were planted at the same date as Bima planting date. Minibulbs for experiment II were raised at Lembang as described in Part I of this report. Minibulbs for experiment III were obtained from the transplants sowed at as described in Part II of this report. The transplant plots not used for the field phase were left in the nursery to produce minibulbs for the third experiment (Table 27).

At both experiments sowing of the late transplanting treatment took place at the planting of Bima. Once these transplants were large enough for transplanting, more or less with a same age and size at transplanting as the early transplants before, they were also planted in the same experimental field as the other treatments. For this designated plots were kept empty until the date of transplanting of this treatment.

Table 27 Treatments with planting or sowing date and planting or sowing densities per treatment.

Experiment	descript	Planting/sowing date	Distance within rows (cm)	Distance between rows (cm)	Plants / seeds per m2
I (Early)	Bima traditional	11-4-2019	15	15	44
	direct sowing	11-4-2019	2	18	278
	transplant early	11-4-2019	10	10	100
	transplant	16-5-2019	10	10	100
II (Mid)	Bima traditional	24-5-2019	15	15	44
	direct sowing	24-5-2019	2	18	278
	minibulb	24-5-2019	10	15	67
	transplant early	24-5-2019	10	10	100
	transplant	28-6-2019	10	10	100
III (Late)	Bima traditional	13-9-2019	10	15	67
	direct sowing	7-8-2019	2	18	278
	minibulb	13-9-2019	10	15	67
	transplant early	13-9-2019	10	10	100

Shallots were cultivated according to good agricultural practice and were harvested per treatment when maturity was reached

Observations

Per plot five plants were randomly selected at the first observation date and marked for further observations later on. Plant height was determined by stretching the leaves and measuring he tallest one in cm using a ruler and number of present tillers or splits was counted (Table 28). At harvest a last observation was only done on number of tillers or splits per plant. Since treatments were harvested at different dates the actual date was not the same but was related to days after planting.

Table 28 Observation dates per experiment

Observation number	I	II	III
1	25-4-19	11-6-19	23-8-19
2	9-5-19	20-6-19	6-9-19
3	23-5-19	5-7-19	17-9-19
4	11-6-19	18-7-19	27-9-19
5	20-6-19	1-8-19	11-10-19
6	18-7-19	Harvest date	24-10-19
7	Harvest date		07-11-19
8			Harvest date

Per experiment treatments were harvested when reaching maturity (Table 29). An exception on this was direct sowing in the first experiment which was harvested one to two weeks before reaching full maturity. This was due to the occurrence of diseases. At the other experiments total field period of direct sowing was about 100 days and therefore at least one month longer than the other treatments. This might have an impact on farming management strategies. In the first place the land utilization rate with more crops is less with direct sowing. Secondly the window for shallot production is more limited, direct sowing can only start when the weather conditions are good enough to ensure good emergence.

Table 29 Harvest dates and crop age at harvest in days after planting or sowing.

	Harvest Date			Crop age at harvest			
Experiment	I	II	III	I	II	III	mean
Bima traditional	11-06-19	25-07-19	07-11-19	61	62	55	59.3
direct sowing	28-06-19	31-08-19	15-11-19	78	99	100	92.3
minibulb	n/a	25-07-19	15-11-19		62	63	62.5
transplant early	20-06-19	01-08-19	15-11-19	70	69	63	67.3
transplant	01-08-19	31-08-19	n/a	69	64		66.5

At harvest the same five plants per plot as marked for observing plant height and number of tillers were observed on number of bulbs per plant and total weight of all bulbs per cluster was determined in gram. Based on these observations average bulb weight in gram was calculated. Per plot all bulbs were harvested and weighed at the day of harvest. Subsequently bulbs were air dried in a covered space and after 7 days weighed again.

Climatic data was obtained from the weather station located at Citeko (-6.70000, 106.85000; Alt. 920 m A.S.L.) via the website from the Meteorological, Climatological, and Geophysical Agency (BMKG): http://dataonline.bmkg.go.id/data_iklim. (Fig. 10).

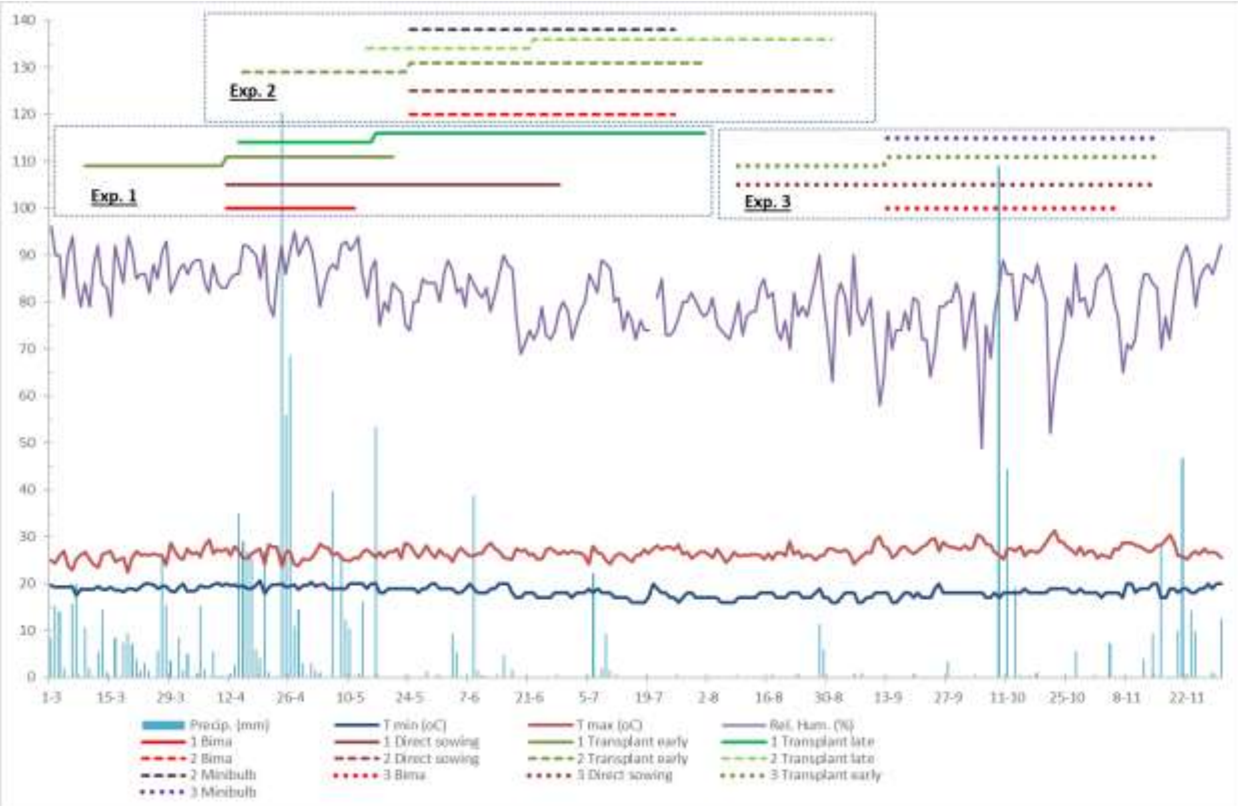

Figure 10 *Climatic data between March 1 and November 30 at Citeko and duration per treatment indicated where the nursery phase is indicated by a lower line and the field phase with upper line.*

Citeko station is the nearest station to the experimental site from which data is available but is still at a 70 km distance in southwesterly direction. Therefore precipitation quantities might be different. However, the observed data indicates that the rainy period lasted until early May. Therefore especially during experiment I one can expect the presence of frequent rains.

5.1.2 Results

Plant length of shallots grown from Bima showed a length of 36 to 37 cm at it's maximum length which was reached 4 weeks after planting (Fig. 11). The early transplant showed a longer length with 45 cm which was reached at 6 weeks after planting. The plant length of direct sowing shallot remained shorter with a maximum of 32-33 cm. The late transplant showed it's maximum length close to its harvest date while the other treatments already showed a decline in plant length.

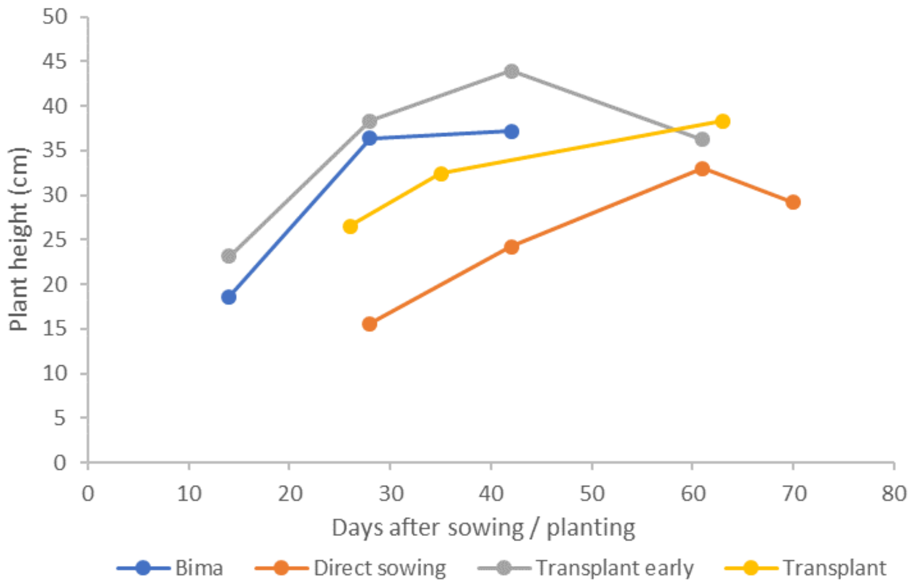

Figure 11 *Plant length of shallots in experiment I.*

In the second experiment the plant length was overall longer than during the first experiment (Fig. 12). Bima showed a maximum length of 45 cm and also transplant (late) and direct sowing showed a similar plant length of 45 cm. The maximum length of the shallots produced from minibulbs and early transplants showed a maximum length of 55 cm at 6 weeks after planting. With Bima and transplant (late) no decline in plant length was observed. This might indicate that those treatments were not at its full maturity at harvest or that maturing was fast during the period between the last length observation and harvest the plants at which plant length also shortened.

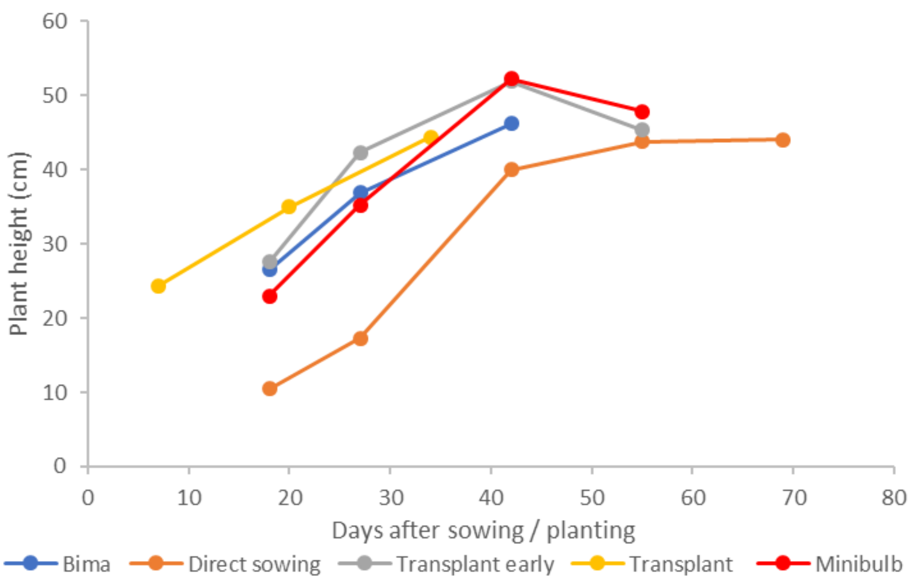

Figure 12 *Plant length of shallots in experiment II.*

In experiment III maximum plant length was a bit shorter than in experiment II but still longer than in experiment I (Fig. 13). Remarkable is that in the first two experiment length of direct sowing was the lowest while in in the third experiment the length was the tallest.

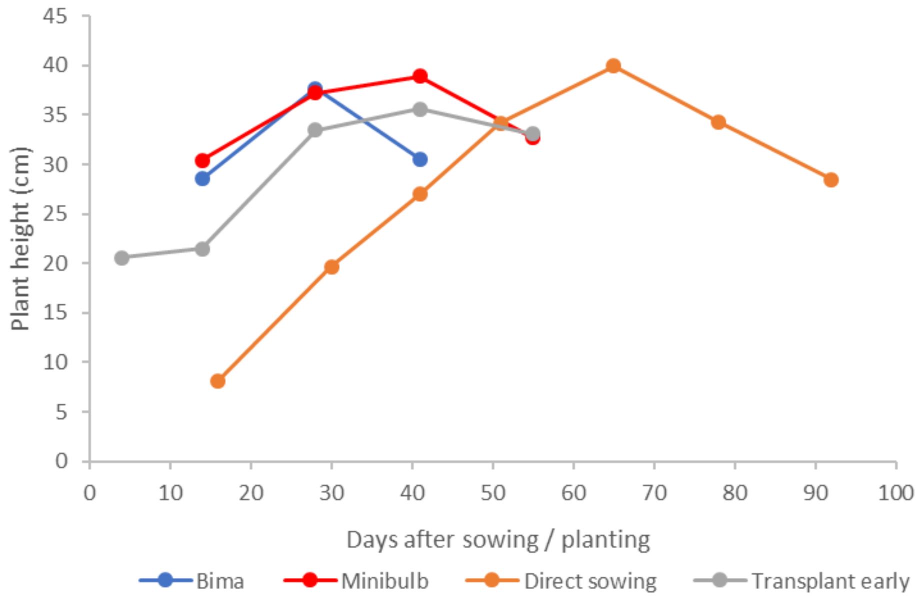

Figure 13 Plant length of shallots in experiment III.

During the production of shallot the bulb or plant splits into more bulbs which is shown in figure 14. At harvest Bima bulbs have formed between 7 and 8 bulbs per plant. When using minibulbs they produced a slightly lower number of bulbs per plant. In experiment II the final number was 6 while with experiment III the number was 4.5 to 5. In experiment III the number of bulbs declined which could be an indication of the presence of diseases reducing the number of bulbs per plant. When using transplants or direct sowing the plants tend to split less and at harvest only 2 to maximum 3 bulbs per plant were present. In case of using minibulbs the splitting seems to start soon after planting since two weeks after planting already more than 3 bulbs per plant were observed. With transplants the first splits seems to occur three to four weeks after planting. Splitting at direct sowing occurs approximately 7 weeks after sowing or 5 weeks after emergence.

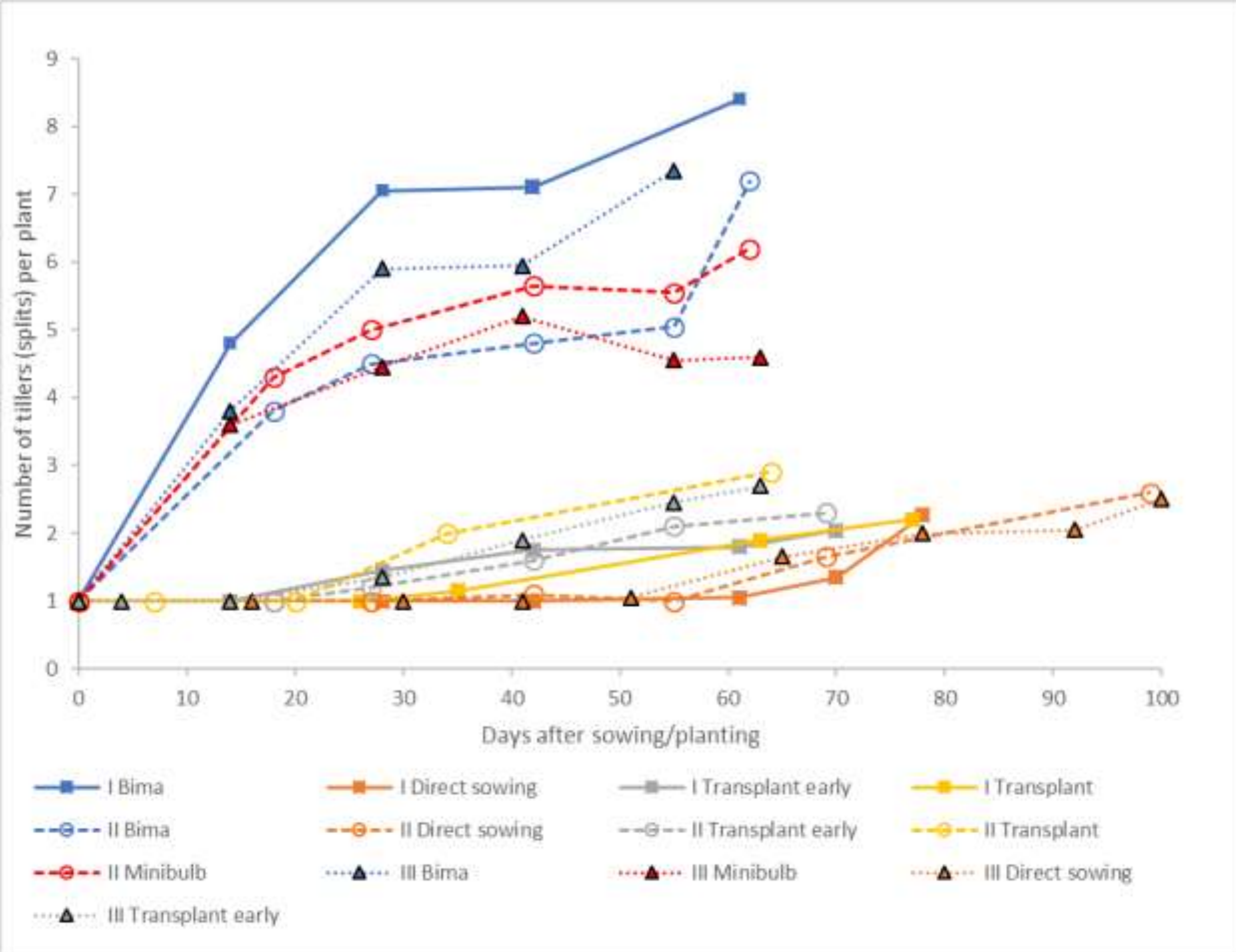

Figure 14 Number of tillers per plant or seed of shallot in all experiments.

In all experiments the loss of plants related to the number of sowed seeds or planted plants was the highest for direct sowing (Table 30). In experiment I and III this was significant more than the percentage present at other treatments. In experiment II the loss was not significant different from the Bima and minibulb treatment. In all experiment the plant loss was lower with transplants. However, when considering the loss that takes place during the nursery phase were at Purwakarta about 60% of the seeds did not emerge the total loss from seed to harvest is about 70% still.

The highest yield was present in experiment II where Bima showed a fresh yield of 25.5 t/ha and after drying a yield of 20.7 t/ha. This level is two times higher than the average common in practice fields. This is due to the better quality of planting bulbs as used by farmers and by the better crop management possible in the experiments than farmers can do on larger scale plots. Compared to Bima all TSS treatments showed significant higher yields. In experiment I the yield of Bima was 13.8 t/ha after drying. Only the treatment with transplants planted at the same time as Bima showed a significant higher yield. The direct sowing resulted in a low yield of only 3.8 t/ha while the later planted transplants resulted in 12.7 t/ha. Direct sowing suffered a lot from the rainy conditions that occurred during this period. Also the seedlings for the later planted plants were raised at more rainy conditions than the earlier planted plants. In experiment III yield of Bima was 11.3 t/ha after drying. Yield of direct sowing and minibulb was significant higher while yield of transplants was comparable to the Bima performance.

Table 30 Plant loss and yield determined as fresh and field dried weight of Bima bulbs and Sanren F1 grown from different starting materials, of three experiments, Purwakarta 2019 (n=4).

Exp	Treatment	Plant loss (%)	Fresh weight (t/ha)	Dried weight (t/ha)
I	Bima traditional	53 c	18.5 bc	13.8 b
	direct sowing	92 d	5.3 a	3.8 a
	transplant early	29 a b	27.4 de	19.9 d
	transplant	34 b	22.9 cd	12.7 b
II	Bima traditional	56 c	25.5 de	20.7 d
	direct sowing	59 c	37.0 g	34.6 g
	transplant early	34 a b	39.5 h	25.7 e f
	transplant	23 a b	33.9 fg	29.5 f
	minibulb	55 c	37.2 g	24.7 e
III	Bima traditional	20 a	16.1 b	11.3 b
	direct sowing	63 c	29.2 ef	22.6 d e
	transplant early	32 a b	16.7 b	14.5 b c
	minibulb	20 a	24.5 de	18.8 c d
	Fprob	< 0.001	< 0.001	<0.001
	LSD 0.05	13.7	5.3	4.4

Drying losses due to water loss and removing rotten bulbs were 25% for Bima in experiment I (Table 31). The losses for the other treatments were not significant different from Bima, except for the transplant (late) where losses of 45% were observed. In experiment II drying loss of Bima was less than in experiment I but not significant different. Losses in experiment III was higher except for transplant early were losses were lower than in the other experiments.

No significant differences in bulb weight were present. However, there is a strong indication that bulbs from TSS weigh more than bulbs from Bima and therefore are also larger in size. With TSS larger bulbs are present because of the variety and because of the lower number of splits per plant. A lower number of splits means that a same amount of assimilates will be divided over less bulbs compared to plants with more splits.

Table 31 Drying losses and average bulb weight of Bima bulbs and Sanren F1 grown from different starting materials, of three experiments, Purwakarta 2019 (n=4).

Exp	Treatment	Drying losses (%)		Average bulb weight fresh (g)
I	Bima traditional	25	c d e	8.8
	direct sowing	26	c d e	16.2
	transplant early	28	d e f	26.9
	transplant	45	g	22.9
II	Bima traditional	19	b c	10.8
	direct sowing	6	a	11.6
	transplant early	35	f	27.1
	transplant	13	a b	18.9
	minibulb	33	e f	23.6
III	Bima traditional	30	d e f	4.9
	direct sowing	23	c d	11.4
	transplant early	12	a b	10.3
	minibulb	23	c d	11.2
	Fprob	<0.001		0.11
	LSD 0.05	8.5		16.9

5.2 Experiments at PT Sumbawang

5.2.1 Materials and methods

Two experiments were implemented at the premises of PT Sumbawang on Sumbawa (Table 32).

Table 32 General data.

Location	:	PT Sumbawang, Rhee, Sumbawa, West-Nusa Tenggara.
GPS coordinates	:	-8.405685, 117.233802
Altitude	:	10 m A.S.L.
Soil type	:	Sandy Loam
Variety	:	Maserati F1 (TKW 3.2)
Design	:	Complete Randomized Block Design
Blocks	:	4
Plot size	:	1 x 10 m

For the treatments the TSS variety Maserati F1 from De Groot en Slot was used and compared with the traditional cultivation method with Bima Curut (Table 33). Bima bulbs were from the same lot as used for the tests in Purwakarta.

Table 33 Treatments with planting or sowing date an planting or sowing densities per treatment.

Experiment	descript	Plant/sow date	Distance within rows (cm)	Distance between rows (cm)	Plants / seeds per m2
I (Early)	Bima traditional	10-5-2019	10	15	67
	direct sowing	10-5-2019	2	18	278
	transplant early	10-5-2019	10	10	100
	transplant	7-6-2019	10	10	100
II (Mid)	Bima traditional	3-6-2019	10	15	67
	direct sowing	3-6-2019	2	18	278
	transplant early	3-6-2019	10	10	100
	transplant	9-7-2019	10	10	100
	minibulb	3-6-2019	10	15	67

Shallots were harvested at maturity stage on dates as indicated in table 34. Bima, transplants (late) and minibulb treatments were mature around 60 days. Transplant early was mature at 70 days and direct sowing could be harvested about 80 days after sowing. Direct sowing therefore has a three week longer field period than the current standard of growing Bima which could be an issue for farmers who prefer to have short crop cycles to utilize the available land as much as possible in a season.

Table 34 Harvest dates and crop age at harvest in days after planting or sowing.

	Harvesting Date		Crop age at harvest		
Experiment	I	II	I	II	mean
Bima traditional	05-07-19	29-07-19	56	56	56
direct sowing	27-07-19	26-08-19	78	84	81
minibulb	n/a	29-07-19	n/a	56	56
transplant early	19-07-19	12-08-19	70	70	70
transplant	09-08-19	10-09-19	63	63	63

Climatic data was obtained from the weather station located 20 km south east of the experimental field (Fig. 15). During all experiments the maximum temperature was between 30 and 35 oC and the minimum temperature was between 20 and 25 oC. Only until the first week of May a few showers were present with significant rainfall observed in the first week of May which was just before the field phase of the treatments.

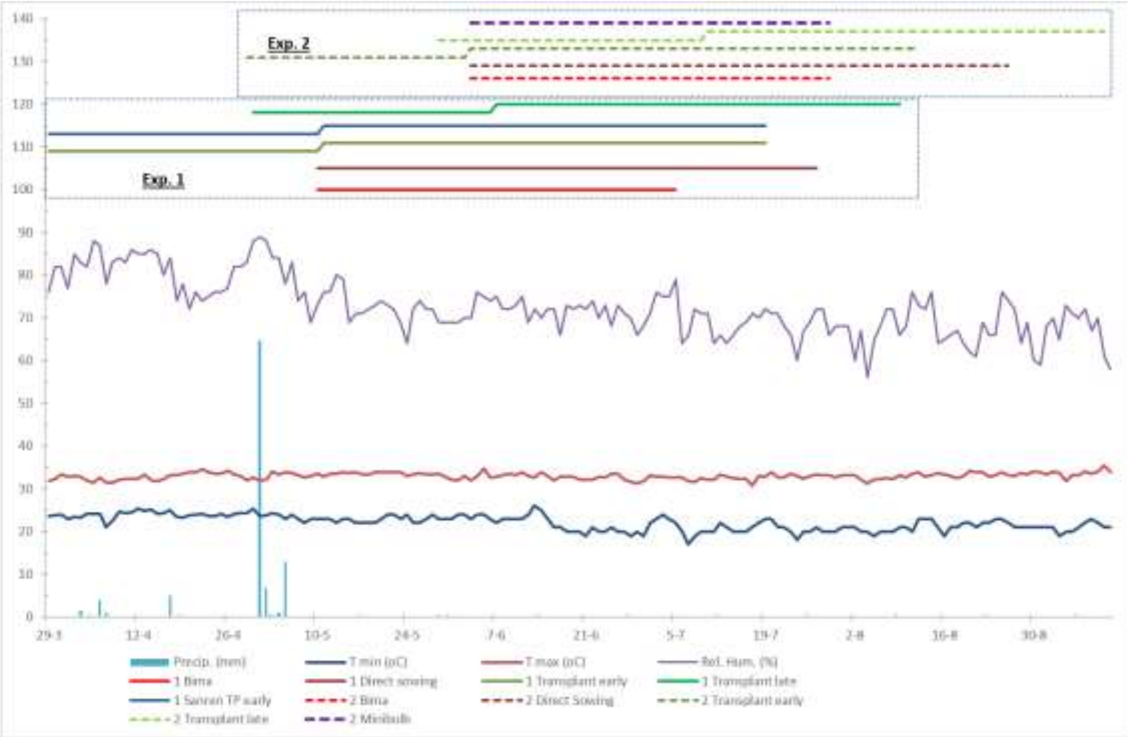

Figure 15 *Climatic data recorded at Sultan Muhammad Kaharuddin station (-8.48845, 117.41336; 10 m A.S.L.) and periods of the different treatments per experiment indicated in the graph where the lower line represents the transplant nursery phase and a upper line the field phase.*

5.2.2 Results

Plant length of shallots was for Bima and transplants more or less the same with a maximum length of about 45 cm (Fig. 16). Direct sowing showed a shorter length with a maximum length of 20 cm.

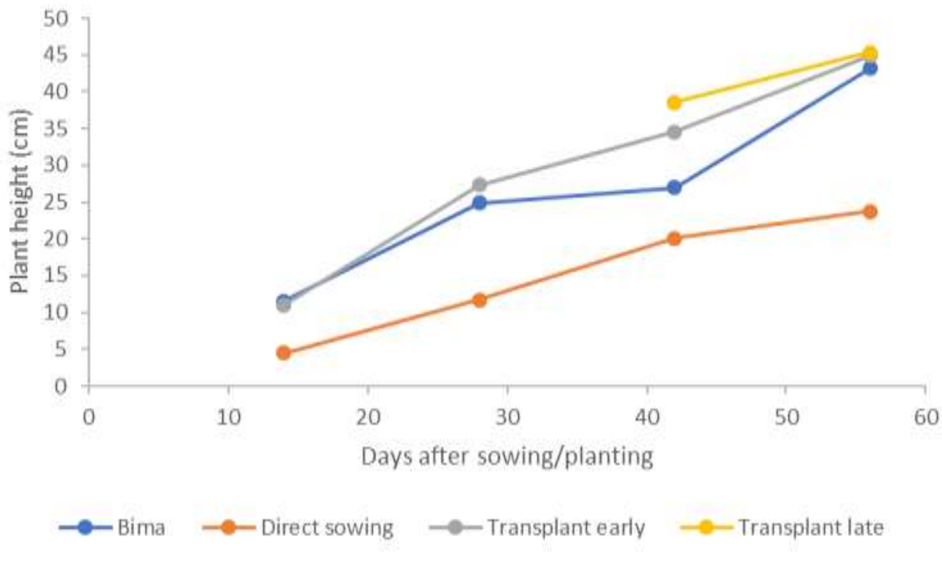

Figure 16 *Plant length of shallots in experiment I.*

Also in experiment II the plant length of direct sowing remained the shortest with 20 cm while at other treatments the length was about 35 to 40cm (Fig. 17). The transplant treatments showed the longest plant length.

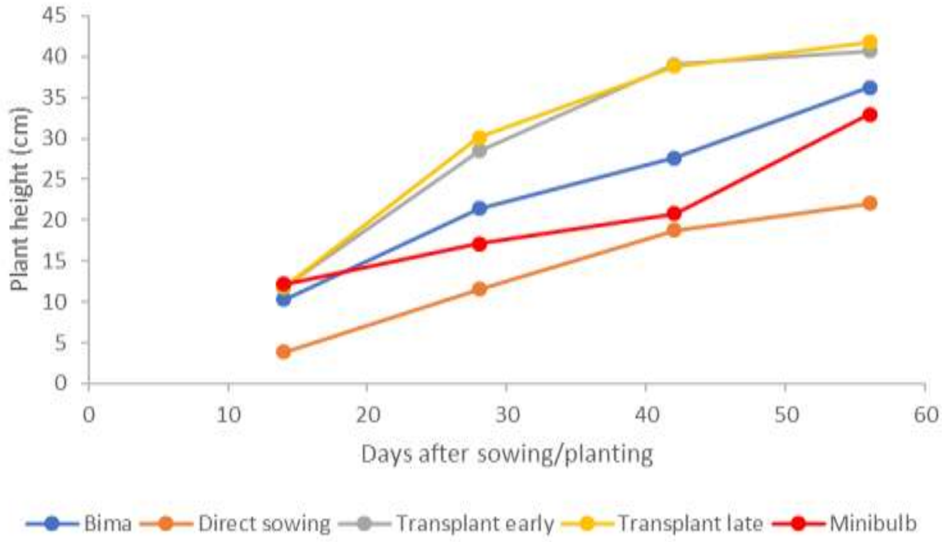

Figure 17 Plant length of shallots in experiment II.

In experiment I the number of tillers or splits per plant was 4.5 for Bima which is less than the number at Purwakarta for the same period (Fig. 18). Also the number of splits per plant at the TSS treatments was low with a number of tillers just slightly more than 1.

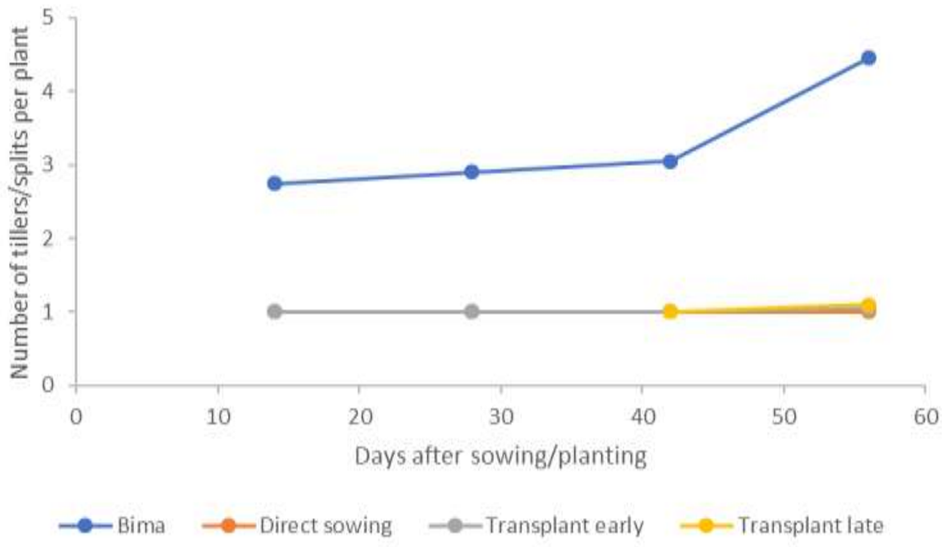

Figure 18 Number of tillers per plant in experiment I.

In experiment II the TSS treatments minibulb and transplants showed a higher number of tillers than in experiment I (Fig. 19). Direct sowing still showed only 1 tiller per plant. Bima showed a lower number of tillers in experiment II than in I.

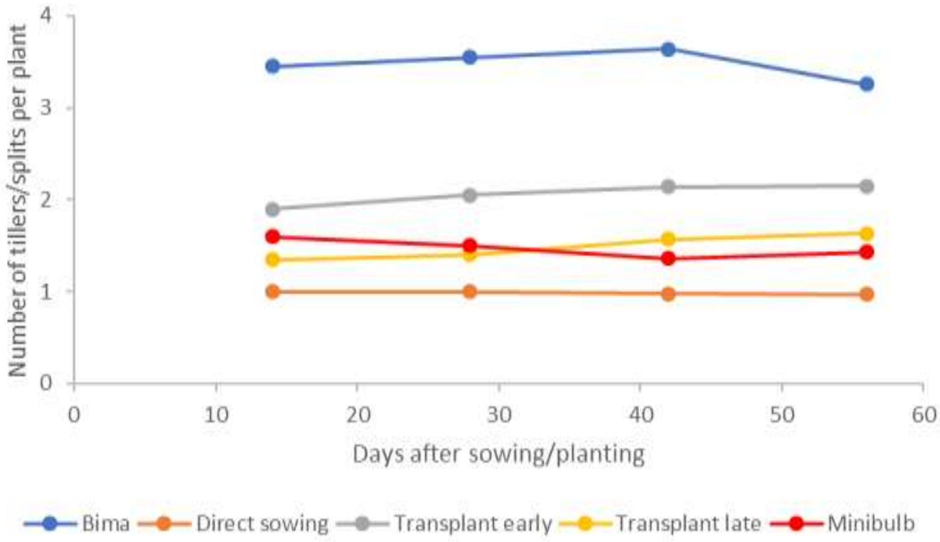

Figure 19 Number of tillers per plant in experiment II.

Plant loss of direct sowing was in experiment 91%, and as a result yield of this treatment was low although differences in yield between treatments were not significant (Table 35). In all cases the yield of other TSS treatments were higher but not significant different from the yield with Bima.

Table 35 Plant loss at harvest relative to number of sowed seeds or planted plants or bulb, yield of shallot at harvest and after field drying.

Exp	Treatment	Plant loss %	Fresh weight (t/ha)	Dried weight (t/ha)	Drying losses (%)
I	Bima	9 a	28.5	21.8	24
	direct sowing	91 c	19.0	13.8	28
	transplant early	22 a b	36.5	29.5	22
	transplant	27 a b	32.8	25.5	25
II	Bima	9 a	25.8	18.5	30
	direct sowing	73 c	32.3	25.3	22
	minibulb	0 a	29.5	22.5	25
	transplant early	37 b	27.0	22.3	20
	transplant	45 b	27.8	20.8	24
Fprob		<0.001	0.21	0.31	0.96
LSD 0.05		27.4	11.8	11.6	17.4

In experiment II the yield of bulbs larger than 2.5 cm diameter was higher in the TSS treatments than in Bima (Table 36). Also in the first experiment the yield of bulbs larger than 2.5 cm was higher in TSS treatments than for Bima but not significant different except for the early transplant treatment. Share of large bulbs in the total yield was for all TSS treatments higher than the reference Bima crop except for direct sowing in experiment I.

Table 36 Grading of shallot bulbs

		Weight of field dried shallots per grade (t/ha)			Share of large bulbs (%)
Exp	Treatment	small	medium	large	
		< 1.5 cm	1.5 - 2.5 cm	> 2.5 cm	
I	Bima	5.5	7.0	9.3 a b c	45 a b
	direct sowing	1.5	4.8	7.5 a b	54 b c
	transplant early	3.0	6.3	20.3 d	69 c
	transplant	3.5	7.1	14.9 b c d	61 c
II	Bima	3.3	8.3	7.0 a	37 a
	direct sowing	2.8	5.5	17.0 c d	69 c
	minibulb	2.8	5.8	14.0 a b c d	60 c
	transplant early	3.0	5.8	13.5 a b c d	62 c
	transplant	2.4	5.8	10.1 a b c	57 b c
Fprob		0.42	0.84	0.02	0.03
LSD 0.05		3.1	4.31	7.77	14.8

6. Conclusions

In all situations the use of TSS varieties lead to a bigger bulb size than the traditional Bima. Generally speaking the use of TSS results in higher yields than the traditional Bima shallot variety.

For producing minibulbs it is important to grow them in good soils and during dry conditions. In Indramayu the minibulbs were produced in heavy clay and during the wet season resulting in high losses due to soil borne pathogens. The same is the case for producing transplants. In that aspect high quality seeds with good emergence rates are needed as well. When the germination and emergence rates are low the costs of structures and nursery beds will be relatively high resulting in high cost price per transplant.

Season, location and starting material had an effect on performance of True Shallot Seed. At Purwakarta the yield was the highest at the second experiment. Direct sowing performance was high in the second and third experiment at Purwakarta. At Sumbawa no differences were present between season and type of starting material. In Sumbawa the climate was on average somewhat drier and also the soil type was less clayey than at Purwakarta. It seems that when soil is less clayey and when the climate is less rainy all treatments will perform well.

In case of direct sowing, high seed losses in the field can occur while with transplant or minibulb production the seed use efficiency is generally speaking higher. Crop duration of direct sowing is longer than the other treatments. This makes that planning with direct sowing needs more attention to start when taking into consideration that a too early start risks of losing seeds is high when rains are still prevalent while starting too late makes that the field is used less efficiently since less crops can be grown after the shallot.