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Economics and agronomics of Atlantic and Granola potato cultivation in the dry season of 2013 in West Java

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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

vegIMPACT is a program financed by The Netherlands' Government promoting improved vegetable production and marketing for small farmers in Indonesia, contributing to the food security status and private sector development in Indonesia. The program builds on the results of previous joint Indonesian-Dutch horticultural development cooperation projects and aligns with recent developments in the horticultural private sector and retail in Indonesia. The program activities (2012 – 2016) include the Development of Product Market Combinations, Strengthening the Potato Sector, Development of permanent Vegetable Production Systems, Knowledge Transfer and Occupational Health.

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Contents

Executive summary

Potato is a major horticultural crop in Indonesia. Its cultivation is concentrated in the highlands of Western Java with smaller production areas in Central Java, East Java, North Sumatra and West Sumatra. The vegIMPACT Work Package Potato focuses mainly on increased yield levels and contributions to themes such as reduced crop protection compounds use and increased labour opportunities for women. To analyse the existing situation, crop data of each of 40 potato growers were collected in both Garut and Pangalengan (Western Java): ten Granola growers and ten Atlantic growers in either one of both locations during the period March-August 2013. Granola is the most widely grown variety and is mainly used for fresh consumption and partly for home-made processing into a kind of chips. Atlantic is the most popular variety for industrial processing into chips. Both varieties have been around for the past about 40 years. Average planting and harvesting dates were 2 April-30 June (Atlantic) and 14 May and 19 August (Granola); average field crop duration was 89 days for Atlantic and 97 days for Granola. Average field size was 3,985 m^2 in Garut and 3,135 m^2 in Pangalengan. Elevations above sea level were slightly different: 1,324 m and 1,447 m for Garut and Pangalengan respectively. Seed rates for Atlantic and Granola were 1,964 kg and 1,807 kg respectively. Distances between and in rows were rather similar. On average 32 % of the growers used plastic mulch for weed control and moisture preservation in the ridge. The amounts of organic manure (chicken manure collected from chicken battery farms) were substantial; on average 23.2 tons was applied per hectare. Mineral fertilizer rates were on average 158 kg N, 316 kg P_2O_5 and 197 kg K_2O for Atlantic and 186 kg N, 282 kg P_2O_5 and 157 kg K_2O for Granola. The total calculated amounts of nitrogen, phosphate and potassium was rather high as compared to the average yield level of 16.6 ton for Atlantic and 16.7 tons for Granola. However the variation in yield was large: from less than 5 tons (Pangalengan) up to about 29 tons (Garut) for Atlantic and less than 9 tons (Pangalengan) up to about 29 tons (Pangalengan) for Granola. Adequate late blight control was a challenge to the growers. Highest cost components from the total cost of materials were seed (49 % in Garut and 43 % in Pangalengan); fertilizer (28 % Garut and 22 % Pangalengan) and fungicides (20 % Garut and 20 % Pangalengan). The share of seed, fertilizer and fungicides accounted for 91-96 % of the total production costs. Our approach in identifying production key factors in increasing profit margins is to increase the output per unit of input of seed, fertilizer and late blight controlling fungicides. Therefore three priorities for yield / profit increase were identified: seed potato quality, reduction in fertilizer rates and more effective scenarios for late blight control. Thus the topics for the vegIMPACT knowledge transfer program are: seed quality, nitrogen and late blight control. The first late blight control demonstrations were started in December 2013.

Acknowledgement

This study could only be done with the support of the participating farmers who were willing to fill in each day the logbooks and spend time with the filed officers to check the data. We also thank the local field officers employed by Balitsa to collect all the data and assist the farmers with filling in the log books.

1. Introduction

Indonesia is the largest potato producer in Southeast Asia (Dimyati 2003) and only second after China of the priority countries in the East and South East Asia and the Pacific Region of the International Potato Center (CIP-ESEAP region) (Chujoy 1995). The potato production in Indonesia has nearly doubled in the last 19 years, from 525,839 t in 1991 to 1,060,580 t in 2010. The area of potato has increased more than 50% from 39,620 ha in 1991 to 66,508 ha in 2010; and productivity increased by 22% from 13.2 to 15.9 t/ha (FAO 2011). However, the last few years the total production gradually declines. This may partly due to diminishing yields per ha, and/or partly due to a decreasing area grown. Both seem to originate from the decreasing profitability of the crops due to a steadily decrease in quality and availability of planting stock (seed potatoes).
The potato has been selected as priority crop in the strategic plans of research and development program of the Indonesian Center for Horticulture Research and Development (ICHORD), the Indonesian Agency for Agricultural Research and Development (IAARD) in Indonesia in the last 30 years. This is due to its potential as alternative source of carbohydrates in food diversification and as export commodity.
The main potato variety since the 1980's is Granola which covers 80 to 85% of the potato area. Late blight and bacterial wilt are the most important diseases followed by viruses. Other pests include thrips, mites, aphids, tuber moths and leaf miner flies. Late blight (*Phytophthora infestans*) is a severe epidemic occurring especially during the wet season. Excessive use of fungicides (up to 20 times the recommended rates) was noted. Both mating types 1 and 2 of *Phytophthora infestans* have been isolated in the country and it has been established that Mancozeb, the common fungicide used by the farmers, is no longer effective to control the disease. The latter finding may also indicate the occurrence of fungus strains with resistance to metalaxyl, as reported in the USA. Potato viruses are widespread in major potato areas (West Java, Central Java, East Java, North Sumatra, and West Sumatra). PLRV, PVY and PVX are the most important viruses. Crops with 1 to 5 % virus-like diseased plants are common. It appears that more virus disease occurs in areas where quality seed is difficult to obtain or is too expensive. Resistance to viruses (mainly PLRV and PVY) is required for a sustained seed production. The moderate resistance to PLRV and PVY of Granola appears to have contributed to making it a successful variety in Indonesia. As such resistance levels plus some tolerance/ resistance to bacterial wilt will lead to low degeneration levels. There is an ever increasing demand for processing potatoes in Indonesia, especially in Java (Chujoy 1995), similar to other areas in urban Asia and the Pacific (Ezeta 2008). Indonesia produces a very low output of processing potato and depends on imported raw materials for most of its requirements. The variety Granola is still the main variety in chips processing, as there is insufficient supply of the preferred variety Atlantic. Atlantic however, is an old variety which is in short supply nowadays, and degenerates rapidly. In order to fulfil the demand for potatoes either for fresh potato or processing potato, it is necessary to evaluate potato varieties for their suitability for the various uses. These varieties shall have high levels of resistance to late blight, viruses and potato cyst nematodes (*Globodera rostochiensis, G. pallida*, PCN/NSK).

1.1. Potato cultivars

Granola (*Solanum tuberosum* L. cv. Granola) is a white to yellow coloured potato with a light yellow to yellow flesh colour. The cultivar was introduced in 1975 in Germany and is since long the most important ware potato grown in Indonesia. In 2002 of the total acreage cultivated with potato 91.4% was with Granola. In Indonesia different Granola types are distinguished, amongst them are Granola-L, Granola-J and Granola-PO. Granola is considered to have a fairly firm cooking type and often a poor to moderate crisp suitability. Yield potential of Granola is medium to high. Fungal disease resistance is only present at a high level against Fusarium dry rot and wilting. Late blight (*Phytophthora infestans*) resistance is low in both foliage and tubers. Drought resistance is assessed as high.

Atlantic (*Solanum tuberosum* L. cv. Atlantic) is a cultivar bred in the United States of America and introduced in 1976 This cultivar has good crisp characteristics and has a fairly firm to mealy cooking type. Tubers are white to yellow with a white cream flesh colour. Contrary to Granola this cultivar can be seen more often flowering in the field. Yield potential of this cultivar is high to very high. It shows resistance to dry rot (*Fusarium* spp.) and to Fusarium wilt (*Fusarium oxysporum*). Resistance to late blight in both tubers and foliage is low. Compared to Granola it's even more susceptible to late blight.

Seed potatoes are imported and produced locally by official institutes. However, a large part of the seed potatoes are taken from preceding production fields. Whenever there are not many problems with diseases during production and the yield is good farmers keep a large share of the produced potatoes back to be used for a next planting. The use of own planting material can be as high as 80% of the total seed potato use. One aspect is price, imported seed potatoes can be 7 times more expensive than the selling price of harvested potatoes while for seed potatoes bought from colleague farmers are only two times more expensive. A second aspect is the availability of certified seed potatoes at the right quantity and quality at the right period. Local production of seed potatoes has been tried but in most cases the results were disappointing. The downside of using own planting material is the degeneration which will result in lower yields. Currently governmental organisations are setting up a seed potato producing system which seems to produce good reliable seed potatoes for Granola. The multiplication starts with selecting virus and disease free tuber and tissue is taken to produce mini tubers. These tubers are multiplied in several steps or generations which start in the laboratory. After this tubers are multiplied in screen net houses and after that in open fields. The fourth generation finally is the generation that is commercially available to farmers for producing table ware or crisp potatoes.

In the past several studies have been carried out to asses costs and profit of potato cultivation. Mostly those studies are based on interviews with farmers. In order to have accurate data on timing of activities and labour requirements this method shows some flaws. Positive is that with this method data for different seasons can be obtained in a short period. With registration in log books data is collected real time and is highly accurate while farmers are writing daily in a logbook what activities were carried out that day and what inputs were used at what costs and how much labour was spend that day. The downside of this method is that results are available only after the period of recording and are valid only for the period in which the data were recorded.

However, based on records more reliable conclusions on fertilization and crop protection can be drawn. Next to that although farmers have a good recollection on used materials and cost of materials and yield in only a few cases they have good knowledge of labour requirements and labour costs.

The data is reported in Indonesian rupiah (IDR) which at the time of the study had a value of about 12,500 IDR per 1 Euro in March 2013 and 15,500 IDR per 1 Euro in September 2013 (Fig. 1). However, no price increases of inputs or labour in the study area occurred during the period of the study.

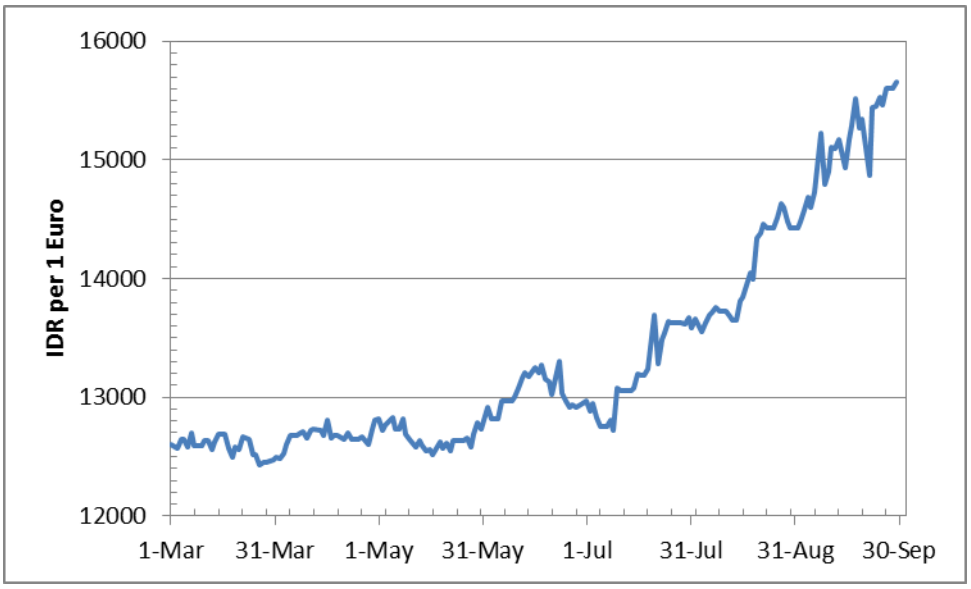

Figure 1. Exchange rate of the Indonesian rupiah for the period of 1 March till 30 September 2013.

2. Materials and methods

2.1. Regions

Data were taken from a total of 40 farmers equally divided over two regions, i.e. Garut and Pangalengan (Fig. 2), and two cultivars, i.e. Atlantic and Granola. Hence per region – variety combination a total of 10 records were taken. Pangalengan is located 30 km south of Bandung, West Java, while Garut is located 50 km southwest of Bandung.

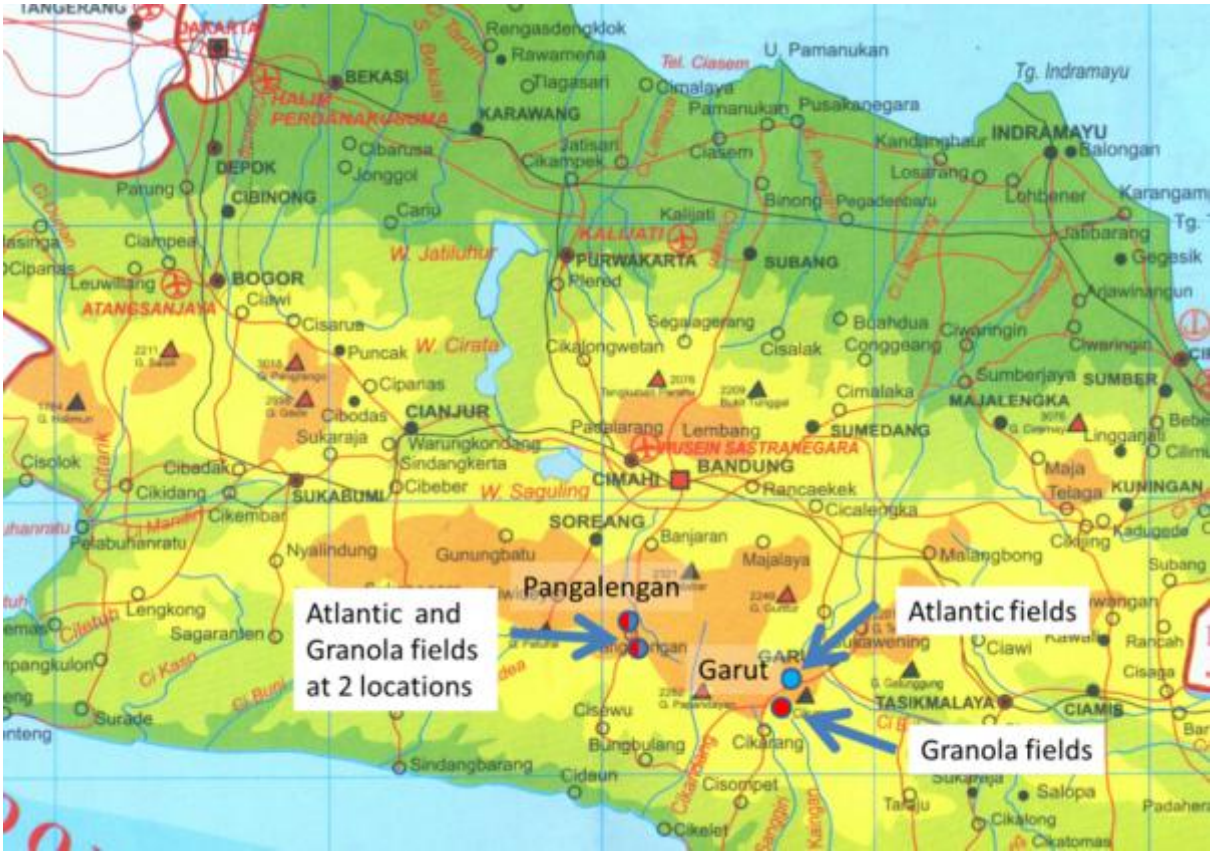

Figure 2. Location of potato fields near Pangalengan and Garut.

Granola and Atlantic fields which were included in the record taking in Pangalengan are concentrated near Lake Cileunca (Fig. 3). A second concentration is approximately 4 km north of the lake. In Garut potato fields are located on the slopes of the volcano Cikuray. Atlantic fields were near the village Cigadug and the Granola fields were located just south of these fields near the village Cikajang. Fields in Pangalengan are in most cases accessible by car, or are near a road, only 2 fields were only reachable after a 2 - 3 km walk. In Garut all except one Granola field were relatively easily accessible, five fields were accessible by road, four fields were within 1 km walking distance from the road and one field could only be reached after a 2 km motor ride and 1 km walk. All except one Atlantic field could only be reached by motorbike. All inputs and products are also transported from the main road to the field by motorbikes which are hired by the farmer.

Figure 3. Lake Cileunca in Pangalengan, some farmers have to use boats to reach the potato fields

Soils in all locations are of volcanic origin and highly fertile. Fields are in the mountains and are in most cases sloping, and in a few cases fields are terraced. In both regions it is quite common to observe that potato fields are being established in former tea plantations (Fig. 4). Water is ample available and irrigation is when needed done by furrow gravity irrigation.

Figure 4. Potato fields in the midst of tea plantations in Pangalengan

Figure 5. Terraced fields with potato, the crop is supported by bamboo poles and rope to prevent collapsing of the foliage.

2.2. Record taking

Records were taken daily by farmers of potato crops grown partly in the dry season and start of the wet season, with planting in March till June. Farmers wrote their data in logbooks which were weekly collected for processing. Included in the record were description of activity, quantity of used materials applied in the activity, unit costs of materials used, costs of materials, labour spend on the activity in hours and costs per category, i.e. on farm male and female labour, hired male and female labour. For fertilizers content of N, P_2O_5, and K_2O were recorded as well. For pesticides name of active ingredient (A.I.), A.I. content, mode of action group classification and WHO hazardous classification were recorded (Table 1).

Table 1. Pesticide classification system by the World Health Organization (WHO).

Class	Description
Ia	Extremely hazardous
Ib	highly hazardous
II	moderately hazardous
III	slightly hazardous
U	unlikely to pose an acute hazard in normal use
NL	not listed (mostly related to new pesticides of which no or limited information is available)

2.3. Climate during the study

The climate in the highland is moderate with rainfall occurring in the months September till April. The period between the months May till August can be characterized as dry. In Pangalengan monthly precipitation in the months December, January, February and March ranges between 250 and 500 mm. In the dry period monthly precipitation can still be as high as 200 mm. Although the season in which the study was carried out usually is considered as a dry season, significant rain was present at both locations. The months June and July showed 220 and 316 mm precipitation in Garut (Table 2) respectively. July was a wet month with 21 days at which rain was present. Maximum temperature was for all months about 30 to 32°C while minimum temperature was between 23 and 25°C.

Table 2. Average high and low temperature, precipitation and number of rain days in Garut.

Month	Average high Temperature (°C)	Average low Temperature (°C)	Precipitation (mm)	Number of days with rain
February	32.5	24.4	253	18
March	32.3	24.8	136	20
April	32.0	25.1	129	16
May	31.9	24.7	93	14
June	30.9	24.4	220	15
July	30.0	23.8	316	21
August	29.5	23.5	104	14
September	29.3	23.7	24	8
Mean	31.0	24.3	1275	126

Source: www.accuweather.com/en/id/garut/

In Pangalengan precipitation was less than in Garut with a total of 671 mm compared to 1275 mm in Garut (Table 3). June did not show a lot precipitation but July was also in Pangalengan a wet month with 16 rain days and a total precipitation of 217 mm. Temperature is similar to the temperature in Garut, maximum temperature is on average 32°C and minimum temperature 24°C.

Table 3. Average high and low temperature (°C), precipitation and number of rain days in Pangalengan.

Month	Average high Temperature	Average low Temperature	Precipitation (mm)	Number of days with rain
February	31.1	24.4	148	14
March	32.6	24.6	39	11
April	32.3	25.0	52	8
May	32.2	24.6	73	9
June	32.7	24.5	9	6
July	30.7	23.7	217	16
August	32.3	23.6	82	5
September	32.1	24.2	51	6
Mean	32.0	24.3	671	75

Source: www.accuweather.com/en/id/pangalengan/

3. Results and discussion

3.1. General data of recorded fields

Atlantic and Granola have on average a similar number of growing days, except in Pangalengan where Atlantic on average had only 80 days (Table 4). Atlantic matured earlier as compared to Granola: 88.5 days and 97 days respectively. Growth period at Cikajang was longer (96 days) as in Pangalengan (89.5 days). Based on discussion with farmers the short growth period of Atlantic in Pangalengan was greatly caused by poor seed quality resulting in a high disease pressure that caused the crop to deteriorate sooner than when using healthy seed potatoes. Average planting date of Atlantic was early April where planting started slightly earlier in Garut. Granola was planted late April in Pangalengan and early June in Garut. Harvest of Atlantic took place late June - early June while Granola was harvested in August.

In Pangalengan field size of Granola is on average 3,930 m^2 and Atlantic are smaller with 2340 m^2. At the other hand Atlantic fields are much bigger in Garut while Granola fields are quite small with only 1480 m^2 per field. Farms in Pangalengan are for both varieties more or less the same, while in Garut Atlantic is grown by specialized farms. Farms with Granola have only limited land available. Fields in Pangalengan are on average located at a higher altitude than fields in Garut. Average altitude of the potato fields is 1,376 m ASL. The small scale farmers of Granola tend to have their fields in lower areas at an altitude of 1,300 m. Atlantic farmers seem to have better access to plots higher up in the mountains where they can rent or buy land from tea plantations.

Table 4. Growing days, planting and harvest date, average field size and altitude of recorded potato fields.

		Growing days	S.E.	Planting date	S.E.	Harvest date	S.E.	Field size (m^2)	S.E.	Altitude (m ASL)	S.E.
Atlantic	Garut	96.9	3.2	29-03-13	9.9	04-07-13	11.8	6,490	1,575	1,356	22
	Pangalengan	80.0	3.9	07-04-13	3.9	26-06-13	5.4	2,340	344	1,410	21
	Mean	88.5	3.1	02-04-13	5.3	30-06-13	6.4	4,415	918	1,382	16
Granola	Garut	95.0	3.8	02-06-13	8.4	05-09-13	10.0	1,480	256	1,291	3
	Pangalengan	98.9	4.6	26-04-13	8.1	03-08-13	8.8	3,930	1,064	1,484	56
	Mean	97.0	2.9	14-05-13	7.3	19-08-13	7.7	2,705	618	1,370	33
Mean		92.7	2.2	23-04-13	5.6	25-07-13	6.4	3,560	566	1,376	18

3.2. Seed potatoes and planting

Between regions difference in seed potato use were small (Table 5). In Atlantic more seed potatoes were used with on average 2 ton/ha. In Granola this was less with 1.65 ton/ha. It seems that farmers were using only certified seed potatoes which is with an average generation of G4 fairly new planting material. Tubers of Atlantic seed potatoes are in Garut on average 89 gram and cutting of seed potatoes is done by six farmers (Table 5). Although in Pangalengan Atlantic tuber weight is 68 gram still four farmers cut the seed potatoes. Granola tubers were smaller than Atlantic with an average of 44 gram. In Garut none of the farmers cut the seed potatoes and average tuber weight was only 30 gram. In Pangalengan four farmers cut the seed potatoes.

Table 5. Seed potato use (kg/ha), generation of planting material, seed potato tuber weight, number of farmers cutting seed potatoes for planting.

		Seed potatoes (kg/ha)	S.E.	Generation	S.E.	Tuber weight	S.E.	Seed potatoes cutting
Atlantic	Garut	1,870	168	4.0	0.2	89.4	12.3	6
	Pangalengan	2,058	104	4.6	0.3	68.2	5.2	4
	Mean	1,964	99	4.3	0.2	78.8	6.9	10
Granola	Garut	1,607	113	4.1	0.7	30.0	1.4	0
	Pangalengan	1,695	174	4.1	0.5	58.3	4.9	5
	Mean	1,651	101	4.1	0.4	44.1	4.1	5
Mean		1,807	74	4.2	0.2	61.4	4.8	15

Figure 6. Storage of seed potatoes cv. Granola in Pangalengan

Figure 7. Quality of Atlantic seed potatoes is often low due to poor storage conditions and aging of the tubers.

Figure 8. Cutting of seed potatoes is common practice with large sized tubers.

Planting distance between rows was with an average of almost 75 cm similar for all regions and cultivars (Table). Within a row Granola is planted at approximately 33 cm and Atlantic in Pangalengan was also planted at 32 cm. Planting distance of Atlantic in Garut was 41.5 cm. This resulted also in a lower plant density of 3.4 plants/m^2 compared to 4.0 to 4.2 plants/m^2 in the other situations. Plastic mulch was applied by all Atlantic farmers in Garut, in Granola it is not used. In Pangalengan plastic mulch is used by a few farmers. Mulching reduces weed growth (and herbicide application and labour for weeding) and reduces leaching out of nutrients. So mulching can be considered as a contribution to sustainable production.

Table 6. Plant density and planting distance and number of farmers using plastic mulch.

		Plants /m^2	S.E.	Between row (cm)	S.E.	In row (cm)	S.E.	Plastic mulch use (number of farmers
Atlantic	Garut	3.4	0.2	73.0	3.0	41.5	1.5	10
	Pangalengan	4.2	0.1	75.3	1.0	32.0	0.8	1
	Mean	3.8	0.2	74.2	1.6	36.8	1.4	11
Granola	Garut	4.0	0.1	76.0	1.0	33.0	0.8	0
	Pangalengan	4.1	0.2	75.0	1.5	33.2	0.8	2
	Mean	4.1	0.1	75.5	0.9	33.1	0.5	2
Mean		3.9	0.1	74.8	0.9	34.9	0.8	13

Figure 9. Potato planting in beds covered with plastic mulch.

3.3. Fertilization

All farmers used organic manure to fertilize potatoes and applied on average 23 ton/ha (Table 8). Slightly higher amounts were applied by farmers in Garut. Type of manure usually applied by the farmers was Grade I, the so called Pupuk Baterai which is chicken manure collected from chicken battery farms. Content of minerals in the manure is not known by the farmers and they do not take this into account in their fertilization strategy. Grade II manure contains other compounds besides manure and a high amount of rice husk or straw can be found in this manure. In Garut and Pangalengan four samples were taken from both Grade I and Grade II manure to get some information about the content of macro nutrients in the manure. Since Grade II manure contains more crop debris than Grade I manure the C content and the C/N ratio is higher in this Grade. Based on these results it was decided to calculate the N, P_2O_5 and K_2O content of manure by taking 1% as an average for N and K_2O and 1.5% for P_2O_5.

Table 7. Nutrient content of organic manure

Location	Grade	pH H_2O	pH KCl	Dry matter %	Content in fresh manure				
					C org %	N total %	C/N	P_2O_5 %	K_2O %
Garut	I	8.6	8.5	41	5.4	0.6	3.7	1.3	0.7
	II	8.4	8.3	57	12.2	1.0	6.7	1.0	0.7
Pangalengan	I	8.5	8.4	74	12.2	1.5	5.9	1.2	1.5
	II	6.8	6.7	58	10.1	0.8	7.6	2.4	1.1
Mean	I	8.6	8.4	57	8.5	1.0	4.9	1.3	1.0
	II	7.6	7.5	57	11.2	0.9	7.1	1.7	0.9

Figure 10. Transport of manure by motorbike from the main road to the field.

Nitrogen amount applied with chemical fertilizer was on average 172 kg/ha. Considering the nitrogen content of manure the total nitrogen was calculated as 304 kg/ha. Atlantic and Granola in Pangalengan had lower rates while Granola farmers in Garut apply more than the other farmers do. This might be related to the small field size where it is easier to apply more since total direct involved cash is limited than when buying larger amount needed to apply on larger fields. Total N (chemical and organic) was calculated as 522 kg/ha on average. High N dose rates in a potato crop promote foliage growth and delay the start of tuber growth. As a consequence high N levels may lead to lower tuber yields under short day conditions which itself promote earlier maturing of potato crops. Therefore one has to have a critical view at high N levels in potato crops grown under short days conditions such as in West Java.
Next to nitrogen a high amount of phosphorus is applied by farmers in Garut in both Atlantic and Granola. In Pangalengan the average phosphorus amount with chemical fertilizer was 185 kg/ha in Atlantic and Granola while in Garut this amount was as high as 443 kg/ha in Atlantic and 317 kg/ha in Granola. Another 350 kg/ha is given with manure, resulting in very high total P_2O_5 rates: 632 kg/ha on average.
Potassium is also applied with chemical fertilizer and remarkable is that Atlantic farmers in Garut apply rather high amounts while the Granola farmers in the same area apply low rates. In Pangalengan in both cultivars more or less a similar amount of on average 150 kg/ha is applied.

Table 8. Organic manure use (kg/ha) and amount of N, P_2O_5 and K_2O (kg/ha) from chemical fertilizers applied in potato.

		Org. manure	S.E.	N (chem)	S.E.	P_2O_5 (chem)	S.E.	K_2O (chem)	S.E.
Atlantic	Garut	25,764	2,217	149	17	443	54	238	33
	Pangalengan	22,641	3,163	167	25	190	26	157	28
	Mean	24,202	1,914	158	15	316	41	197	23
Granola	Garut	23,005	1,400	217	23	317	29	89	35
	Pangalengan	21,543	1,861	155	29	180	28	143	33
	Mean	22,274	1,146	186	19	248	25	116	24
Mean		23,238	1,112	172	12	282	24	157	18

For chemical fertilizer use farmers apply a broad range of various fertilizers. In spite of distrusting its content most commonly used fertilizer in all regions and cultivars is NPK 15-15-15 (NPK Ponska) since

this fertilizer is heavily subsidized by the Indonesian Government. Other commonly used fertilizers are SP 0-36-0, and Ammonium sulphate 21-0-0. Urea is easily available in stores but is hardly used by the farmers in the period in which the records were taken. Foliar fertilizers are applied together with spraying against pests and diseases. Especially farmers in Garut apply foliar fertilizers.

Table 9. Granular fertilizer types applied in potato by farmers (% of farmers).

	Atlantic		Granola		Mean
	Garut	Pangalengan	Garut	Pangalengan	
NPK 15-15-15	60	100	70	60	73
SP 0-36-0	100	40	100	40	70
Ammonium Sulphate 21-0-0	100	20	100	40	65
KCl 0-0-60	90	0	20	20	33
NPK 16-16-16	10	0	20	10	10
NPK 18-12-8	0	20	0	10	8
Saprodap 16-20-0	10	0	20	0	8
Fertiphos 0-20-0	10	10	0	0	5
Gandasil B 20-15-15	10	0	0	10	5
NPK 15-9-20	0	10	10	0	5
Grand K 3-0-46	0	10	0	0	3
KNO3 13-0-46	0	10	0	0	3
NPK 12-12-18	0	10	0	0	3
Sunye	0	10	0	0	3
Urea 46-0-0	0	10	0	0	3
Foliar fertilizers	60	0	80	30	43
Chicken manure	100	100	100	100	100

When taking into account the nutrient content of N, P_2O_5 and K_2O in the organic manure more than half of the total nitrogen applied in the potatoes is applied with organic manure. In Garut (Cikajang) ammonium sulphate is used a lot to apply nitrogen while in Pangalengan NPK 15-15-15 is used to apply nitrogen.

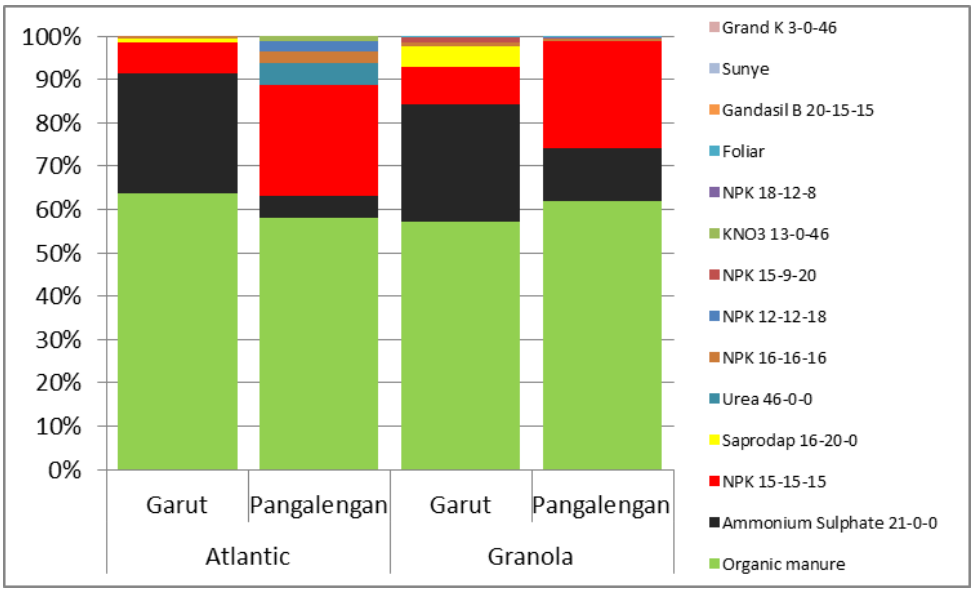

Figure 11. Nitrogen containing fertilizer use expressed as percentage of the average nitrogen amount applied per hectare.

For phosphorus the organic manure has a share of approximately 40 to 50% in the total amount of phosphorus applied per hectare. In Garut farmers use mostly SP 0-36-0 to apply phosphorus and NPK 15-15-15 is used in Pangalengan. Foliar fertilizers hardly contribute to the total amount of phosphorus applied.

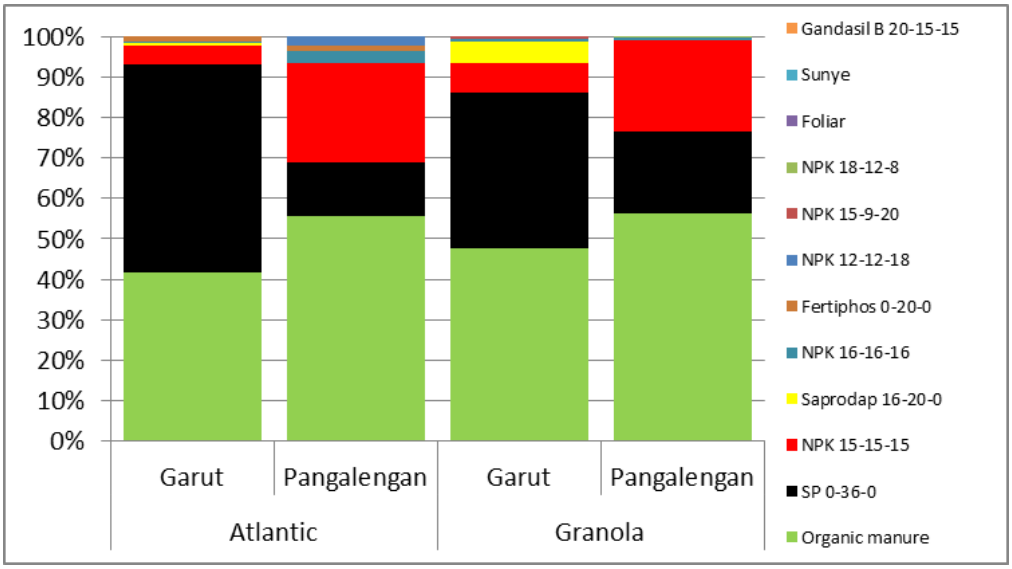

Figure 12. Phosphorus containing fertilizer use expressed as percentage of the average phosphorus amount applied per hectare.

In Granola in Garut the lowest amount of potassium was applied but a similar amount of organic manure was applied compared with the other region and cultivar. Hence the share of organic manure in potassium application is higher than in other situations. In the total amount applied the organic manure contributes for 35 to 60%. In Garut KCl 0-0-60 was used and in the other situations NPK 15-15-15 was mostly used.

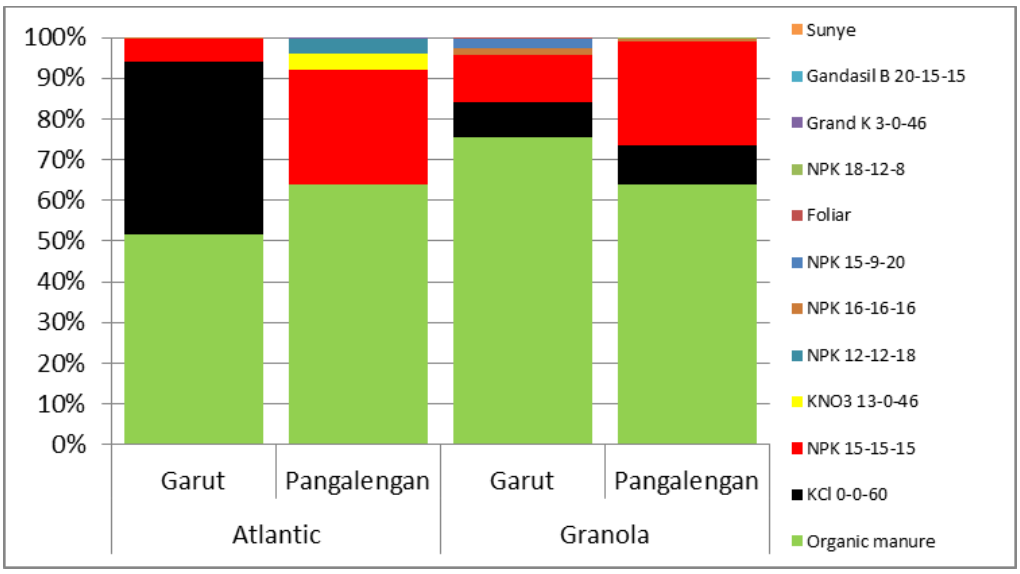

Figure 13. Potassium containing fertilizer use expressed as percentage of the average potassium amount applied per hectare.

Especially in Garut farmers of both Atlantic and Granola have applied foliar fertilizers (Table). In Garut foliar fertilizers were applied almost 6 times per season in Granola and 2.3 times in Atlantic. In Pangalengan it was applied 2.3 times when farmers are using foliar fertilizer.
Organic manure was applied by all farmers and took place about 4 days before planting. In Garut the manure was applied 12 days before planting since between applying manure and planting a lot of time was needed to apply the mulch and to cultivate the soil.
For nitrogen, phosphorus and potassium it is common to apply 80 to 90 % of the total amount pre-planting. The exception is in Atlantic in Pangalengan where about 50% of the total amount was applied pre-planting and the remaining later in the season. On average fertilization was applied in 1.5 time, meaning that about half of the farmers apply only once at or just before planting and that the other half have applied a large amount at planting while a small remainder was applied later in the season. The second application was about 3 to 5 weeks after planting in Atlantic and 6 weeks after planting in Granola.

Table 10. Timing of fertilization with N, P_2O_5 and K_2O with broadcasting and application of foliar fertilizers.

	Atlantic		Granola		Mean
	Garut	Pangalengan	Garut	Pangalengan	
Foliar fertilizer use (% of farmers)	60	0	80	30	43
Number of foliar applications per season	2.3	0	5.9	2.3	1.7
Number of chemical nitrogen applications per season	1.5	1.6	1.5	1.6	1.6
Chemical nitrogen applied before planting (% farmers)	100	70	80	80	83
Nitrogen amount applied pre planting (% of total amount)	90	51	90	80	82
Second nitrogen application (DAP)	36	25	43	43	40
Number of chemical P_2O_5 applications per season	1.6	1.6	1.5	1.6	1.6
Chemical P_2O_5 applied before planting (% farmers)	100	70	80	70	80
P_2O_5 amount applied pre planting (% of total amount)	83	58	89	80	85
Second P_2O_5 application (DAP)	35	25	43	43	40
Number of chemical K_2O applications per season	1.6	1.5	1.2	1.6	1.5
Chemical K_2O applied before planting (% farmers)	100	60	60	60	70
K_2O amount applied pre planting (% of total amount)	96	61	94	81	90
Second K_2O application (DAP)	37	25	44	43	42
Organic manure application (DBP)	12	4	4	5	6

3.4. Crop protection

Late blight (caused by *Phytophthora infestans*) is the most important fungal disease in potato production in West Java. The disease impact is potentially very severe during the wet (rainy) season: September-December as the foliage of the crop may be killed at a too early stage.
Therefore crop protection to control late blight is a very relevant component in potato cropping and is a substantial share of the total production cost particularly during the rainy season. Pesticides are applied to the potato crop by spraying with either a knap sack sprayer or a motor sprayer. A motor sprayer has an electric pump with which the pesticides are sprayed with high pressure onto the crop. With both methods high volumes of water are used to spray the pesticide on the crop. In Atlantic on average 1,088 litre of water per hectare is used to apply the pesticides. The Granola farmers in Garut apply pesticides with lower volumes of water.

Figure 14. Stationary motor sprayer to apply pesticides in potato.

Fungicides are applied mainly to control late blight (*Phytophthora infestans*) in potato. In one season on average 16.6 times fungicides were sprayed on the crop. In Granola a lower number of applications was noted due to a slightly higher interval since the crop is somewhat less susceptible to late blight than Atlantic. The low number of fungicide applications in Atlantic by farmers in Pangalengan was caused by the shorter growing period that occurred this season in that area. In most cases a sticker or spreader (no distinguishing between these by farmers) is added to increase the rain fastness of the fungicides on the potato leaves. About 70% of the farmers use sticker to add to the fungicide, except in Garut where only 10% of the farmers add sticker to the fungicide application.
Insecticide was applied to control leaf miner (*Liriomyza* spp.) and took more place in Granola with 11.5 insecticide sprayings in a season. In Garut in about 63% of all sprayings an insecticide was sprayed, in Pangalengan more often an insecticide was sprayed in 89% of all applications. In Atlantic insecticide applications were less as compared to Granola. In Garut only 5.8 times an insecticide was applied which is 26% of all applications.

Table 11. Average spray volume per application, and total number of applications with a fungicide and with an insecticide

		Average of spray volume applied in one season (l/ha)	S.E.	Nr of fungicide applications	S.E.	Nr of insecticide applications	S.E.
Atlantic	Garut	998	139	22.4	1.6	5.8	1.1
	Pangalengan	1,177	142	13.8	0.9	8.7	1.7
	Mean	1,088	99	18.1	1.3	7.3	1.0
Granola	Garut	507	52	15.2	1.3	9.5	2.3
	Pangalengan	993	115	15.0	0.6	13.4	2.7
	Mean	750	83	15.1	0.7	11.5	1.8
Mean		919	69	16.6	0.8	9.4	1.1

Figure 15. Use of high water volumes results in run off of pesticides visible by the white edges on the leaves.

Farmers start spraying immediately after emergence of the potato plant above the ground. Granola emergence was about 3 weeks after planting and emergence of Atlantic was about 2 weeks. Spraying continues till the foliage has died off, in Atlantic 2 weeks before harvest and in Granola 3 weeks before harvest farmers stop spraying. In some cases market prices are at such a high level that farmers decide to terminate the crop earlier than planned and commence harvest. In such situations a herbicide is sprayed to desiccate the foliage.

Table 12. Number of days between planting and first fungicide application, between first and last application and between last application and harvest.

		Days between planting and first application	S.E.	Days between first and last application	S.E.	Days between last application and harvest	S.E.
Atlantic	Garut	16.7	1.5	68.2	4.7	12.0	2.2
	Pangalengan	15.4	0.9	50.3	2.7	14.3	1.9
	Mean	16.1	0.9	59.3	3.4	13.2	1.5
Granola	Garut	22.7	1.7	54.7	2.2	17.6	2.9
	Pangalengan	20.0	1.4	59.2	2.2	19.7	3.0
	Mean	21.4	1.1	57.0	1.6	18.7	2.1
Mean		18.7	0.8	58.1	1.8	15.9	1.3

In general every 3 to 4 days farmers sprayed Atlantic with a fungicide. Granola on the other hand is slightly more resistant against Late blight and therefore the average interval is about 4 days. Per application on average 2.3 fungicide products were sprayed on the crop.

Table 13. Application interval of fungicides and average number of fungicides used per single application.

		Fungicide application interval	S.E.	Nr of fungicide products per application	S.E.
Atlantic	Garut	3.1	0.2	2.2	0.1
	Pangalengan	3.7	0.2	2.2	0.1
	Mean	3.4	0.1	2.2	0.1
Granola	Garut	3.8	0.3	2.5	0.1
	Pangalengan	4.0	0.2	2.3	0.2
	Mean	3.9	0.2	2.4	0.1
Mean		3.6	0.1	2.3	0.1

Figure 16. Farmers have access to a wide range of fungicides to control late blight.

Fungicides can be categorized in preventive and in curative products. Preventive products contain active ingredients like chlorothalonil or mancozeb and need to be sprayed on the foliage before spores reach the surface of the leaf. The fungicide layer on top of the leaf inhibits germination of the spore and thus prevents infection. Curative products can be sprayed after a spore has germinated and penetrated the leaf and will be able to kill the fungal structure in this phase. However, for good control of the late blight disease also curative products need to be applied before visible symptoms are present. Some curative products have good preventive characteristics as well but in most cases this is less good than the preventive action of mancozeb or chlorothalonil. Therefore it is recommended to apply both a preventive as well as a curative active ingredient per spray either as an already formulated product combining those two or by making an own mix of a preventive and a curative active ingredient containing product.
In Garut on average per each application a mix contained about 2 products with a preventive mode of action and 0.5 products with a curative active ingredient, meaning that in half of the cases a curative product is added to the spray mix. In Pangalengan at the other hand on average 1.5 preventive products were applied and around one curative product. In Pangalengan a more balanced mix was applied containing a slightly higher than recommended preventive active ingredient and a curative active ingredient. One might expect better control effect in the latter region than in Garut.

Table 14. Total number of fungicide applications per season and number of fungicides with a preventive active ingredient (Prev. A.I.) and fungicides with a curative active ingredient (Cur A.I.) per application.

	Atlantic		Granola		mean
	Garut	Pangalengan	Garut	Pangalengan	
Total applications	22	14	15	15	17
Nr of Prev. A.I. per application	1.9	1.4	1.9	1.5	1.6
Nr of Cur. A.I. per application	0.5	1.1	0.7	0.9	0.8

A high amount of chlorothalonil and/or mancozeb based products with a preventive mode of action were applied in Atlantic with respectively 27 and 39 kg active ingredient per hectare. Only a small part of the total applied active ingredient was from products with a curative mode of action. In Atlantic grown in Garut a total of 97.4 kg active ingredient was applied of which 93.7 kg is preventive active ingredient. In Pangalengan the total active ingredient amount was only 54.3 kg, but this was also caused by the shorter cultivation period. In Granola fungicide use was quite lower with on average 33.6 kg A.I./ha only. Especially the farmers in Garut used lower amounts. Although the amount of curative active ingredient used in Atlantic was low, in Granola it was even lower with an average of 2 kg/ha.

Table 15. Chlorothalonil and Mancozeb use (kg A.I./ha) and total fungicide use per type of fungicide (kg A.I. /ha per preventive or curative).

		Chlorothalonil	S.E.	Mancozeb	S.E.	Preventive fungicide	S.E.	Curative fungicide	S.E.	Total fungicide	S.E.
Atlantic	Garut	30.3	5.7	58.8	11.7	93.7	14.8	3.7	1.5	97.4	14.2
	Pangalengan	24.3	4.3	18.4	6.7	47.8	8.8	6.5	1.5	54.3	9.6
	Mean	27.3	3.5	38.6	8.1	70.7	9.9	5.1	1.1	75.8	9.7
Granola	Garut	10.5	2.9	12.7	2.7	24.5	5.2	1.1	0.2	25.6	5.3
	Pangalengan	18.6	4.8	14.4	4.0	38.8	5.3	2.8	0.6	41.6	5.5
	Mean	14.5	2.9	13.6	2.4	31.6	4.0	2.0	0.4	33.6	4.1
Mean		20.9	2.5	26.1	4.6	51.2	6.1	3.5	0.6	54.7	6.2

Preventive fungicides are mostly chlorothalonil or mancozeb containing products. Almost all farmers used these products. Maneb was used by one farmers instead of mancozeb. Propineb was sometimes used with a product that contains this active ingredient together with a curative compound and in a few cases also as a single compound with the product Antracol. Ziram was only used by 1 farmer.

Table 16. Fungicide use with preventive active ingredients amongst farmers (% using).

	Atlantic		Granola		mean
Active ingredient	Garut	Pangalengan	Garut	Pangalengan	
Chlorothalonil	100	90	90	80	90
Mancozeb	90	80	100	80	88
Maneb	20	20	10	10	15
Propineb	0	10	20	30	15
Ziram	0	10	0	0	3

A broad range of curative active ingredients were used in potato. The active ingredients difeconazole, propiconazole and tebuconazole are effective against early blight (*Alternaria* spp.) only and not against late blight. Acilbenzolar s methyl is somewhat different than the others due to its presumed mode of action which is believed to enhance plant resistance against late blight rather than preventing or curing late blight infection. Most farmers used dimethomorph and cymoxanil, the former especially used by farmers in Garut and the latter in Pangalengan. Some Atlantic farmers used

propamocarb as well. Almost all Granola farmers in Garut used dimethomorph. These farmers hardly used any other curative active ingredients.

Table 17. Fungicide use with curative active ingredients amongst farmers (% using).

	Atlantic		Granola		mean
Active ingredient	Garut	Pangalengan	Garut	Pangalengan	
Dimethomorph	60	60	80	40	60
Cymoxanil	40	90	20	60	53
Propamocarb	40	30	10	20	25
Famoxadone	30	0	20	20	18
Mefenoxam / Metalaxyl	10	20	0	30	15
Difenoconazole	10	30	0	10	13
Fluopicolide	0	10	10	30	13
Azoxystrobine	10	20	0	10	10
Acilbenzolar s Methyl	0	0	0	10	3
Mandipropamid	10	0	0	0	3
Propiconazole	0	10	0	0	3
Tebuconazole	0	0	0	10	3

Of the total fungicide applications in Garut by Atlantic farmers chlorothalonil was applied in 52% of the applications followed by mancozeb with 43%. In Pangalengan more often chlorothalonil was applied when a preventive fungicide was applied. When applying a curative fungicide Granola farmers in Garut applied dimethomorph in 82% of the applications. Atlantic farmers also applied dimethomorph in most cases but also applied other curative fungicides. In Pangalengan farmers are using often cymoxanil followed by dimethomorph. For applying a preventive active ingredient in most cases chlorothalonil is applied in Atlantic. Chlorothalonil is a more expensive than mancozeb but has a better rain fastness. Granola farmers in Garut mostly used mancozeb because it is cheaper.

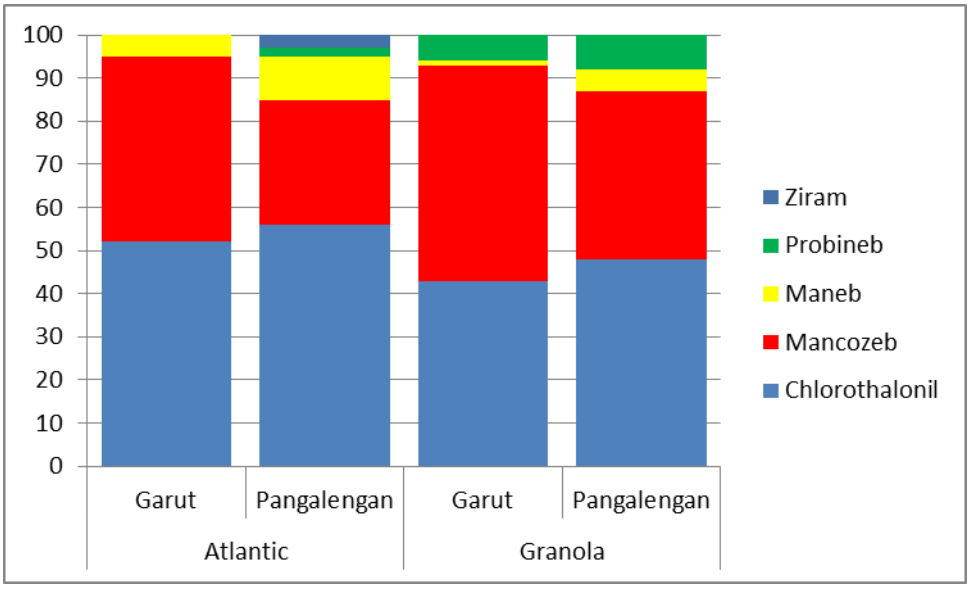

Figure 17. Fungicide use with preventive active ingredients per season (% of total number of applied preventive active ingredients per season).

When applying a curative product farmers in Garut applied in most cases dimethomorph while farmers in Pangalengan used cymoxanil more. Atlantic farmers in Garut used more different active ingredients more often than the Granola growers. Atlantic farmers in Pangalengan used also quite often mefenoxam or metalaxyl based products. Granola farmers in Pangalengan used the new

product fluopicolide quite a lot which also explains the high use of propineb which is part of the formulated product (e.g. Trivia).

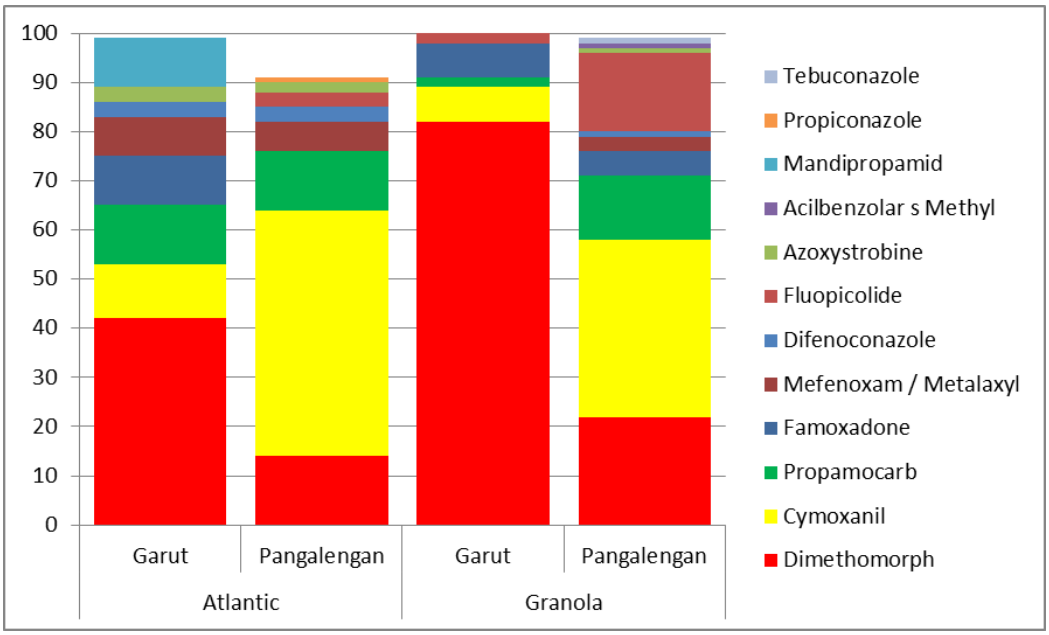

Figure 18. Fungicide use with curative active ingredients per season (% of total number of applied curative active ingredients per season).

A broad range of products with different brand names exists for both chlorothalonil and mancozeb. Daconil is the most common use brand name used by farmers when applying chlorothalonil. Although more expensive farmers reckons that this product is better due to a higher degree of dissolving in the tank, mixing with other products and spraying without clogging nozzles.

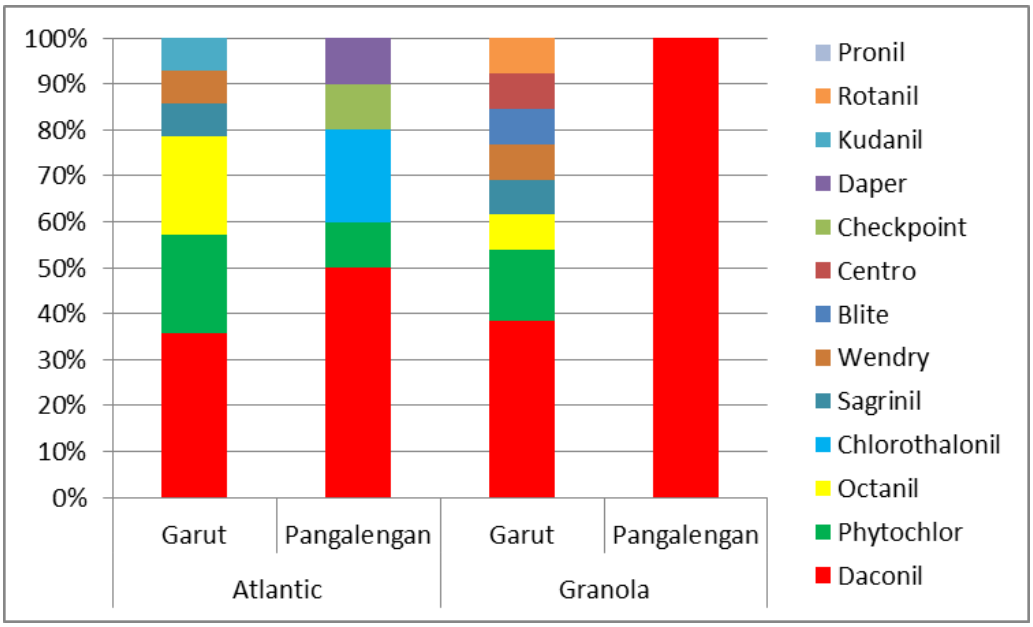

Figure 19. Percentage of farmers using single compound chlorothlonil containing fungicide products (% of farmers using chlorothalonil).

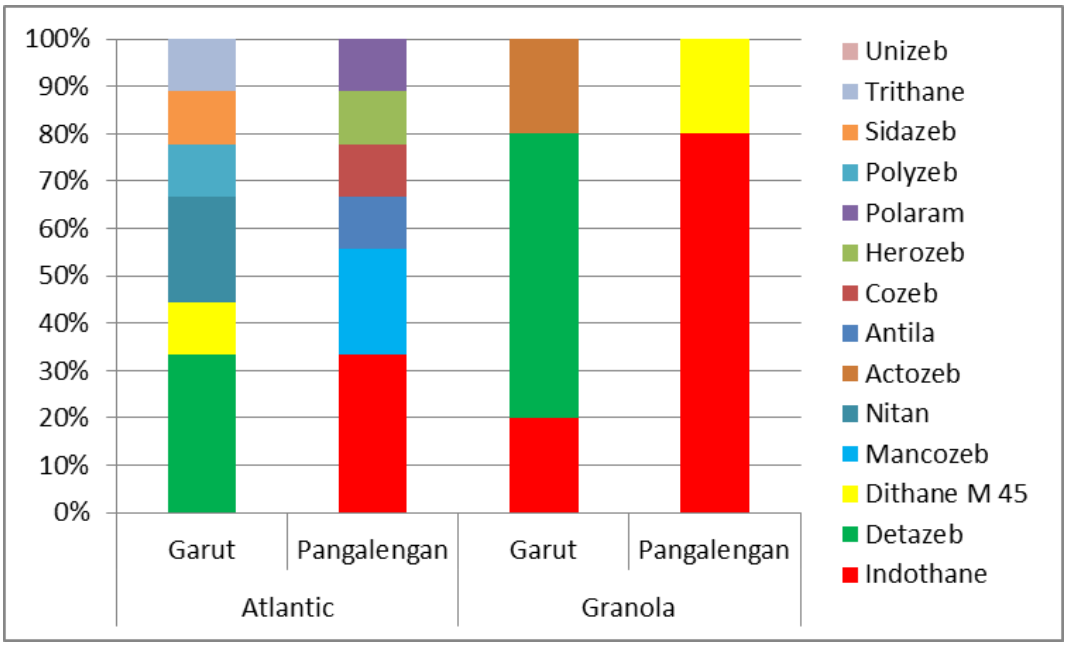

Figure 20. Percentage of farmers using single compound mancozeb containing fungicide products (% of farmers using mancozeb).

In potato a total of on average 2,474 gram insecticide active ingredient was applied. In Garut in both Atlantic and Granola lower amounts were applied as compared to farmers in Pangalengan. Number of insecticide applications in Garut was lower than in Pangalengan hence the lower amount of active ingredient. About 40% of the farmers applied an insecticide in the form of a granulate to the soil to treat against soil-born pests. Furadan (carbofuradan), Regent (fipronil) or Marshal (carbosulfan) were used for this purpose. The insecticide is mixed with the fertilizer and applied before planting. Granola farmers in Garut used on average the lowest amounts while the Atlantic farmers in Garut used the highest amounts. Atlantic farmers in Garut used low amounts of insecticides but the share of broad spectrum insecticides was also low. Organophosphates (e.g. profenofos) and pyrethroids (e.g. lambda cyhalothrin or permethrin) were hardly applied. To control pests mostly abamectine was applied. Farmers in Pangalenan used high amounts of the organophosphates and pyrethroids. However, Atlantic farmers in Pangalengan used more specific insecticides than Granola farmers.

Table 18. Total insecticide use in potato, use of granulated insecticides applied as soil treatment, use of organophosphates and pyrethroids and other insecticides (gram Active Ingredient per hectare)

		Total Insecticide use	Use of granulates as soil treatment	Use of Organophosphates and pyrethroids	Use of other insecticides
Atlantic	Garut	1,339	605	134	600
	Pangalengan	3,232	351	2,388	493
	mean	2,286	478	1,261	546
Granola	Garut	1,151	121	980	50
	Pangalengan	4,173	321	3,781	71
	mean	2,662	221	2,381	61
mean		2,474	350	1,821	304

Figure 21. Mixing of fertilizers with Furadan (package can be seen at the right hand side of the labourer's leg)

In Atlantic for soil treatment Regent (fipronil) WHO class II was mostly used by farmers in Garut while farmers in Pangalengan used the WHO class Ib Furadan (carbofuran) or Marshal (carbosulfan). In Pangalengan some farmers also sprayed Marshal 20 EC (carbosulfan), hence the highest use of WHO Ib pesticides. The use of WHO II pesticides was also the highest by Atlantic farmers in Pangalengan. This was in the first place caused by a higher use of curative fungicide products by those farmers. In Pangalengan farmers have applied more often WHO Ib and II products in their crop sprays than farmers in Garut.

Table 19. Use of pesticides per WHO classification and type of pesticide in kg or l formulated product per hectare

			Ib	II	III	U	NL	Nr of applications with Ib and II products
Atlantic	Garut	Fungicide	0.0	4.7	0.0	123.0	0.0	2.9
		Insecticide	0.0	3.6	0.2	0.0	3.7	1.7
		Insect-Granulate	1.8	17.3	0.0	0.0	0.0	0.6
		Total	1.8	25.6	0.2	123.0	3.7	5.2
	Pangalengan	Fungicide	0.0	24.2	0.1	58.4	0.0	10.2
		Insecticide	0.2	8.8	0.0	0.0	1.3	6.4
		Insect-Granulate	10.9	0.9	0.0	0.0	0.0	0.3
		Total	11.1	33.8	0.1	58.4	1.3	16.9
Granola	Garut	Fungicide	0.0	0.1	0.0	33.8	0.0	0.5
		Insecticide	0.0	4.3	0.1	0.0	0.8	6.7
		Insect-Granulate	1.4	2.6	0.0	0.0	0.0	0.3
		Total	1.4	7.0	0.1	33.8	0.8	7.5
	Pangalengan	Fungicide	0.0	9.3	0.0	50.4	0.0	7.2
		Insecticide	0.0	9.4	0.0	0.0	0.7	9.8
		Insect-Granulate	7.3	2.1	0.0	0.0	0.0	0.3
		Total	7.3	20.8	0.0	50.4	0.7	17.3
Total	average		5.4	21.8	0.1	66.4	1.6	11.7

3.5. Labour

In potato on average 2,785 hours, the equivalent of 557 days, of labour is spent on activities starting with land preparation till after harvest. Between cultivar and regions difference in labour were recorded. On average a higher number of labour hours was spent in Garut in both Atlantic and Granola than in Pangalengan. Also in Atlantic a higher number of labour was spent than in Granola. When looking at the labour per gender especially in Garut more labour by females was used than male labour. In Pangalengan the amount of female labour hours was 300 hours less than male labour hours and contributed to 44% of the total labour hours. In Granola the share of female labour in the total labour hours was about one third.

Table 20. Labour hours per gender excluding piece wage paid labour (hour/hectare).

		Total male (h)	S.E.	% of total	Total female (h)	S.E.	% of total	Total hours	S.E.
Atlantic	Garut	1,253	191	38	2,072	655	62	3,325	718
	Pangalengan	1,462	256	56	1,127	356	44	2,588	412
	Mean	1,357	157	46	1,599	358	54	2,957	412
Granola	Garut	1,878	317	68	890	281	32	2,767	319
	Pangalengan	1,541	365	63	917	290	37	2,458	371
	Mean	1,709	238	65	903	202	35	2,613	241
Mean		1,533	144	55	1,251	198	45	2,785	237

In potato cultivation it is difficult to evaluate labour hours per operation except for harvest and crop protection. This is because in some cases farmers combine land preparation with fertilization, in one operation fertilizer is applied and the field is cultivated and labour hours therefore could not be assigned specifically to one operation. While another farmer cultivates the soil first and applies

fertilizer later. It is also possible that weeding and fertilization is combined in one operation. Therefore it is almost impossible to separately calculate labour hours for land preparation, fertilization, ridging up of plants and weeding. When assessing the highest labour need this is no doubt field preparation. Harvest takes about 18% of the total labour requirement in potato and crop protection takes up about 17% of the total labour.

Figure 22. Land preparation, fertilization with manure and planting of potatoes in one operation

Table 21. Labour hours spent on harvest and crop protection.

		harvest hours	S.E.	% in total hours	crop protection hours	S.E.	% in total hours
Atlantic	Garut	538	87	16	580	107	17
	Pangalengan	425	75	16	471	66	18
	Mean	481	57	16	525	62	18
Granola	Garut	634	48	23	392	63	14
	Pangalengan	426	49	17	399	80	16
	Mean	530	41	20	395	50	15
Mean		506	35	18	460	41	17

In labour hours only the hired labour hours have been included. Besides hiring persons to work on the field based on a daily wage it is quite common in both Garut and Pangalengan to hire a team of workers and agree with them on the work to be done at the field for a fixed payment. This piece wage labour arrangement is mostly present for field preparation and for transporting of manure and of harvested product. This type of labour is more common in Atlantic cultivation and especially in Pangalengan than in Granola. In Garut Granola farms are quite small and therefore only a low amount is spent on piece wage labour. Total labour costs in Pangalengan was the highest with 20,600,000 IDR/ha. Female labour costs in Atlantic in Garut are the same as male labour costs although the amount of labour hours by females was twice as much as male labour hours. Therefore we assume females receive about half payment rate as compared to males.

Table 22. Labour costs of potato cultivation per cultivar and region categorized per labour type (IDR x 1,000,000).

		Total labour	SE	Male labour	SE	Female labour	SE	Piece wage labour	SE
Atlantic	Garut	14.3	1.3	5.1	0.7	5.1	1.6	4.1	1.1
	Pangalengan	20.6	3.9	7.6	1.1	3.8	0.7	9.3	2.8
	Mean	17.4	2.1	6.4	0.7	4.4	0.8	6.7	1.6
Granola	Garut	10.8	1.4	7.8	1.4	2.5	0.5	0.6	0.3
	Pangalengan	12.5	1.4	7.6	1.5	3.1	0.4	1.8	0.5
	Mean	11.7	1.0	7.7	1.0	2.8	0.3	1.2	0.3
Mean		14.6	1.2	7.1	0.6	3.6	0.5	3.9	0.9

Figure 23. Piece wage labour is mostly for field preparation and for transport of product from the field to the loading point.

3.6. Yield of potato

Potatoes are sold per different class namely, ABC, DN and TO. The classes are based on number of potatoes per kg.

Table 23. Classification of Atlantic and Granola production.

Classification	Atlantic		Granola	
ABC	6	tubers/kg	7-8	tubers/kg
DN	15-16	tubers/kg	20	tubers/kg
TO	35-40	tubers/kg	40	tubers/kg

Atlantic cultivation in Garut showed the highest yield with 20.5 ton/ha. In Pangalengan the yield was low with only 12.7 ton/ha. Yield of Granola was in both regions about the same with on average 16.7 ton/ha. On average 2.5 ton/ha of Granola is not sold but kept to be used as seed potatoes for a next crop. In Atlantic a lower amount is kept for this purpose. For own use also some potatoes are not sold and are consumed by the farmers' households or shared with the labourers at harvest as an

additional benefit. However, most of the times the potatoes that are used for own consumption are of a lower grade than the ABC class.

Table 24. Potato yield (ton/ha) per class sold or kept for seed potatoes or own consumption.

		Total yield	S.E.	Class ABC	S.E.	Class DN	S.E.	Class TO	S.E.	Lower classes	S.E.	Kept for seed	S.E.	Own use	S.E.
Atlantic	Garut	20.5	2.0	18.7	0.4	0.6	0.4	0.0	0.00	0.0	0.00	0.9	0.4	0.4	0.2
	Pangalengan	12.7	2.4	11.0	0.2	0.6	0.2	0.1	0.06	0.3	0.20	0.5	0.2	0.2	0.1
	Mean	16.6	1.8	14.8	0.4	0.6	0.2	0.0	0.03	0.2	0.10	0.7	0.2	0.3	0.1
Granola	Garut	16.9	1.3	12.4	0.3	2.0	0.4	0.1	0.10	0.1	0.08	2.0	0.8	0.2	0.1
	Pangalengan	16.5	1.7	11.0	0.3	1.0	0.5	0.1	0.07	0.4	0.20	3.0	1.0	1.1	0.4
	Mean	16.7	1.1	11.7	0.4	1.5	0.3	0.1	0.06	0.2	0.11	2.5	0.6	0.7	0.2
Mean		16.6	1.0	13.3	0.4	1.1	0.2	0.1	0.03	0.2	0.08	1.6	0.4	0.5	0.1

Between fields there were big differences in yield with the highest variation in Atlantic in Pangalengan where the lowest yield was about 4 ton/ha and the highest almost 27 ton/ha, a difference of 23 t/ha. However, also in Garut difference between the lowest Atlantic yield and highest yield was about 20 t/ha. In Granola difference between farmers was less but still high with about 14 ton/ha difference between the worst and best performing field in Garut and 18 ton/ha in Pangalengan.

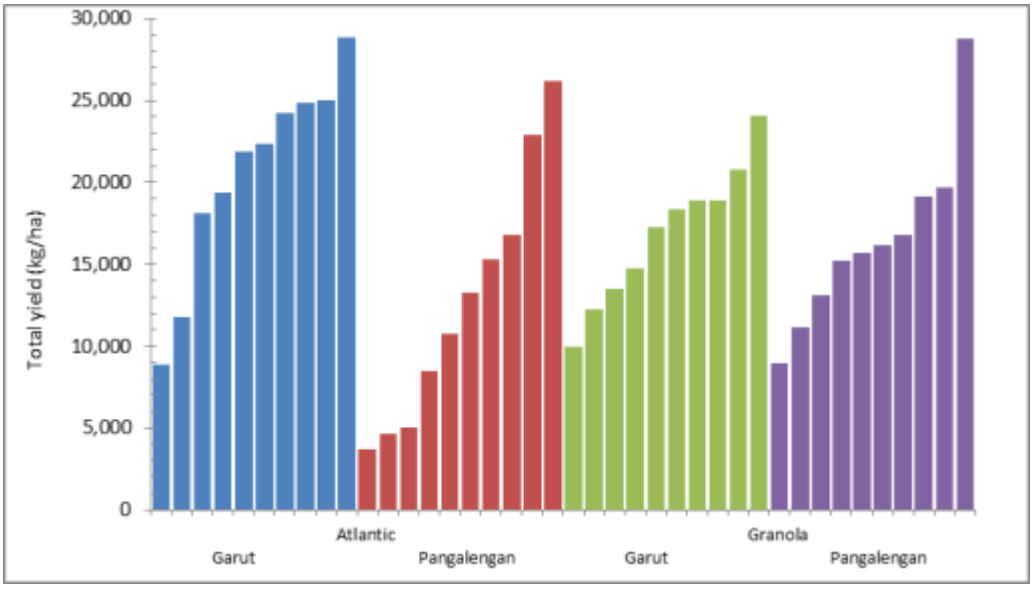

Figure 24. Yield per field of Atlantic and Granola in Garut and Pangalengan.

3.7. Economic results of potato cultivation

Atlantic cultivation in Garut showed on average a profit of 15,600,000 IDR/ha while in Pangalengan on average farmers made a loss of 16,400,000 IDR/ha. Total production costs in both regions were quite similar with 78,400,000 IDR/ha in Garut and 72,500,000 IDR/ha in Pangalengan. However, yield and hence income in Pangalengan was lower. In Garut farmers spent more money on plastic mulch, fertilizer, fungicide, insecticide, bamboo poles and transport. Labour costs were significantly lower and were most likely related with less labour needed for weeding and earthing up of plants which farmers in Pangalengan do since they did not apply plastic mulch. Labour costs in Pangalengan were also higher since daily wage of a male labour is 25% higher than the daily wage of a male labourer in Garut. The wage of female labourers in Pangalengan is 35% higher than the wage paid in Garut.

Table 25. Crop balance sheet of Atlantic cultivation (IDR x 1,000,000/ha).

	Garut		Pangalengan		Average	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
Income	93.7	9.8	56.2	11.7	74.9	8.6
Plastic mulch	2.5	0.0	0.2	0.2	1.3	0.3
Plant material	23.3	2.1	24.9	1.3	24.1	1.2
Fertilizer	17.3	1.4	11.1	1.6	14.2	1.2
Growth regulator	0.1	0.1	0.0	0.0	0.1	0.0
Fungicide	12.3	1.6	10.0	1.4	11.1	1.1
Herbicide	0.1	0.1	0.2	0.1	0.1	0.0
Insecticide	3.1	0.5	2.2	0.4	2.6	0.3
Sticker	0.4	0.1	0.4	0.1	0.4	0.1
Fuel and transport for spraying	0.5	0.1	0.4	0.1	0.4	0.1
Bamboo poles	1.4	0.3	0.3	0.2	0.8	0.2
Others	1.0	0.1	0.9	0.4	0.9	0.2
Total materials	61.9	3.4	50.4	3.7	56.2	2.8
Transport	2.2	0.6	1.5	0.4	1.9	0.4
Male labour	5.1	0.7	7.6	1.1	6.4	0.7
Female labour	5.1	1.6	3.8	0.7	4.4	0.8
Contract labour	4.1	1.1	9.3	2.8	6.7	1.6
Total labour	14.3	1.3	20.6	3.9	17.4	2.1
Total costs	78.4	4.4	72.5	7.3	75.5	4.2
Profit	15.2	10.6	-16.4	5.6	-0.6	6.9

Profit of Granola in Garut was on average 40,900,000 IDR/ha and was almost twice as much as the average profit in Pangalengan. This is mainly caused by higher yield and a higher income of farmers in Garut as compared to farmers in Pangalengan. Total cost was very similar for both regions. In Garut farmers spent more money on fertilizer due to the high use of foliar fertilizer, but spent less on fungicide and insecticide and labour. In Granola the differences in wages between Garut and Pangalengan were less than in Atlantic, still both male and female wages were 20% higher in Pangalengan.

Table 26. Crop balance sheet of Granola (IDR x 1,000,000/ha).

	Garut		Pangalengan		Average	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
Income	95.6	7.9	77.9	9.8	86.7	6.5
Plastic mulch	0.0	0.0	1.1	0.8	0.5	0.4
Plant material	20.3	2.3	19.1	2.6	19.7	1.7
Fertilizer	14.3	1.0	9.6	0.8	11.9	0.8
Growth regulator	0.4	0.1	0.1	0.0	0.2	0.1
Fungicide	4.5	0.8	8.2	0.9	6.4	0.7
Herbicide	0.1	0.0	0.3	0.1	0.2	0.1
Insecticide	1.3	0.4	2.8	0.5	2.0	0.3
Sticker	0.0	0.0	0.2	0.1	0.1	0.0
Fuel and transport for spraying	0.5	0.1	0.3	0.1	0.4	0.1
Bamboo poles	0.0	0.0	0.4	0.2	0.2	0.1
Others	0.7	0.1	1.0	0.3	0.8	0.2
Total materials	42.1	3.6	42.9	5.0	42.5	3.0
Transport	1.8	0.3	1.9	0.3	1.8	0.2
Male labour	7.8	1.4	7.6	1.5	7.7	1.0
Female labour	2.5	0.5	3.1	0.4	2.8	0.3
Contract labour	0.6	0.3	1.8	0.5	1.2	0.3
Total labour	10.8	1.4	12.5	1.4	11.7	1.0
Total costs	54.7	3.3	57.3	6.2	56.0	3.4
Profit	40.9	7.3	20.6	10.7	30.8	6.7

Figure 25. Bamboo poles used to support the potato plant can be used in three seasons.

Just like yield also profit shows a large variation between fields. In Pangalengan only one Atlantic farmer made a profit with his potato cultivation while the other farmers lost money ranging from 35,000,000 IDR/ha to 5,000,0000 IDR/ha. In Garut eight farmers made a profit ranging from 10,000,000 to 45,000,000 IDR/ha, but two farmers made a loss of about 30,000,000 and 60,000,000 IDR/ha. Between the best and worst a difference of more than 100,000,000 IDR. In Granola difference between the worst and best performing field is also quite high with a difference of 65,000,000 IDR/ha between the lowest and the highest profit in Garut and over 90,000,000 IDR/ha in Pangalengan. In Pangalengan three out of 10 farmers made a loss while in Garut all farmers made a profit.

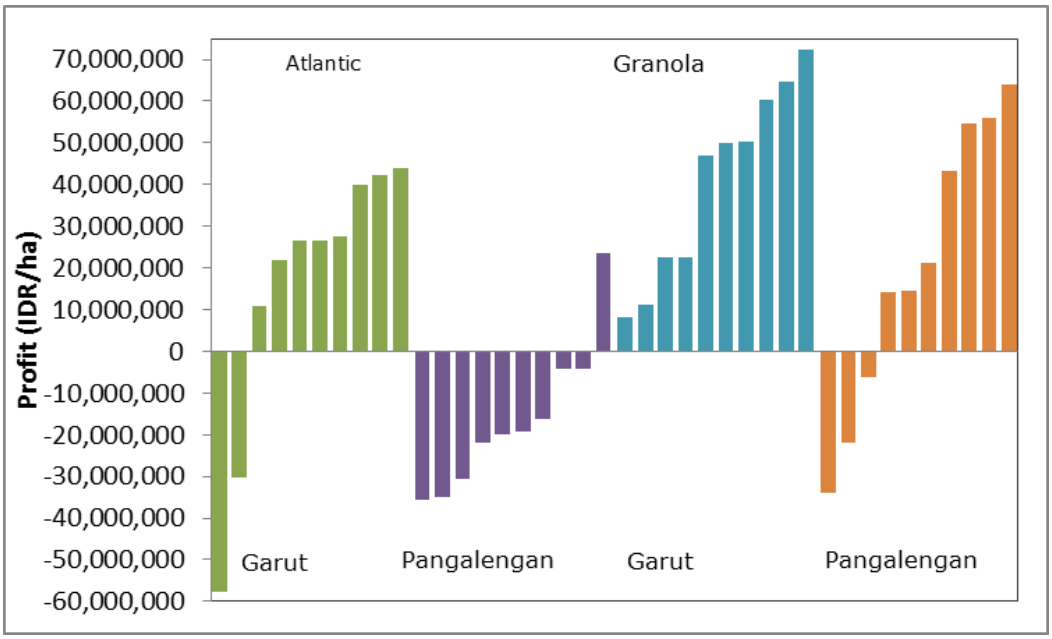

Figure 26. Profit of individual potato fields with Atlantic or Granola in Garut and Pangalengan.

Average cost price of Granola is in both regions about the same with on average 3,550 IDR per kg. Atlantic cost price in Garut is higher with 4,430 IDR per kg. A high cost price of Atlantic is present in Pangalengan which was greatly caused by rather disappointing yield levels.

Table 27. Cost price of potato cultivation.

		Cost price (IDR/kg)	S.E.
Atlantic	Cikajang	4,430	847
	Pangalengan	7,271	1,082
	Mean	5,850	744
Granola	Cikajang	3,405	298
	Pangalengan	3,693	402
	Mean	3,549	246
Mean		4,700	428

4. Discussion and conclusions

Costs of seed, fertilizers and crop protection compounds (fungicides, herbicides and insecticides) are substantial and are responsible for a very large share of the total crop production costs: 91 % - 96 %. Increasing profit margins for growers is to either (1) reduce the costs of these inputs, or (2) increase the efficiency of the inputs and (3) working along both approaches: cutting costs and increase productivity.

Cultivars and seed quality

The most widely grown cultivars are Granola for fresh market and Atlantic for processing into chips. The Granola seed is often carried over as farm saved seed and fourth generation seed originating from mini-tubers.

The cost of Granola seed constitutes 46 % of the total material cost. This level can be considered rather high in comparison with other potato cropping regions where seed costs are often 30-40 % of total costs. So the question comes in whether good quality seed for a lower price can be purchased. This matter is not an easy topic as seed potato production systems cannot be changed easily.

The origin of Atlantic seed is partly carried over as farm saved seed and partly available as fourth generation (imported G4) seed. Atlantic seed cost is 43 % of the total material cost; a similarly high proportion as with Granola. Refreshing seed is considered to be a relevant factor in increasing potato yields. However the question is whether better seed quality is sufficiently available for the potato growing community in West Java.

Nutrient management

The calculated (chemical and organic) amounts of nitrogen and phosphorus are quite high: 522 kg N per hectare and 632 kg P_2O_5 per hectare respectively. These levels are high in comparison to the three months field cropping period and the average yield level of 16.1 tons/ha. Mulching of the crop reduces leaching out of soluble nutrients like nitrogen and potassium. The share of fertilizer in the total material cost is 25 % (Atlantic) and 28 % (Granola). The high cost is due to the large amount of chemical fertilizer and, in addition, organic manure applied to the potato crops. Plastic mulching is widely applied in potato production fields in West java and should reduce leaching out of nitrogen and potassium. Reduced application rates need more attention as such will reduce cost levels and, hopefully, increase yield levels.

Crop protection

Fungicides are very relevant ingredients in potato production in West Java; both in terms of keeping the crop as much as possible free from Phytophthora infestans (late blight) and in terms of actual cost. The combined cost of fungicides, herbicides and insecticides is 25 % (Atlantic) and 20 % (Granola) of the total costs. Fungicides constitute about 75 % of the total pesticide cost. The implementation of the right late blight strategy in terms of selected fungicides and interval is essential to increase the number of production days and therefore contributing to a higher yield level. Using the right fungicides and the right dose rate with an optimal application technique should reduce late blight incidence and result in lower incidence and better yield levels.

5. Probable production constraints

Based on the effects discussed in the (previous) chapter (Discussion and conclusions) we conclude to focus on three growth factors:

1) Seed potato
2) Nutrients and fertilization strategies
3) Late blight control.

This implies these growth factors will be the topics of the demonstrations to be laid out in the Knowledge Transfer Work Package of the vegIMPACT Potato Work Package:

1. Seed quality
2. Nutrient management
3. Late blight control

Conducting demonstrations with NPK rates and late blight control scenarios is expected to be quite feasible. Conducting seed quality demonstrations is more challenging as better quality seed is not easily available to potato growers. This applied specifically to Granola variety, as the bulk of Granola seed is farm saved seed. A slight amount of Granola seed is produced through rapid multiplication; hopefully some good Granola field produced seed originating from such mini tubers can be obtained for the planned seed quality demo. The Work Package needs to communicate with Indofood in order to obtain good quality Atlantic seed; preferably freshly imported Atlantic seed for the purpose of a seed quality demo at both our Work Package locations: Garut and Pangalengan.

6. Proposed demonstrations for 2013 and 2014

1. Late blight control demonstration will be conducted from November 2013-March 2014
2. Nitrogen application demonstrations will be conducted from May-September 2014
3. Late blight control demonstrations will be conducted from May-September 2014

7. Literature

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