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vegIMPACT
Improved Vegetable Production and Marketing for small farmers to Increase the Food Security status and to promote Private Sector Development in Indonesia

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1. Introduction

Potato is one of the most important crops in the world. Although it ranks fourth after rice, wheat and maize, the major food crops in the world, either in production or in the economic value, in terms of energy and protein production per hectare and per unit of time, the potato ranks first which is significantly above cereals, pulses and cassava (CIP 1984). In many countries potato is considered a vegetable, but the interest for potato as staple crop increases especially in developing countries, including Indonesia which is the largest potato producer in Southeast Asia. At present, the potato areas in Indonesia varies between 60,000 and 70,000 ha with a total production of about 1.2 - 1.3 million tons per year. The potato has been considered a priority crop in the strategic plan of research and development program of the Indonesian Agency for Agricultural Research Development (IAARD) in the last 30 years because of its potential as alternative carbohydrate source in food diversification and for export markets.

The potato originally comes from the cool tropical highlands of the Andes in South America (Horton and Anderson 1992) and therefore the potatoes in Indonesia are mainly grown in the highland areas (> 1,000 m). The main potato variety in Indonesia since the 1980's is Granola, which covers 80 to 85% of the potato area. The moderate resistance of Granola to PLRV and PVY appear to have contributed in making it a successful variety in Indonesia (Chujoy 1995).

Seed is the most costly component of potato production, and potato profitability often depends on access to quality seed. Seed accounts for 30-40% of the total costs of potato production in Indonesia (De Putter*, et al.* 2014; Pronk*, et al.* 2017a; Van den Brink*, et al.* 2015). High quality seed is relatively expensive and is not affordable by most farmers. Therefore, most potato farmers often use potato seed tubers saved from their previous crops. Small tubers are usually selected and saved for seeds for planting in the following season. This unhygienic practice results in carrying over diseases (e.g. viruses and bacteria contained in the small seed tubers) with the result that yields decrease over time. Farmers will need to buy seed tubers from other farmers or traders when their own seed stock has degenerated due to build up diseases. The degeneration of seed stock depends on the seed selection and also on the variety grown. Varieties differ in levels of resistance to virus infections and virus particle multiplication within the plant (Salazar 1996).

One method to reduce the degeneration rate is through so-called positive selection (Gildemacher*, et al.* 2007). In this method, the best potato plants in a field are marked before crop senescence and they serve as mother plants for seed potatoes used in the following season. Positive selection in Kenya gave an average yield increase in farmer-managed trials of 34%, corresponding to a 284 € increase in profit per hectare at an additional production cost of only 6 € /ha (Gildemacher*, et al.* 2011).

Within the vegIMPACT program demonstration trials have been carried out to show farmers the potential benefits of positive selection on the seed potato quality in the subsequent season. The demonstrations showed potato farmers the importance of plant selection in one planting season in order to obtain good quality seeds in the following planting season. Positive selection is a technique to maintain good quality seeds by reducing the degeneration rate of farm saved seed. This technique potentially reduces the costs for the most costly input, i.e. seed potatoes, in potato production.

2. Materials and methods

The demonstrations to show the effect of plant selection in one season on the seed potato quality in the next season were carried out in two planting seasons. The first planting season used for positive selection was in Cikajang, Garut. The second planting season to assess the effect of positive selection on potato yield and performance were carried out in two locations, *i.e.* Margamekar, Pangalengan and in Cikajang, Garut.

2.1 The first planting season

Two generations (G2 and G3) of cv. Granola and one imported seed of *cv.* Atlantic (unknown generation) were grown. Two methods of seed production were demonstrated, i.e. positive selection and farmers' practice. Hence, the demonstration consisted of six treatments. The potatoes were planted on 16 November, 2015 and harvested on 2 March, 2016. Field plots were prepared with furrows spaced 75 cm apart, and plant spacing within the row was 30 cm. The plot sizes were 13 x 12.5 m consisting of sixteen rows with each 50 plants (Annex I). Therefore, the total number of potato plants was 800 plants per plot. Two methods of seed selection were applied:

1. Positive selection: During the growing season infected plants were selected and removed from the plots and the healthy looking plants were marked with a stick. The selection process was carried out three times at 7, 9 and 12 weeks after planting. At harvest the tubers from the selected (healthy marked) plants were graded and selected once again before storing. In the storage, the selected seeds were screened on quality again at one, two and three months after harvest. At all times, the selected seeds were stored separately from the other seeds to prevent mixing.

2. Farmers' practice: During the growing season, the farmers selected and marked infected plants, which were not removed. The selection was done twice during the growing season at 9 and 12 weeks after planting. At harvest the selected plants during the growing season were harvested after the non-selected plants were harvested. The healthy looking tubers from the infected plants were still selected and stored as seed for the next season. In the storage, the management was the same as in the positive selection treatment.

2.2 The subsequent planting season

The demonstration plots showing the effect of different plant selection methods and planting material on the potato growth and yields were planted in Pangalengan and Garut on 15 June and 16 June 2016, respectively. The demonstration consisted of six treatments, *i.e.* G2.S (Granola generation 2 and positive election method), G2.P (Granola generation 2 and farmers' practice), G3.S (Granola generation 3 and positive selection method), G3.P (Granola generation 3 and farmers' practice), Atl.S (Imported Atlantic and positive selection method) and Atl.P (Imported Atlantic and farmers' practice). The six treatments were layout using a randomized complete block design and each treatment was replicated three times (Annex II). Each experimental unit consisted of twelve rows and twelve plants per row and therefore the total number of potato plants was 144 plants per plot. The planting distance was 75 x 30 cm and, therefore the size of the experimental units was (9.0 x 3.6 m =) 32.4 m^2. Soil tillage, fertilisation and crop protection were uniformly carried out in all plots but were different between Pangalengan and Garut as disease pressure in Pangalengan was higher.

Harvest was done only at a net plot of (7.5 x 3.0 m =) 22.5 m^2 consisting of 10 rows and 10 plants per row. At harvest, tuber fresh weight per plot, per plant and the number of tubers per plant were determined. Additionally, the percentage of tubers in three weight classes was determined, *i.e.* 0-50 g, 50-100 g and > 100 g. The marketable yield was determined as the percentage of tuber > 50 g.

All parameters observed were analysed by the analysis of variance using the MSTATC statistical program. The treatment means were compared using Least Significant Difference (LSD) at the 5% probability level.

3. Results and discussion

Harvest of the demo plots in Pangalengan and in Garut were carried out on October 5 and October 6, 2016, respectively at 16 weeks after planting or at 112 days after planting. One week before harvest, the haulm was killed using a herbicide. The results of the demonstration in the different seasons are described in the following sections.

3.1 The first planting season

The number of diseased plants being removed in the positive selection method or identified in the farmers' practice varied between the different seed sources (Table 3.1). The positive selection method started earlier with the removal/identification than the farmers practice' while in the latter method also diseased plants remained in the field. Leaving diseased plants in the field increases the risk of infection of healthy neighbouring plants and thus decreasing the seed quality of the plot. The total number of diseased plants in Atlantic was higher than of both generations of Granola, while there was little difference between the selection methods. This suggests that the use planting material of Atlantic was more degenerated than of Granola. We did not observe a difference between Granola G2 and G3 in the number of diseased plants. Although the number of removed plants between Granola G2 and G3 was comparable, the number of healthy selected plants from Granola G3 was even slightly higher than of Granola G2. The unexpected better performance of G3 potato plants seems to support farmers' complaints about the quality of certified seed of different generations.

Table 3.1 The number of identified diseased plants (removed or indicated by a bamboo stick) at the different selection times, the total number of diseased plants and the number of selected plants by positive selection and farmers practice for the different seed sources.

Selection method	Seed source	Weeks after planting			Total # diseased plants	# of selected plants
		7	9	12		
Positive selection	G2	8	7	7	22	628
	G3	8	9	4	21	654
	Atlantic	18	33	27	78	485
Farmers' practice	G2	0	14	7	21	666
	G3	0	7	20	27	671
	Atlantic	0	57	38	95	562

3.2 The subsequent growing season

3.2.1 Pangalengan

The effect of the selection method on the tuber yield in the subsequent season in Pangalengan is shown in Table 3.2. There was no significant interaction between plant material and selection method and, therefore only the main effects are discussed. Tuber yield per plot differed significantly between planting material, Granola G3 had the highest tuber yield per plot followed by Granola G2 and Atlantic with the lowest tuber yield. Although both Granola G2 and G3 were certified, the results of the demonstration plot indicated that the quality of Granola G2 was lower than that of Granola G3. The apparent better performance of G3 was also observed in the first planting season (Table 3.1). The younger generation (G2) did not perform better than G3 in the subsequent planting season while the G2 lot was certified, which should normally outperform G3. The variable seed quality based on the generation was also observed in earlier experiments (Gunadi*, et al.* 2011).

Table 3.2 Effect of selection method in the previous season on the tuber yield in the subsequent season, Pangalengan, October 2016.

Treatment	Tuber yield (kg/22.5 m^2)	Tuber yield (g/plant)	Tuber number (#/plant)	Tuber yield (ton/ha)
Variety (V):				
Granola G2	77.19	844.7	8.6	27.4
Granola G3	98.29	1002.7	11.0	34.9
Atlantic	30.14	363.7	3.8	10.7
Selection (S):				
Positive Selection (S)	73.35	778.8	8.5	26.0
Farmers' Practice (P)	63.74	695.3	7.1	22.6
V x S:				
G2.S	86.07	922.9	8.7	30.6
G2.P	68.31	766.5	8.6	24.3
G3.S	102.09	1042.9	12.8	36.3
G3.P	94.48	962.5	9.2	33.6
Atl.S	31.79	370.7	3.9	11.3
Atl.P	28.50	356.8	3.6	10.1
Mean	68.54	737.1	7.8	24.4
P ($LSD_{0.05}$) V	<0.001 (8.19)	<0.001 (79.9)	<0.001 (2.0)	<0.001 (2.9)
S	0.0094 (6.68)	0.0171 (65.2)	0.0102 (0.9)	0.0094 (2.4)
V x S	0.1826 (11.58)	0.1888 (112.9)	>0.05 (2.8)	>0.05 (4.1)
CV (%)	9.3	8.4	20.1	9.3

Note: LSD = Least Significance Different; CV = Coefficient of Variation

The tuber yields per plot from positive selected seeds was significantly higher than those from the farmers' practice (Table 3.2). This is in agreement with other research results (Gildemacher*, et al.* 2007; Gildemacher*, et al.* 2011; Kakuhenzire*, et al.* 2013).

Observation and discussion with Dr. Annette Pronk (WUR) in the demo plot of the effect of plant selection on potatoes in the subsequent season in Margamekar village, Pangalengan

The potatoes in the demo plot of the effect of plant selection on potatoes in the subsequent season in Giriawas village, Cikajang, Garut

Similar observations were also found for tuber yield per plant, tuber number per plant and tuber yields per ha. Compared to the farmers' practice, the positive selection increased the tuber yields per ha by 26%, 8% and 12% for Granola G2, Granola G3 and Atlantic, respectively (Figure 3.1).

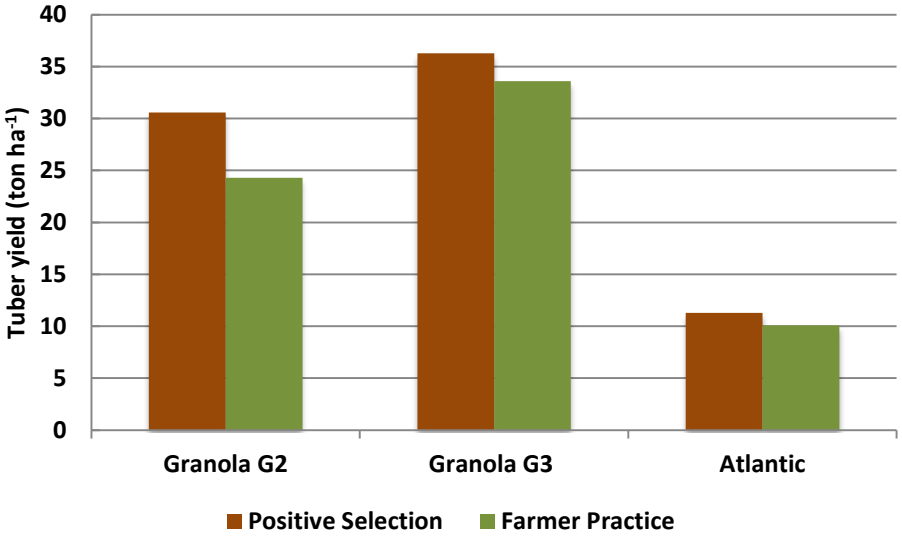


Figure 3.1 Tuber yields of three different potato materials grown using positive selection and farmer practice in Pangalengan, October 2016.

The higher plant tuber yields in the positive selection treatments compared to the farmer practice treatments were mainly due to the healthier and vigorous potato plants in the positive selection treatment plots.

The potatoes in the demo plot of the effect of plant selection on potatoes in the subsequent season in Margamekar village, Pangalengan

Discussion between researcher and farmers in the demo plot of the effect of plant selection on potatoes in the subsequent season in Giriawas village, Cikajang, Garut

The distribution of tubers per weight class at harvest is shown in Table 3.3. No significant differences were found between planting materials for the percentage tubers > 100 g and 50-100 g. The positive selected seeds had a higher percentage of tubers > 100 g than the seeds from farmers' practice but the differences were not significant. There was a significant difference found for the percentage tubers < 50 g: positive selection had a lower percentage than farmer's practice in this class, most likely because more tubers were bigger and found in the other classes.

There was no significant difference between planting materials (Variety V) in terms of the percentage of marketable tubers. However, a significant difference was found between selection methods: the positive selected seeds had a significantly higher percentage of marketable tubers than seeds from farmers' practice (Table 3.3).

Table 3.3 Effect of the selection method in the previous season on potato size distribution in the subsequent season, Pangalengan, October 2016.

Treatment	% tubers > 100 g	% tubers 50-100 g	% tubers < 50 g	% marketable tubers
Variety (V):				
Granola G2	57.9	24.5	17.5	82.5
Granola G3	54.1	26.1	19.7	80.2
Atlantic	58.6	25.1	16.2	83.7
Selection (S):				
Positive Selection (S)	59.8	25.5	14.6	85.3
Farmer Practice (P)	53.9	25.0	21.0	79.0
V x S:				
G2.S	63.3	23.2	13.5	86.4
G2.P	52.5	26.0	21.4	78.5
G3.S	56.1	28.9	14.9	85.0
G3.P	52.1	23.3	24.5	75.4
Atl.S	60.0	24.5	15.5	84.5
Atl.P	57.2	25.8	17.0	82.9
Mean	56.8	25.3	17.8	82.2
P ($LSD_{0.05}$) V	>0.05 (11.3)	>0.05 (8.8)	0.2262 (4.2)	0.2262 (4.2)
S	0.189 (9.2)	>0.05 (7.2)	0.0023 (3.5)	0.0023 (3.5)
V x S	>0.05 (16.0)	>0.05 (12.4)	0.1349 (6.0)	0.1349 (6.0)
CV (%)	15.5	27.0	18.6	4.0

Note: LSD = Least Significance Different; CV = Coefficient of Variation

3.2.2 Garut

The effect of the selection method on the tuber yield in the subsequent season in Cikajang, Garut is shown in Table 3.4. There was no significant interaction between plant material and plant selection method and, therefore only the main effects are discussed. As in Pangalengan, tuber yields per plot differed significantly between planting material. Granola G3 had the highest tuber yield per plot although not significantly higher than Granola G2. Granola G2 and G3 had significantly higher tuber yields than Atlantic. As in Pangalengan, G3 performed slightly better than G2 despite the fact that both seed lots were certified.

Harvesting the potatoes in the demo plot of the effect of plant selection on potatoes in the subsequent season in Margamekar village, Pangalengan

Harvesting the potatoes in the demo plot of the effect of plant selection on potatoes in the subsequent season in Giriawas village, Cikajang, Garut

Table 3.4 Effect of selection method in the previous season on the tuber yield in the subsequent season, Cikajang, Garut, October 2016

Treatment	Tuber yield (kg/22.5 m^2)	Tuber yield (g/ plant)	Tuber number (#/)	Tuber yield (ton/ha)
Variety (V):				
Granola G2	70.0	753.9	8.1	24.9
Granola G3	77.6	783.1	9.5	27.6
Atlantic	38.2	456.7	4.3	13.6
Selection (S):				
Positive Selection (S)	65.3	696.7	7.6	23.2
Farmer Practice (P)	58.5	631.8	7.0	20.8
V x S:				
G2.S	76.3	798.1	8.3	27.1
G2.P	63.7	707.7	7.8	22.6
G3.S	81.6	820.9	10.1	29.0
G3.P	73.5	745.3	8.9	26.1
Atl.S	37.9	471.1	4.4	13.6
Atl.P	38.4	442.4	4.2	13.5
Mean	61.9	664.3	7.3	22.0
P ($LSD_{0.05}$) V	<0.001 (8.6)	<0.001(61.6)	<0.001 (0.8)	<0.001 (3.0)
S	0.0578 (7.0)	0.0166 (50.3)	0.0847 (0.6)	0.0578 (2.5)
V x S	0.2771 (12.1)	>0.05 (87.2)	0.2145 (1.1)	0.2771 (4.3)
CV (%)	10.8	7.2	8.3	10.7

Note: LSD = Least Significance Different; CV = Coefficient of Variation

Although the tuber yields per plot of plants using positive selected seeds in the previous season was higher than that of seeds from the farmer practice, the difference was not significant (Table 3.4).

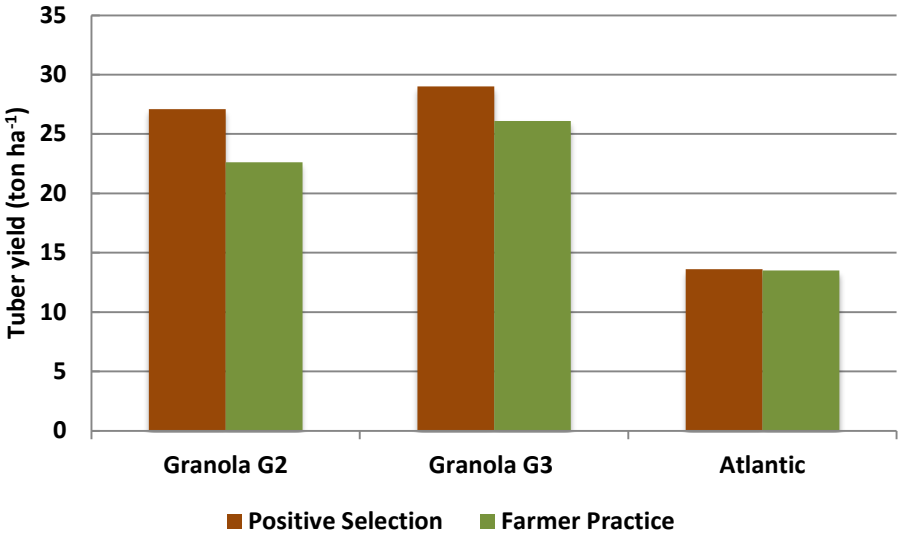


Figure 3.2 Tuber yields of three different potato materials grown using positive selection and farmer practice in Cikajang, Garut, October 2016

Similar observations were found for tuber number per plant and tuber yield per ha. In terms of tuber

yields per plant, however, a significant difference was found between plant selection methods: the tuber yield per plant from positive selection was significantly higher than that of farmer practice. Compared to the farmer practice, the positive selected seeds increased tuber yields per ha by 20%, 11% and 7% of Granola G2, Granola G3 and Atlantic, respectively (Figure 3.2). As in Pangalengan, the higher tuber yields were a result of the healthier and vigorous potato plants in the positive selected seed plots.

The distribution of tubers per weight class at harvest is shown in Table 3.5. In terms of % of tubers > 100 g, the variety Atlantic had a significant higher percentage of tuber > 100 g than Granola G3 and equal to Granola G2. The positive selected seeds resulted in a slightly higher percentage of tubers > 100 g than the seeds from the farmers' practice but these differences were not significant. There was a significant interactive effect of selection method: the farmer's practice of Granola G3 had a lower % of tubers > 100 g compared to the treatments of positive selection (Granola G2 and Atlantic) where the % of tubers >100 g of the other two farmers practice did not differ. In the class 50-100 g, no significant differences were found between the planting materials and or between the selection treatments. Only in the class < 50 g a significant difference was found between planting materials and also between selection treatments. Atlantic had a significantly lower percentage of tubers < 50 g compared to Granola G2 and Granola G3 where Granola G2 and G3 had comparable percentages of tubers < 50 g. In terms of selection treatment, the potato plants grown from the positive selection seeds had a significant lower percentage of tubers < 50 g than the farmer practice seeds. In terms of the percentage of marketable tuber yield, there was a significant difference between planting materials: Atlantic had the highest percentage of marketable tuber yield followed by Granola G2 and the lowest percentage of marketable tuber yield was obtained by Granola G3. A significant difference was also found between selection treatments: the potato plants grown using seeds derived from the positive selection treatment had significantly higher percentage of marketable tuber yield than those grown using seeds derived from the farmer practice treatment (Table 3.5).

Table 3.5 Effect of selection method in the previous season on potato size distribution in the subsequent season, Cikajang, Garut, October 2016.

Treatment	% tubers > 100 g	% tubers 50-100 g	% tubers < 50 g	% marketable tubers
Variety (V):				
Granola G2	53.5	32.8	13.7	86.3
Granola G3	42.0	40.3	17.7	82.3
Atlantic	54.3	38.8	6.9	93.1
Selection (S):				
Positive Selection (S)	52.3	36.6	11.1	88.9
Farmer Practice (P)	47.6	38.0	14.4	85.6
V x S:				
G2.S	52.9	34.6	12.4	87.5
G2.P	54.1	30.9	14.9	85.1
G3.S	46.3	39.1	14.6	85.4
G3.P	37.8	41.4	20.8	79.2
Atl.S	57.8	35.8	6.3	93.7
Atl.P	50.8	41.7	7.4	92.5
Mean	49.9	37.3	12.7	87.2
P ($LSD_{0.05}$) V	0.0396 (10.1)	0.1846 (8.7)	0.0001 (3.4)	0.0001 (3.4)
S	0.2308 (8.3)	>0.05 (7.2)	0.0277 (2.8)	0.0277 (2.8)
V x S	>0.0500 (14.4)	>0.05 (12.4)	0.2798 (4.9)	0.2798 (4.9)
CV (%)	15.8	18.3	21.0	3.1

Note: LSD = Least Significance Different; CV = Coefficient of Variation

4. Conclusions and recommendations

The number of removed plants in the first planting season was higher in the younger generation of Granola (G2), showing a common problem with certified seed in Indonesia. Older seeds of Granola G3 were of better quality than the seeds of the younger G2 generation. According to the certification protocol, this should not be possible (Fuglie*, et al.* 2005) but in practice often found as echoed by farmers complaining about the quality of certified seed. Within the scope of this study it was not possible to trace the problem in the certification process that caused the poor performance of the G2 lot.

The number of plants removed from Atlantic in the first planting season showed that the imported seed was more degenerated than the used Granola seed (G2 and G3). Although we did not know the origin and generation of used Atlantic seed, imported Atlantic seed is usual certified G4 seed.

The positive selected seeds planted in Pangalengan and Garut in the subsequent season were all from the same treatment and treated equally: all seeds were stored in the farmers' storage in Cikajang, Garut and one week before planting in the second season, part of the stored seeds were transported to Pangalengan. Yields of Granola G3 and Atlantic were a bit different between Pangalengan and Garut, where yields of Granola G2 were more comparable between both locations. There are no obvious reasons for these differences but they may be related to differences in production practices between both regions. In the area where farmers are used to cultivate Granola, i.e. Pangalengan, yields of the same seeds (V) were higher than in Garut. In contrast with Atlantic: in the area where farmers are used to produce Atlantic, i.e. Garut, yields of Atlantic were higher than in Pangalengan. This yield trend of Granola and Atlantic, i.e. higher yields of Granola in Pangalengan and higher yields of Atlantic in Garut, has been observed before (De Putter*, et al.* 2014; Pronk*, et al.* 2017b; Van den Brink*, et al.* 2015). The higher yields of Granola in Pangalengan in general, is most probably associated with the easiness to access to the good quality of seeds in Pangalengan as relatively many potato seed growers are present in the region. In contrast, the farmers in Garut have relatively easier to access to the imported Atlantic seeds than to Granola seeds as the source of Atlantic seeds is located in Garut area.

The positive selection resulted in higher tuber yields compared to the farmers' practice of farm saved seeds. This result was found for both varieties, Atlantic and Granola, and for both generations of Granola, G2 and G3, and for both regions, Garut and Pangalengan. However, yield increase of Atlantic was smaller than of Granola G2 and G3, 1.2, 5.5 and 7.4 tons/ha marketable yield in Pangalengan and 0.1, 2.9 and 4.5 tons/ha in Garut, respectively. Although such yield gains may seem small, they represent an estimated increase in the gross revenue of 5.9 to 36.8 million IDR/ha for Granola and 0.5 to 21.2 million IDR/ha for Atlantic at farm gate prices of 5,000 and 4,700 IDR/kg, respectively. With average gross revenues in Pangalengan of 70 million IDR/ha for Atlantic and 126 million IDR/ha for Granola, and in Garut of 110 million IDR/ha for Atlantic and 122 million IDR/ha for Granola (Pronk*, et al.* in prep.), the maximum increase of the gross revenue is 29% using positive selected seeds.

Besides an immediate increase in gross revenue, another benefit must be considered when looking at farm saved seeds. Seed presents commonly the largest input cost (De Putter*, et al.* 2014; Pronk*, et al.* 2017a; Van den Brink*, et al.* 2015). On average, seed costs range between 26 to 36% of the total cost price. The standard system is therefore that farmers invest in good quality seeds and practice farm saved seed techniques for a number of years thereafter. After the ban on the import of high quality seed potatoes in 2003, farmers have faced an increase in cost price because they have to renew their seed stock more frequently. Farmers were used to renew the seed stock every 5^{th} to 7^{th} cultivation depending on the crop performance, but nowadays they may have to renew as early as two cultivations as the seed is highly degenerated by then. As also the quality of the certified seeds can be questionable, which is supported by this demonstration by a lower seed quality of Granola G2 than Granola G3, farmers complain and encounter serious problems with access to good quality seed potatoes. So, when the period of using own farm saved seeds can be extended by one or may be two seasons due to improved seed quality, farmers can reduce the frequency of buying an expensive "fresh" seed stock and in the meantime improve seed availability as well.

The conclusion of demonstrating the positive selection method is that the method is suitable for potato farmers in Indonesia to improve the quality of the farm saved seed. The additional effort that farmers have to make by applying the positive selection method is rewarded with:

- A substantial increase of the marketable potato yield and associated increase in gross revenue;
- Farmers can use the expensive certified or “freshly” bought seeds for an increased number of seasons as degeneration is slowed down;
- Improved and secured seed availability.

Following the conclusions of the demonstration it is recommended to:

- Continue to train farmers on the positive selection method to enable farmers to increase marketable yields and income, secure seed availability and increase the number of years farm saved seeds can be used;
- Initiate an investigation on the quality of certified seed of different generations available on the market;
- Analyse what the bottlenecks are in the certification process to make sufficient seed potatoes of a well-defined and guaranteed quality available for farmers in Indonesia.

5. References

Chujoy E., 1995. Report on Potato Research in Indonesia. International Potato Center, Lembang, Indonesia, pp.

CIP, 1984. Potatoes for the developing world, Lima, Peru.

De Putter H., N. Gunadi, Uka, R. Wustman & H. Schepers, 2014. Economics and agronomics of Atlantic and Granloa potato production in the dry season of 2013 in West Java. vegIMPACT Internal Report 10. Wageningen-UR, Wageningen, 43 pp.

Fuglie K. O., W. Adiyoga, R. Asmunati, S. Mahalaya & R. Suherman, 2005. Supply and demand for quality potato seed in Indonesia: Farmers' perspectives and policy options. UPWARD Working Paper Series No. 8. CIP-UPWARD. International Potato Center, Los Baños, Laguna, Philippines. 53 p.

Gildemacher P. R., P. Demo, P. Kinyae, M. Wakahiu, M. Nyongesa & T. Zschocke, 2007. Select de Best. Positive selection to improve farm saved seed potatoes. Trainers manual. International Potato Center, Peru. 110 p.

Gildemacher P. R., E. Schulte-Geldermann, D. Borus, P. Demo, P. Kinyae, P. Mundia & P. C. Struik, 2011. Seed Potato Quality Improvement through Positive Selection by Smallholder Farmers in Kenya. Potato Research 54, 253-266.

Gunadi N., R. Wustman, J. Van der Burg, T. Been, A. K. Karyadi, W. Adiyoga, I. Sulastrini & Kusmana, 2011. Potato Seed Quality Evaluation Trials 2011. Effect of seed generation derived from different seed sources on the growth and yield of potato in West Java-Indonesia. WUR, Wageningen, The Netherlands, 34 pp.

Horton D. E. & J. L. Anderson, 1992. Potato production in the context of the world and farm economy. *In* The potato crop: the scientific basis for improvement, Ed P. M. Harris. pp. 794-815. Chapman & Hall, London, UK.

Kakuhenzire R., B. Lemaga, D. Tibanyendera, D. Borus, I. Kashaija, P. Namugga & E. Schulte-Geldermann, 2013. Positive Selection: A Simple Technique for Improving Seed Potato Quality and Potato Productivity among Smallholder Farmers. Acta Horticulturae 1007.

Pronk A. A., N. Gunadi, L. Van den Brink, T. K. Moesakan & U. Komara, in prep. Farm registrations and yield gap analysis of potato in Garut and Pangalengan of the varieties Atlantic and Granola. vegIMPACT External Report ... Wageningen-UR, Wageningen, The Netherlands, pp.

Pronk A. A., L. van den Brink, N. Gunadi & U. Komara, 2017a. Economics and agronomics of Atlantic and Granola potato cultivation in the dry season 2014 in West Java. vegIMPACT External Report ... Wageningen-UR, vegIMPACT, Wageningen, The Netherlands, 47 pp.

Pronk A. A., L. van den Brink, N. Gunadi & U. Komara, 2017b. Economics and agronomics of Atlantic and Granola potato production in the dry season 2014 in West Java. vegIMPACT External Report 36. Wageningen-UR, Wageningen, 47 pp.

Salazar L. F., 1996. Potato viruses and their control. International Potato Center, Lima, Peru, pp.

Van den Brink L., N. Gunadi, R. Wustman, U. Uka, T. K. Moekasan & H. Hengsdijk, 2015. Agronomics and economics of potato production in West Java, Indonesia. vegIMPACT External Report 16. Wageningen-UR, Wageningen, 22 pp.

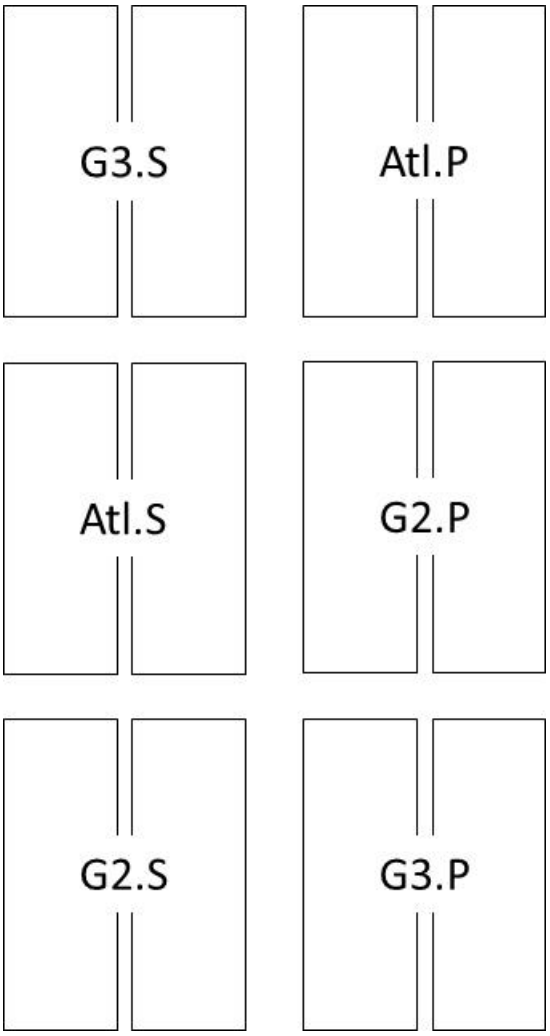
Annex I Layout of the demo plot on plant selection of potatoes, first season (Garut 2015-2016)

Treatments: Combinations of G2, G3 and Atlantic Imported (Atl) with plant selection (S) and farmers practice (P)

Total numbers of plots: 6

Plot size: 2 x 6.5 m x 12.5 m = 13 m x 12.5 m = 162.5 m^2

Plant density: row distance: 0.75 m; plant distance in the row: 0.30 m.



Annex II Layout of the demo plot on plant selection of potatoes, second season (Garut-2016)

Experimental unit: 12 rows x 12 plants = 144 plants

Plot size: 9.0 m x 3.6 m = 32.4 m^2

Treatments:
1. GS.2
2. G2.P
3. G3.S
4. G3.P
5. Atl.P
6. Atl.S

Tree blocks (I, II, III), randomized.