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Agronomics and economics of potato production in West Java, Indonesia

Wet season 2013/2014

Lubbert van den Brink, Nikardi Gunadi, Uka, Romke Wustman, Tonny K. Moekasa, Huib Hengsdijk

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

1. Introduction

The vegIMPACT program, short for 'vegetable production and marketing with impact', aims to improve vegetable production and marketing of small farmers in Indonesia. Vegimpact contributes to increased food security and private sector development in Indonesia and is financed by the Netherlands government. The program (2012-2016) is carried out by Wageningen University and Research Centre together with local partners and national and international companies in vegetable production and marketing.

One of the Work Packages in vegIMPACT focusses at improving potato production in Indonesia. One of the activities in this Work Package involves the training of 40 farmers in Good Agricultural Practices in Pangalengan and Garut, two major potato growing areas in Indonesia. As part of the farmer trainings demo plots are developed to demonstrate and test different fertilizer strategies and late blight control strategies. To better understand the performance of these farmers and to assess the impact of trainings an intensive registration of the management and performance of the participating farmers takes place during different growing seasons, both in wet and dry seasons.

This report presents the results of the registration of management activities and inputs in 40 potato fields during the wet season of 2013/2014 (October till March) in West Java. This is the second report concerning activity and input registration of potato fields in West Java. In the first report of De Putter et al. (2014), which describes results obtained in the dry season of 2013, general information is presented about potato production in West Java and background information on this multi-season study. In the wet season of 2013/2014 the same farmers were involved as in the dry season of 2013 described by De Putter et al. (2014). Twenty fields were located in Garut and twenty fields in Pangalengan. In both regions the varieties Granola and Atlantic were grown. General information about the farmers in Garut and Pangalengan is given in De Putter et al. (2014).

The objective of the multi-season monitoring study is to gain better understanding of farmers' current management of potato fields in different seasons, associated production and resulting economic performance. Because involved farmers received intensive training during the growing season in Good Agricultural Practices, the activity and input registration is also targeted at analysing changes in farmers' practices and performances during different seasons.

2. Materials and methods

2.1 Farmer's fields in wet season of 2013/2014

The project started in the dry season of 2013 with 40 farmers, 20 farmers in Garut and 20 farmers in Pangalengan. In each region 10 farmers produced Atlantic and 10 farmers produced Granola. It was the intention that the number of farmers growing Atlantic or Granola was the same in the wet season of 2013/2014. However, because of a shortage in Atlantic seed potatoes several farmers in Pangalengan changed from Atlantic to Granola. Table 2.1 gives an overview of the number of farmers growing Atlantic and Granola in both regions in the wet season 2013/2014.

Table 2.1 Number of farmers grwoing Atlantic and Granola in Garut and Pangalengan.

	Garut		Pangalengan	
	Atlantic	Granola	Atlantic	Granola
Dry season 2013	10	10	10	10
Wet season 2013/2014	9	10	4	16

2.2 Data collection

Daily data were recorded by the potato farmers themselves in the wet season 2013/2014 with plantings from October 2013 till April 2014. Farmers recorded their data in logbooks which were collected weekly by vegIMPACT staff for processing. Farmers recorded the type of activity, quantity of used materials applied in the activity, unit costs of materials used, costs of materials, labour requirements for the activity expressed in hours per male and female labourer, and the costs of hired labour. Family labour costs were not recorded. For inorganic fertilizers, the amount and concentration of applied N, P_2O_5 and K_2O were recorded. For pesticides, the name of active ingredient (A.I.) and A.I. concentration were recorded. In further data processing used pesticides were classified based on the mode of action group and hazard classification according to the World Health Organization (WHO), Table 2.2 (World Health Organization, 2015).

Table 2.2 Pesticide classification system of the World Health Organization (WHO, 2015).

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 Weather

The rainfall and number of wet days during the study period are shown in Table 2.3. The period May till August is generally characterized as dry (dry season), while from October the rainy season starts in Indonesia. The wet season 2013/2014 was no exception.

Table 2.3 Precipitation and number of days per month with rain in Garut and Pangalengan from September 2013 to July 2014.

	Garut		Pangalengan	
	Precipitation (mm)	Number of days with rain	Precipitation (mm)	Number of days with rain
September 2013	24	8	51	6
October 2013	276	9	153.5	14
November 2013	282	18	131	14
December 2013	508	25	402.5	27
January 2014	293	20	202	25
February 2014	392	17	192	17
March 2014	276	18	239	17
April 2014	257	16	363.5	27
May 2014	222	16	192.5	16
June 2014	133	9	124	12
July 2014	213	13	62	8
August 2014	58	3	87.5	10

2.4 Methods and definitions

- Information about the size of the fields was obtained from the farmers and from GPS measurements. In the analyses only the GPS field measurements were used. Sometimes there was a large difference between field size according to the farmers and the GPS measurement, ranging from -42% to +59%.
- To estimate the true production costs of farmers who planted farm-saved seed potatoes we used the prevailing market price for seed potatoes.
- Mineral contents of inorganic fertilizers were supplied by the farmers. Mineral contents of organic manure were based on manure analyses in the dry season of 2013, 1% N, 1.5% P_2O_5 and 1% K_2O (De Putter et al., 2014). Availability of nitrogen, phosphate and potassium from organic manure for crop uptake was estimated at 50, 70 and 100%, respectively.
- If contract labour was used in activities, only the total costs were registered and not the number of males and females involved.
- Calculation of the financial yield was based on the potatoes produced in different quality classes and associated prices. The financial yield included the financial yield of the potatoes used for farm-saved seed, which were valued at 9,000 IDR/kg. This was the average regional market price for on-farm saved-seed potatoes.

3. Results and discussion

3.1. General information on fields and growing period

Table 3.1 presents information about field sizes, planting dates and length of growing periods.

Field size. On average, field size of all Atlantic and Granola farmers was ca. 0.3 ha (3,000 m^2) within a range of 401 to 15,978 m^2. In Garut, Atlantic is grown on bigger fields than Granola. Four Atlantic farmers had fields larger than 0.5 ha. In Pangalengan, only four farmers cultivated Atlantic on fields ranging from 819 to 3,711 m^2. In Pangalengan, two farmers cultivated Granola on fields larger than 0.5 ha.

Planting date. On average, Atlantic fields were planted mid-November. Planting dates of Atlantic ranged from 12 November to 4 February. In Pangalengan all four Atlantic fields were planted before January; in Garut, only one field (from the 9 fields) was planted after 1 January. On average, Granola fields were planted ca. one month later than Atlantic, both in Garut and in Pangalengan. Several fields of Granola were planted after 1 January: in Garut two fields in January and one field on 17 February; in Pangalengan two in January, two in the beginning of February and one on 2 April, which is actually the dry season.

Growing period. On average, the number of growing days was similar for Atlantic and Granola, 99 days, but the growing period of Atlantic in Garut was on average 14 days longer than in Pangalengan.

Table 3.1 Average, minimum and maximum field size, planting date and length of growing period (days between planting and harvest) of Granola and Atlantic farmers in Garut and Pangalengan.

			average	min	max
Field size in m^2	Atlantic	Garut	5914	1457	15978
		Pangalengan	1799	1186	3261
		all Atlantic farmers	4648		
	Granola	Garut	1539	819	3711
		Pangalengan	2480	401	6641
		all Granola farmers	2118		
	All Atlantic and Granola farmers		2961		
Planting date	Atlantic	Garut	20/11/2013	09/10/2013	04/02/2014
		Pangalengan	12/11/2013	20/10/2013	17/12/2013
		all Atlantic farmers	17/11/2013		
	Granola	Garut	30/12/2013	21/11/2013	10/04/2014
		Pangalengan	04/12/2013	05/10/2013	02/04/2014
		all Granola farmers	14/12/2013		
	All Atlantic and Granola farmers		05/12/2013		
Growing days	Atlantic	Garut	105	91	123
		Pangalengan	91	83	106
		all Atlantic farmers	100		
	Granola	Garut	99	84	110
		Pangalengan	97	74	111
		all Granola farmers	98		
	All Atlantic and Granola farmers		99		

3.2 Seed potatoes and planting

Table 3.2 gives information on the origin and generation of the used seed potatoes, 38% of the Atlantic farmers and 58% of the Granola farmers used farm-saved seed. The majority of Atlantic farmers in Garut (78%) planted purchased G4 certificated seed potatoes. Especially in Pangalengan there was a shortage of Atlantic seed potatoes, therefore, six farmers changed from Atlantic to Granola. From the remaining four farmers three planted farm-saved Atlantic seed and one farmer planted bought certified G0 Atlantic seed potatoes. The use of farm-saved Granola seed potatoes was higher in Garut than in Pangalengan, probably because of the farmers who changed from Atlantic to Granola in Pangalengan. The majority of farmers planted G4 or G5 seed potatoes for both varieties (Granola: 61% and Atlantic 54%).

Table 3.2 Origin and generation of used Granola and Atlantic seed potatoes in Garut and Pangalengan.

		Number of farmers	% of fields												
			Bought								Farm saved				
			With certificate					Without certificate							
			Total	G0	G2	G3	G4	Total	G3	G4	G5	Total	local*	G2	G3	G4
Atlantic	Garut	9	**78**	0	0	0	78	**0**	0	0	0	**22**	22	0	0	0
	Pangalengan	4	**25**	25	0	0	0	**0**	0	0	0	**75**	75	0	0	0
Granola	Garut	10	**0**	0	0	0	0	**30**	0	20	10	**70**	10	0	10	30
	Pangalengan	16	**31**	0	6	19	6	**19**	6	13	0	**50**	0	6	13	6
All Atlantic farmers		13	**62**	8	0	0	54	**0**	0	0	0	**38**	38	0	0	0
All Granola farmers		26	**19**	0	4	12	4	**23**	4	15	4	**58**	4	4	12	15
All Atlantic and Granola farmers		39	**33**	3	3	8	21	**15**	3	10	3	**51**	15	3	8	10

*: local: farm saved without information about generation number

Table 3.3 shows information on seed potato use, mean weight of planted tubers, planting density, seed prize and costs of seed potatoes. Mean weight of planted tubers is calculated by dividing the weight of the total planted seed per ha by the plant number per ha. One farmer in Pangalengan planted G0 seed potatoes, which are very small tubers (3-5 grams/tuber), 38,402 tubers/ha (192 kg/ha) and very different from higher generations of seed potato. Therefore, this farmer is not included in calculating average values.

Seed potato use. On average farmers have planted 1.6 ton seed potatoes per ha, within a range of 0.8 and 2.9 ton/ha. With Granola, there is hardly any difference between Garut (1.5 ton/ha) and Pangalengan (1.6 ton/ha). In Garut, Atlantic farmers used more seed potatoes (1.8 ton/ha) than in Pangalengan (1.3 ton/ha), but this is based on three farmers only.

Planting density. The number of planted tubers per m^2 differed from 2.7 to 5.5 for Atlantic and from 3.3 to 5.3 for Granola across farmers. On 12.5% of the fields planting density is lower than 3.5 plants per m^2, which is rather low for obtaining high yields. Figure 3.1 shows the relationship between yield and planting density. Though clear relationships are lacking for both varieties and regions because of the limited number of observations the overall picture suggests somewhat lower yields at low and high planting density.

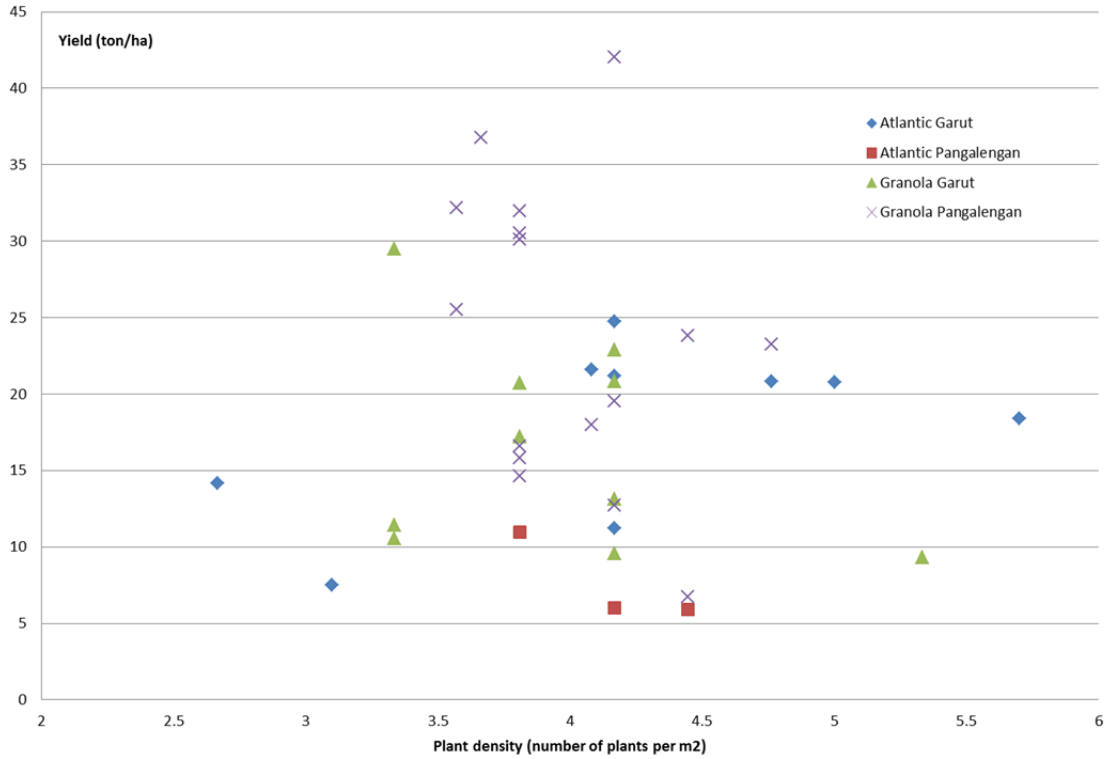

Figure 3.1 *Relationship between yield and planting density of Granola and Atlantic potato varieties in Garut and Pangalengan.*

Mean weight of planted tubers. On average farmers planted tubers with a mean weight of 40 grams within a range of 18 to 65 grams. In Garut, Atlantic farmers planted bigger tubers than Granola farmers (45 *vs* 40 gram). In Pangalengan, Atlantic farmers planted smaller tubers than Granola farmers (31 *vs* 40 gram) but this is based on three farmers only.

Table 3.3 Average, minimum and maximum seed potato use, seed potato weight, seed price, number of plants per m² and costs of seed potatoes of Granola and Atlantic in Garut and Pangalengan. [1)]

			average	min	max
Seed potato use (kg/ha)	Atlantic	Garut	1807	1414	2894
		Pangalengan	1297	843	1840
	all Atlantic farmers		1679		
	Granola	Garut	1509	920	2156
		Pangalengan	1575	812	2341
	all Granola farmers		1549		
	All Atlantic and Granola farmers		1590		
Tuber weight (gram)	Atlantic	Garut	45.1	26.1	66.4
		Pangalengan	30.8	22.1	41.4
	all Atlantic farmers		41.6		
	Granola	Garut	39.5	20.0	64.7
		Pangalengan	40.1	18.3	64.2
	all Granola farmers		39.9		
	All Atlantic and Granola farmers		40.4		
Number of plants per m2	Atlantic	Garut	4.2	2.7	5.7
		Pangalengan	4.2	3.8	4.4
	all Atlantic farmers		4.2		
	Granola	Garut	4.0	3.3	5.3
		Pangalengan	4.0	3.6	4.8
	all Granola farmers		4.0		
	All Atlantic and Granola farmers		4.0		
Seed price (IND/kg)	Atlantic	Garut	11,500	7,000	12,500
		Pangalengan	8,168	7,500	9,000
	all Atlantic farmers		10,667		
	Granola	Garut	11,035	8,000	14,000
		Pangalengan	14,125	8,000	25,000
	all Granola farmers		12,937		
	All Atlantic and Granola farmers		12,220		
Costs seed potatoes [1)] (IDR*1.000.000/ha)	Atlantic	Garut	21.0	9.9	36.2
		Pangalengan	10.5	6.7	13.8
	all Atlantic farmers		18.4		
	Granola	Garut	17.0	7.4	25.9
		Pangalengan	22.6	9.7	43.4
	all Granola farmers		20.4		
	All Atlantic and Granola farmers		19.8		

[1)] One farmer planted G0 potatoes, 192 kg/ha, tuber weight: 5 gram; number pf plants: 5.1/m2; seed price: 812 IND/tuber; costs costs: 31.2 million IND/ha

Seed price. The average planted seed potato price was 12,220 IDR/kg, but prices varied especially for Granola between 8,000 and 25,000 IDR/kg, and for Atlantic between 7,000 and 12,500 IDR/kg. Price differences are mainly a result of differences in the generation number of planting material. For example, in Pangalengan, prices of Granola G2 seed potatoes ranged from 22,000 to 25,000 IDR/kg, prices of G3 seed potatoes ranged from 12,000 to 17,000 IDR/kg, G4 from 11,000 to 15,000 IDR/kg, and G5 from 8,000 to 13,000 IDR/kg.

Figure 3.2 shows the relationship between yield and price of seed potatoes. For Atlantic this relation is very weak, while for Granola there is a tendency that yields increase with higher seed prices (Granola farmers in both regions: R^2= 0.48).

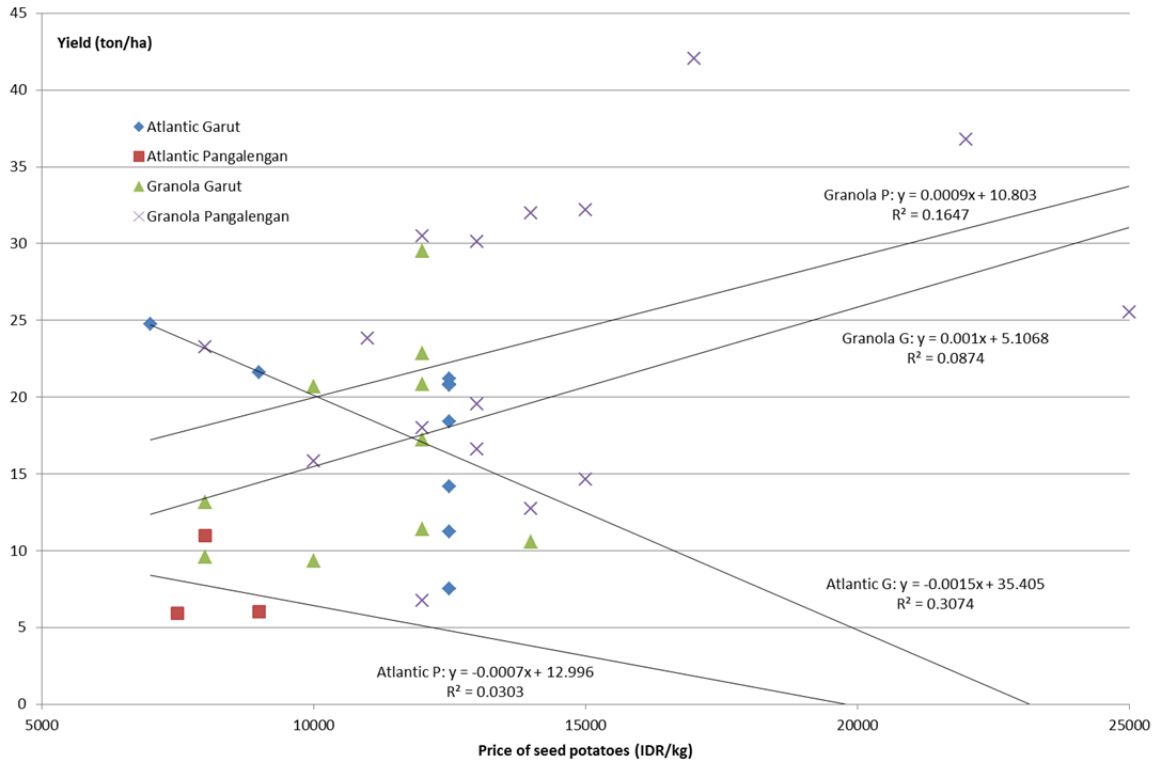

Figure 3.2 *Relationship between yield and price of Granola and Atlantic seed potatoes in Garut and Pangalengan.*

Use and costs of seed potatoes per ha. Figure 3.3 presents the use and costs of seed potatoes per farmer and origin/generation of seed potatoes. Average costs of seed potatoes were 19.8 million IDR/ha (Table 3.3), while average total production costs per ha were 64.6 million IDR/ha in the wet season of 2013/2014. Hence, the costs of seed potatoes accounted for 31% of the total production costs. However, the seed potato costs varied greatly between farmers from 6.7 to 43.4 million IDR/ha associated with differences in the use of seed potatoes per ha and seed prices as a result of differences in seed origin and generation number. Figure 3.4 shows the relationship between yield and seed costs. For both varieties in both regions, there is only a weak correlation because of other confounding management factors like disease control and fertilization. The strongest relation between yield and costs of seed potatoes is found for Granola (Granola growers in both regions: R^2= 0.53).

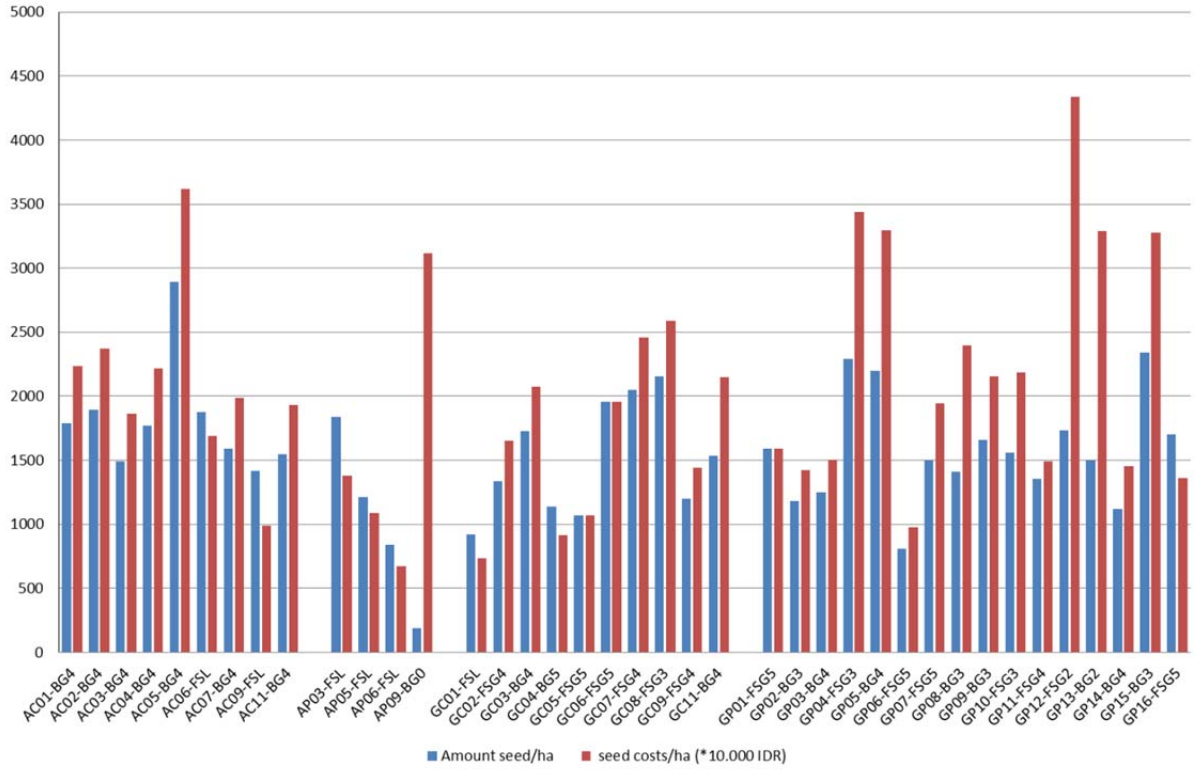

Figure 3.3 *Use of seed potatoes in kg/ha and costs of seed potatoes (*10,000 IDR/ha) by Granola and Atlantic farmers in Garut and Pangalengan; AC= Atlantic in Garut, AP=Atlantic in Pangalengan, GC= Granola in Garut, GP = Granola in Pangalengan, BG. = bought seed generation, FSG = farm-saved seed generation, FSL = farm-saved seed local.*

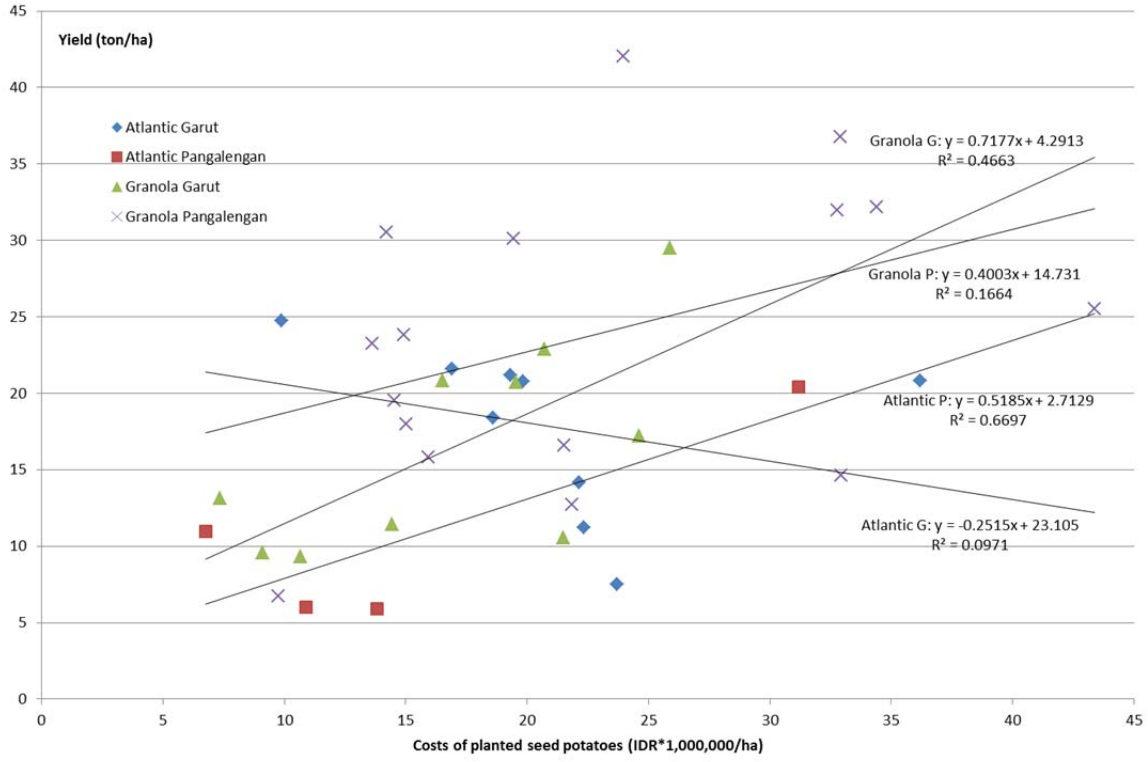

Figure 3.4 *Relationship between yield and total costs of planted Granola and Atlantic seed potatoes in Garut and Pangalengan.*

3.3 Fertilizer management

Table 3.4 gives information about the use and costs of organic manure and inorganic fertilizers.

Use of organic manure. All farmers applied organic manure, mainly chicken manure collected from chicken battery cage farms. On average, farmers applied 20.3 ton organic manure per ha, with a range from 10.6 to 36.6 ton/ha across farmers. Granola farmers in Garut applied less chicken manure than other farmers.

Table 3.4 Use and costs of organic and inorganic fertilizers for Granola and Atlantic farmers in Garut and Pangalengan.

			average	min	max
Organic manure (ton/ha)	Atlantic	Garut	19.9	10.6	31.0
		Pangalengan	19.2	12.6	24.2
		all Atlantic farmers	19.7		
	Granola	Garut	16.5	11.4	23.1
		Pangalengan	23.0	12.9	36.6
		all Granola farmers	20.5		
	All Atlantic and Granola farmers		20.3		
N inorganic fertilizers (kg/ha)	Atlantic	Garut	218	109	331
		Pangalengan	90	58	156
		all Atlantic farmers	179		
	Granola	Garut	206	109	321
		Pangalengan	160	69	241
		all Granola farmers	178		
	All Atlantic and Granola farmers		178		
Total available N (kg/ha) (organic + inorganic)	Atlantic	Garut	318	200	455
		Pangalengan	186	126	248
		all Atlantic farmers	277		
	Granola	Garut	289	167	430
		Pangalengan	275	151	399
		all Granola farmers	280		
	All Atlantic and Granola farmers		279		
P_2O_5 inorganic fertilizers (kg/ha)	Atlantic	Garut	399	294	537
		Pangalengan	160	83	215
		all Atlantic farmers	326		
	Granola	Garut	326	173	548
		Pangalengan	185	73	364
		all Granola farmers	239		
	All Atlantic and Granola farmers		268		
Total available P_2O_5 (kg/ha) (organic + inorganic)	Atlantic	Garut	609	431	808
		Pangalengan	362	337	422
		all Atlantic farmers	533		
	Granola	Garut	500	297	790
		Pangalengan	427	222	601
		all Granola farmers	455		
	All Atlantic and Granola farmers		481		
K_2O inorganic fertilizers (kg/ha)	Atlantic	Garut	212	41	310
		Pangalengan	74	58	92
		all Atlantic farmers	170		
	Granola	Garut	105	0	575
		Pangalengan	151	0	275
		all Granola farmers	133		
	All Atlantic and Granola farmers		146		

Continuation Table 3.4.

Total available K_2O (kg/ha) (organic + inorganic)	Atlantic	Garut	412	182	551
		Pangalengan	266	190	325
		all Atlantic farmers	367		
	Granola	Garut	270	134	743
		Pangalengan	382	190	590
		all Granola farmers	339		
	All Atlantic and Granola farmers		348		
Price organic manure (IDR/kg)	Atlantic	Garut	515	427	624
		Pangalengan	348	286	439
		all Atlantic farmers	464		
	Granola	Garut	542	457	728
		Pangalengan	371	286	500
		all Granola farmers	437		
	All Atlantic and Granola farmers		446		
Costs organic manure (million IDR/ha)	Atlantic	Garut	10.2	5.7	15.1
		Pangalengan	6.7	4.2	9.4
		all Atlantic farmers	9.1		
	Granola	Garut	8.9	5.7	12.2
		Pangalengan	8.4	4.3	12.9
		all Granola farmers	8.6		
	All Atlantic and Granola farmers		8.8		
Costs NPK fertilizers (million IDR/ha)	Atlantic	Garut	6.5	3.2	10.0
		Pangalengan	1.9	1.5	2.4
		all Atlantic farmers	5.1		
	Granola	Garut	5.2	2.5	10.9
		Pangalengan	3.0	1.5	4.2
		all Granola farmers	3.8		
	All Atlantic and Granola farmers		4.2		
Total costs of organic fertilizers, inorganic NPK fertilizers, foliar fertilizers and other fertilizers (million IDR/ha)	Atlantic	Garut	17.1	9.7	24.6
		Pangalengan	8.8	6.3	11.2
		all Atlantic farmers	14.5		
	Granola	Garut	14.4	8.5	23.1
		Pangalengan	11.6	5.8	15.9
		all Granola farmers	12.7		
	All Atlantic and Granola farmers		13.3		

Price of organic manure. On average, the price of organic manure was 450 IDR/kg with a variation ranging from 286 to 728 IDR/kg. It is unknown if these differences are related to quality (nutrient content). Prices of organic manure were on average higher in Garut (529 IDR/kg) than in Pangalengan (367 IDR/kg).

Costs of organic manure. Average costs of organic manure use were 8.8 million IDR/ha within a range of 4.2 and 15.1 million IDR/ha. The share of organic manure costs in the total production costs varied between 7 and 23%. The organic manure costs of Atlantic farmers in Pangalengan were lower than for other farmers, but were based on four farmers only.

Nitrogen use. Inorganic nitrogen fertilizer use mainly consisted of ZA (ammonium sulphate 21-0-0) and Phonska (NPK 15+15+15). Urea was used by few farmers. On average, farmers applied 178 kg N/ha with inorganic fertilizers within a range of 58 and 331 kg N/ha. Farmers in Garut applied considerably more N fertilizers than farmers in Pangalengan, i.e. 212 *vs* 146 kg N/ha. The total N applied (available from

organic and inorganic sources) was 279 kg N/ha, within a range of 126 to 455 kg N/ha. In Garut more N was applied than in Pangalengan, i.e. 302 *vs* 257 kg N/ha. Atlantic in Garut received 29 kg N/ha more than Granola. In Pangalengan, Atlantic received 89 kg N/ha less than Granola, but this is based on only four farmers growing Atlantic.

Figure 3.5 presents the available nitrogen, both from organic manure and from inorganic fertilizers. Figure 3.5 illustrates that farmers do not account for the N applied with organic manure when applying inorganic N fertilizers.

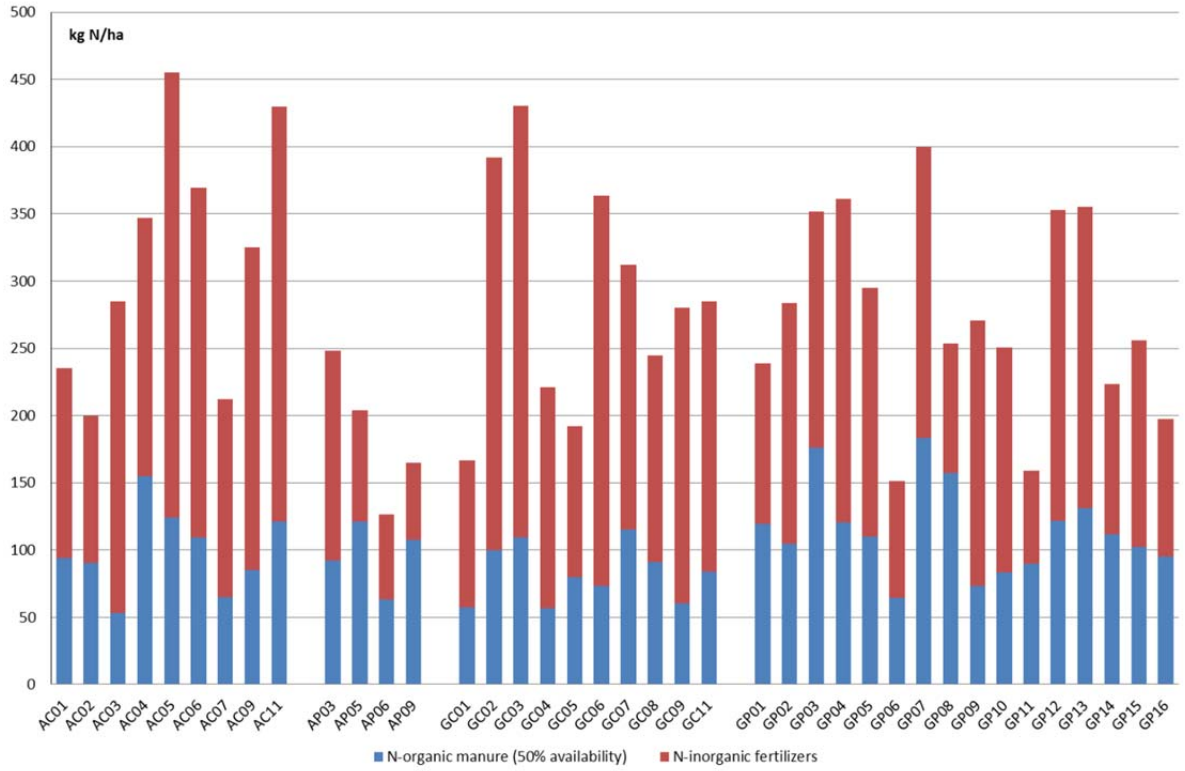

Figure 3.5 *Available nitrogen from organic manure and from inorganic fertilizers of Granola and Atlantic farmers in Garut and Pangalengan; AC= Atlantic in Garut, AP=Atlantic in Pangalengan, GC= Granola in Garut, GP = Granola in Pangalengan*

Figure 3.6 shows that there was a positive relationship between N input and potato yields beyond 250 kg N/ha in the wet season 2013/2014 in both Granola and Atlantic. In the wet season of 2013/2014, 46% of Atlantic farmers and 62% of Granola farmers applied more than 250 kg N/ha. In the dry season of 2013 this was 70 and 65%, respectively (De Putter et al., 2014).

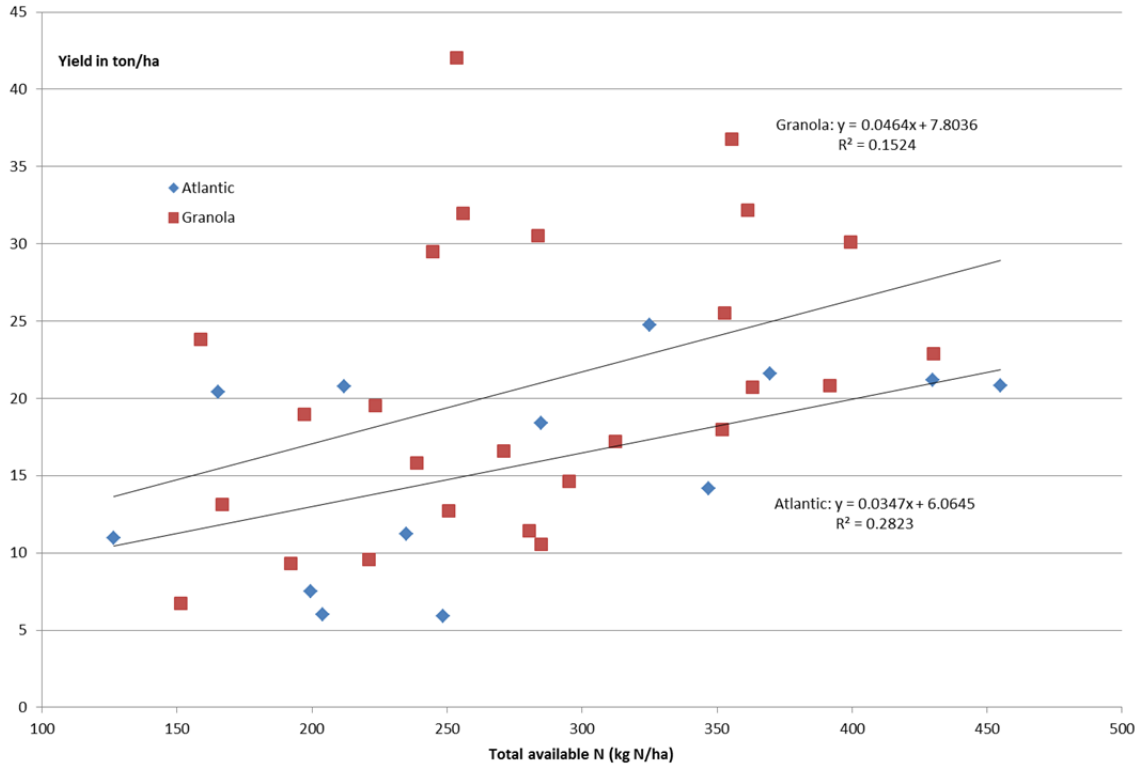

Figure 3.6 *Relationship between total available nitrogen (from organic and inorganic fertilizers) and yield in Atlantic and Granola varieties in Garut and Pangalengan.*

Timing of nitrogen application. Farmers applied inorganic N fertilizers at one or two moments during the growing season: (1) at or before planting and (2) 25 – 30 days after planting. More than half of the farmers (56%) applied all inorganic N before planting and the other farmers applied it in two or more splits. Some farmers applied all inorganic N, or part of it, very early: 8% of the farmers more than three weeks before planting (one farmer: 32 days), 23% of the farmers more than two weeks before planting, Especially in the wet season, there is a high risk of N leaching if the fertilizer is applied untimely.

Phosphate use. Inorganic phosphate fertilizers were mainly applied through SP (0-36-0) and Phonska (NPK 15+15+15). On average, farmers applied 268 kg P_2O_5/ha with inorganic fertilizers, within a range of 73 and 548 kg P_2O_5/ha. Farmers in Garut applied much more inorganic phosphate than farmers in Pangalengan, (i.e. 361 *vs* 180 kg P_2O_5/ha), which was also the case in the dry season of 2013 (De Putter et al., 2014). In Garut, Atlantic farmers gave 73 kg P_2O_5/ha more than Granola farmers. On average, the average available P_2O_5 was 481 kg P_2O_5/ha within a range of 222 and 808 kg P_2O_5/ha. In Garut much more P_2O_5 was applied than in Pangalengan, 551 *vs* 414 kg P_2O_5/ha. Figure 3.7 presents available P_2O_5, both from organic manure and from inorganic fertilizers.

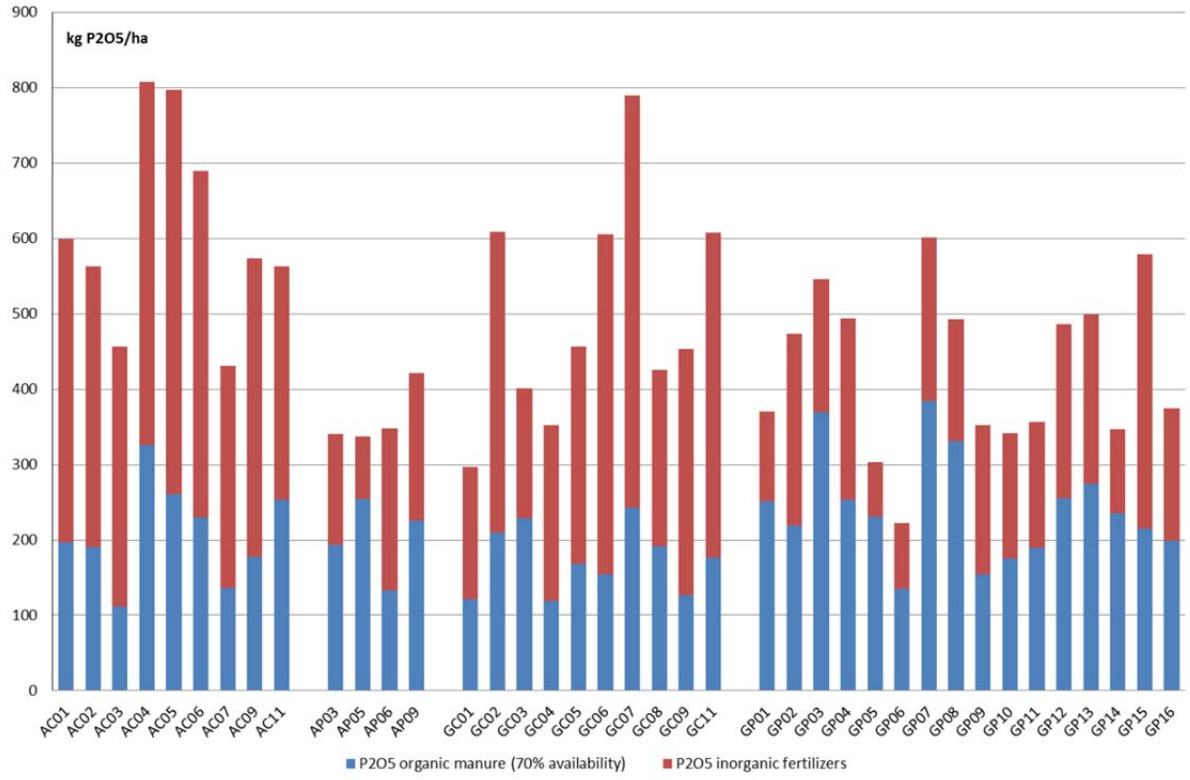

Figure 3.7 *Available P_2O_5 (kg/ha) from organic manure and inorganic fertilizers of Granola and Atlantic farmers in Garut and Pangalengan; AC= Atlantic in Garut, AP=Atlantic in Pangalengan, GC= Granola in Garut, GP = Granola in Pangalengan.*

It is not known why farmers in Garut applied much more phosphate than farmers in Pangalengan. In general, P use was extremely high and much more than the P uptake of a potato crop (approximately 55 kg P/ha at a yield of 50 t/ha).

Potassium use. Inorganic potassium fertilizers were mainly applied through KCl (0-0-60) and Phonska (NPK 15+15+15). On average, farmers applied 146 kg K_2O/ha with inorganic fertilizers, within a range of 0 and 575 kg K_2O/ha. Atlantic fields in Garut received on average most potassium: 212 kg K_2O/ha, which is 107 kg/ha more than Granola fields in Garut. Granola fields in Pangalengan received on average 151 kg K_2O/ha, while Atlantic fields in received 74 kg K_2O/ha. On average, the available K_2O from organic and inorganic sources was 348 kg K_2O/ha within a range of 134 and 743 kg K_2O/ha. Figure 3.8 presents the available K_2O, both from organic manure and from inorganic fertilizers of individual farmers.

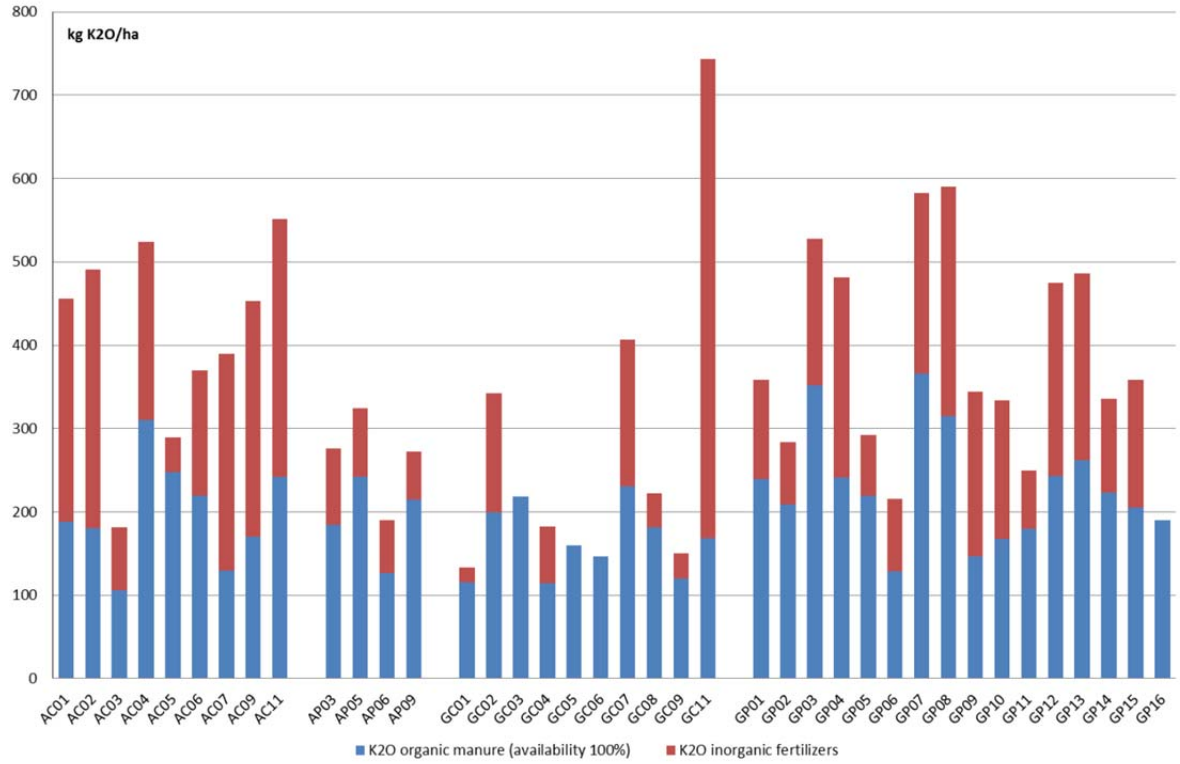

Figure 3.8 *Available K_2O (kg/ha) from organic manure and from inorganic fertilizers of Granola and Atlantic farmers in Garut and Pangalengan; AC= Atlantic in Garut, AP=Atlantic in Pangalengan, GC= Granola in Garut, GP = Granola in Pangalengan.*

Costs of inorganic NPK fertilizers. On average, the total costs of inorganic NPK fertilizers were 4.2 million IDR/ha, but varied among farmers from 1.5 to 10.9 million IDR/ha. This corresponds with 2 to 17% of the total production costs.

Total fertilizer costs. Figure 3.9 presents the total fertilizer costs of individual farmers. The cost of organic manure was the most important factor, followed by the cost of inorganic NPK fertilization. Only a few farmers applied foliar fertilizers or Zeagro of which the costs were of minor importance. Variation among farmers in fertilizers costs ranged from 5.8 to 24.6 million IDR/ha. The total fertilizer costs were 9 up to 38% of total costs across farmers. Average fertilizer costs in Garut were higher than in Pangalengan.

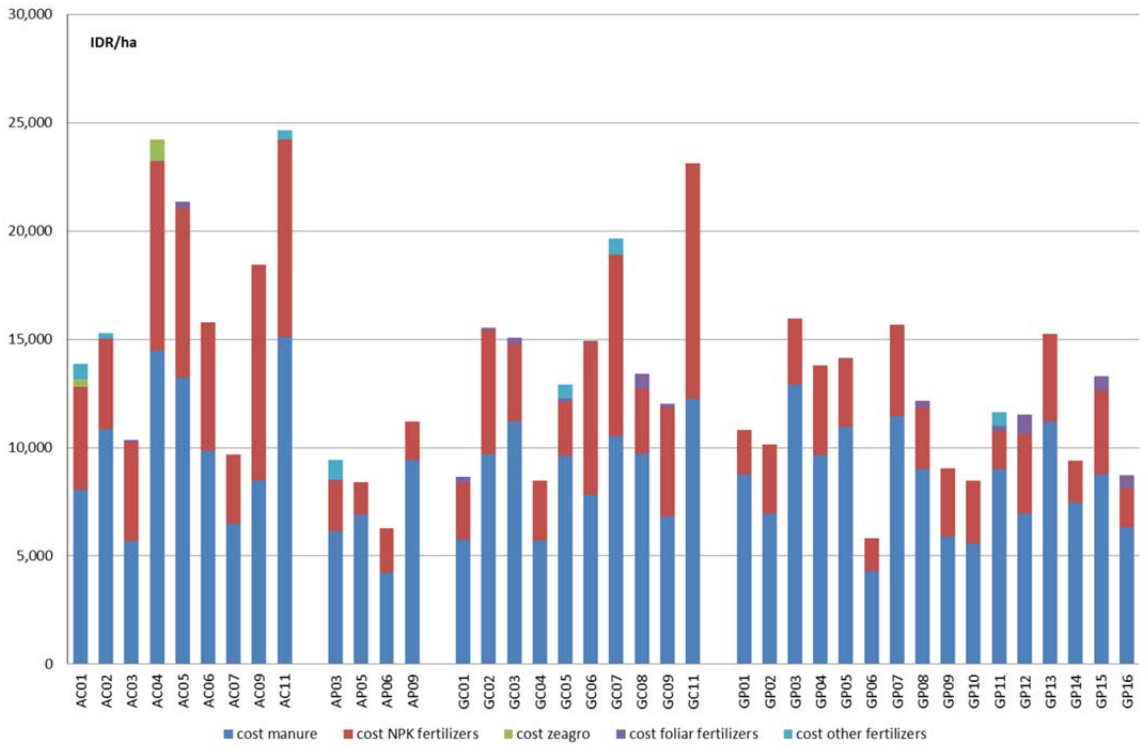

Figure 3.9 *Costs of fertilizers in IDR*1000/ha by Granola and Atlantic potato farmers in Garut and Pangalengan. AC= Atlantic in Garut, AP=Atlantic in Pangalengan, GC= Granola in Garut, GP = Granola in Pangalengan,*

3.4 Crop protection

The most important fungal disease in potato production in West Java is late blight (caused by *Phytophthora infestans*), especially in the wet season. Pesticides are applied to the potato crop by spraying with either a knap sack sprayer or a motor sprayer.

Spray volume. Table 3.5 presents information about pesticide spray volumes. On average, farmers applied pesticides with about 1,000 litre of water/ha per spray event. Granola farmers in Garut applied lower volumes, on average 634 l/ha per spray event. Between farmers, there is a large variation ranging from 239 to 2,135 l/ha. All farmers applied lower volumes in an early crop stage, on average 410 l/ha. Later on in the season, larger volumes were used, up to 2,787 l/ha per spray event. Recommended spray volumes range from 400 to 600 l/ha. Higher volumes increase the risk of run-off of pesticides from the potato leaves. Also in the dry season, farmers used similar high spray volumes to apply pesticides (De Putter et al., 2014).

Table 3.5 Average, minimum and maximum spray volumes used by Granola and Atlantic potato farmers in Garut and Pangalengan.

			average	min	max
Average of spray volume per spraying (l/ha)	Atlantic	Garut	995	722	1422
		Pangalengan	972	656	1378
		all Atlantic farmers	988		
	Granola	Garut	634	239	1220
		Pangalengan	1366	798	2135
		all Granola farmers	1085		
	All Atlantic and Granola farmers		1052		
Average of smallest spray Volume (l/ha)	Atlantic	Garut	294	125	590
		Pangalengan	314	117	538
		all Atlantic farmers	300		
	Granola	Garut	346	168	539
		Pangalengan	544	229	915
		all Granola farmers	468		
	All Atlantic and Granola farmers		412		
Average of biggest spray Volume (l/ha)	Atlantic	Garut	1231	866	1724
		Pangalengan	1245	1037	1536
		all Atlantic farmers	1235		
	Granola	Garut	855	481	1617
		Pangalengan	1632	870	2787
		all Granola farmers	1333		
	All Atlantic and Granola farmers		1300		

Number of fungicide applications. On average, fungicides were sprayed 17 times per season (Table 3.6). In Granola were fewer applications than in Atlantic due to a later start of the first spraying and a larger spraying interval as Granola is less susceptible to late blight. The number of fungicide sprayings ranged from 9 to 24 times per season among farmers. Some farmers started fungicide applications 12 days after planting, while other farmers started only 29 days after planting. It is estimated that plant emergence occurred between 14 and 21 days after planting. So, starting 29 days after planting is probably too late to protect the crop against late blight. The spraying interval used by farmers ranged from 2.8 to 5.3 days in Atlantic and from 2.9 to 6.9 days across farmers. Figure 3.10 presents the number of days between planting and first fungicide spraying and the average fungicide spraying interval. Some farmers combined a late moment of the first spraying with a long spraying interval, which means that protection against late blight was probably not sufficient.

Table 3.6 Number of applications with fungicides and insecticides, number of days between planting and first spraying, and average spray interval of Granola and Atlantic potato farmers in Garut and Pangalengan.

Number of fungicide applications	Atlantic	Garut	20.3	17.0	24.0
		Pangalengan	16.8	13.0	21.0
		all Atlantic farmers	19.2		
	Granola	Garut	18.7	11.0	22.0
		Pangalengan	14.1	9.0	21.0
		all Granola farmers	15.8		
	All Atlantic and Granola farmers		17.0		
Number of insecticide applications	Atlantic	Garut	6.0	2.0	10.0
		Pangalengan	7.5	2.0	14.0
		all Atlantic farmers	6.5		
	Granola	Garut	5.2	0.0	15.0
		Pangalengan	7.8	1.0	17.0
		all Granola farmers	6.8		
	All Atlantic and Granola farmers		6.7		
Days between planting and first application of fungicides	Atlantic	Garut	16.1	12.0	22.0
		Pangalengan	21.0	15.0	29.0
		all Atlantic farmers	17.6		
	Granola	Garut	20.7	15.0	27.0
		Pangalengan	19.8	15.0	27.0
		all Granola farmers	20.2		
	All Atlantic and Granola farmers		19.3		
Days between first and last application of fungicides	Atlantic	Garut	70	64	84
		Pangalengan	54	48	60
		all Atlantic farmers	65		
	Granola	Garut	60	50	72
		Pangalengan	57	35	74
		all Granola farmers	58		
	All Atlantic and Granola farmers		61		
Days between last spraying and harvest	Atlantic	Garut	18	8	28
		Pangalengan	17	6	25
		all Atlantic farmers	18		
	Granola	Garut	18	9	26
		Pangalengan	20	9	29
		all Granola farmers	19		
	All Atlantic and Granola farmers		18.8		
Interval between fungicide sprayings	Atlantic	Garut	3.7	2.8	5.3
		Pangalengan	3.5	2.9	4.0
		all Atlantic farmers	3.6		
	Granola	Garut	3.5	2.9	5.0
		Pangalengan	4.5	3.2	6.9
		all Granola farmers	4.1		
	All Atlantic and Granola farmers		4.0		
Interval between insecticide spraying	Atlantic	Garut	26.6	7.3	68.0
		Pangalengan	20.8	4.4	49.0
		all Atlantic farmers	24.9		
	Granola	Garut	15.2	4.2	30.5
		Pangalengan	11.5	4.0	45.0
		all Granola farmers	12.8		
	All Atlantic and Granola farmers		17.2		

On average the last fungicide spraying was 18.8 days before harvest, within a range of 6 to 29 days. Several farmers (41%) killed the haulms with Gramoxone.

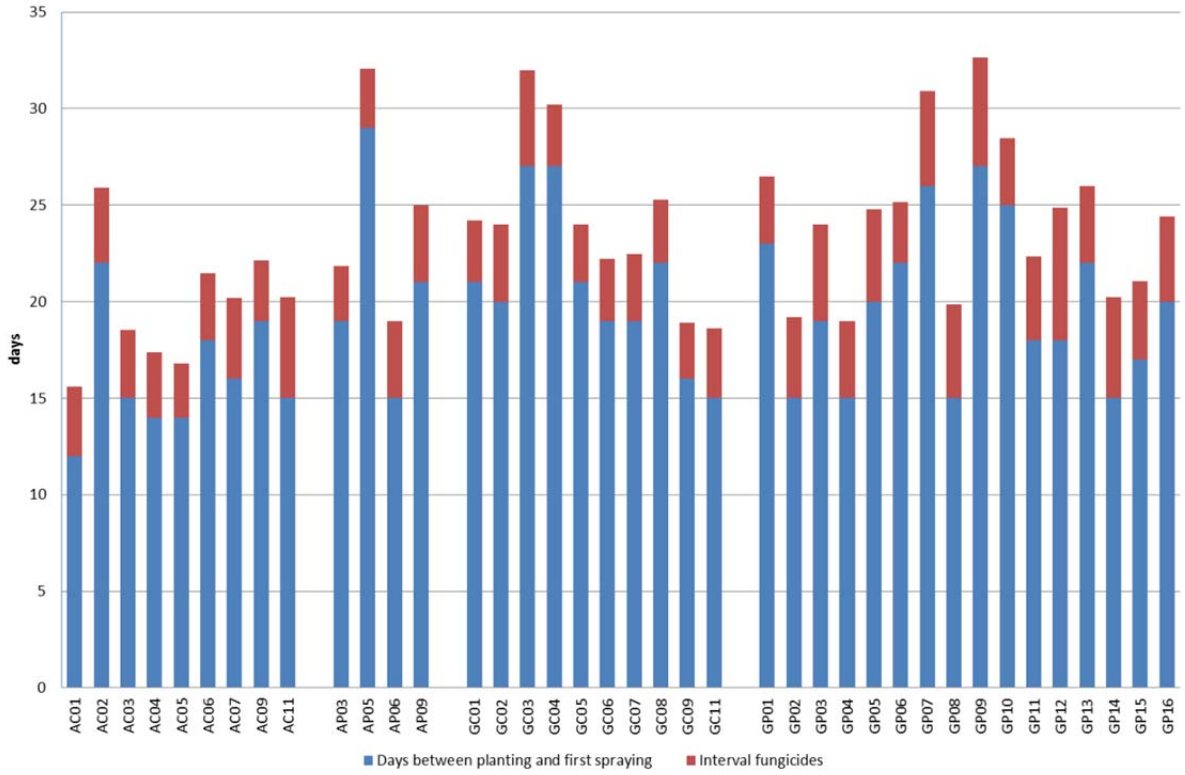

Figure 3.10 *Number of days between planting and first spraying with fungicides and average fungicide spraying interval in days by Granola and Atlantic farmers in Garut and Pangalengan; AC= Atlantic in Garut, AP=Atlantic in Pangalengan, GC= Granola in Garut, GP = Granola in Pangalengan.*

Late blight control. The applied fungicides can be categorized in the following groups with respect to their effect on late blight: contact fungicides, local systemic fungicides and systemic fungicides. The applied contact fungicides have a preventive mode of action. They need to be sprayed on the foliage before spores reach the leaf surface: The fungicide layer on the leaf inhibits germination of the spore. Systemic fungicides have a curative effect. They can kill the fungal structures after penetration in the leaves. It is recommended to apply both preventive as well as curative active ingredients 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.

Used fungicides. Table 3.7 shows the used fungicides by farmers, which hardly differed between Atlantic and Granola. In Pangalengan, the percentage of farmers applying systemic and local systemic fungicides was higher than in Garut (propamocarb, metalaxyl, cymoxanil and fluopikolide).

Stickers. Table 3.7 shows also the percentages of farmers applying stickers. Atlantic farmers used more stickers than Granola farmers.

Table 3.7 Use of different fungicides and stickers by Granola and Atlantic farmers in Garut and Pangalengan (% of farmers).

		Percentage of farmers applying the fungicide or stickers							
		Atlantic			Granola			All farmers	
		Garut	Pangalengan	All farmers	Garut	Pangalengan	All farmers	in Garut	Pangalengan
	# farmers:	9	4	13	10	16	26	19	20
Type of fungicide (late blight):									
contact	mancozeb	100	75	92	90	88	88	95	85
	chlorothalonil	100	75	92	90	88	88	95	85
	maneb	0	25	8	10	0	4	5	5
	Propineb	0	50	15	10	25	19	5	30
	ametoctradin	0	25	8	0	0	0	0	5
contact + local systemic	famoxadone	22	25	23	30	13	19	26	15
local systemic	cymoxanil	67	100	77	50	69	62	58	75
	dimethomorf	44	75	54	60	44	50	53	50
	fluopikolide	0	50	15	10	19	15	5	25
	mandipropamid	22	0	15	0	0	0	11	0
systemic	propamocarb	44	50	46	0	50	31	21	50
	metalaxyl	11	0	8	0	19	12	5	15
controlling other diseases than late blight	azoxystrobine	33	25	31	10	31	23	21	30
	difeconazole	33	25	31	10	31	23	21	30
	propikonazole	0	0	0	0	6	4	0	5
	Tebuconazole	0	0	0	0	13	8	0	10
	carbendazin	0	25	8	0	0	0	0	5
Stickers		89	75	85	30	56	46	58	60

Hazard risk of fungicides. Four of the applied fungicides are classified by the WHO as moderately dangerous (Table 2.2): cymoxanil, metalaxyl, difeconazole and tebuconazole. Cymoxanil was applied by 58% of the farmers in Garut and by 75% of the farmers in Pangalengan. Difeconazole was applied by 21% of the farmers in Garut and by 30% of the farmers in Pangalengan. Tebuconazole and metalaxyl were applied by only a few farmers (10 and 15%, respectively in Pangalengan and 0 and 5%, respectively in Garut).

Table 3.8 presents the average, minimum and maximum use and costs of fungicides in Granola and Atlantic potatoes in Garut and Pangalengan. Figure 3.11 shows the costs of fungicides and stickers of individual Granola and Atlantic farmers in Garut and Pangalengan.

Contact fungicides. On average farmers applied 40.2 kg active ingredients of contact fungicides in total per ha. In Atlantic more contact fungicides were applied than in Granola (49.4 *vs* 35.5 kg/ha). In Garut, Atlantic farmers applied more contact fungicides than Granola farmers, while in Pangalengan, Granola farmers applied more contact fungicides than Atlantic farmers. Most farmers applied mancozeb and chlorothalonil. Only a limited number of farmers applied maneb, propineb or ametoctradin (Table 3.7). There are large differences between farmers in the use of contact fungicides, from 6.2 kg/ha up to 138 kg/ha during the growing period. The latter amount consisted of 86.7 kg mancozeb and 51.2 kg chlorothalonil and was applied in split applications at 24 moments, which means 5.8 kg a.i. per spraying. This is much more than the advised dose, i.e. 1.5 kg a.i. mancozeb per spraying or 2 - 2.5 kg a.i.

chlorothalonil per spraying.

Systemic fungicides. On average, farmers applied on average 2.5 kg systemic fungicides per ha, within a range of 0.4 and 10.0 kg per ha. In Granola more systemic fungicides were applied than in Atlantic. In Pangalengan, farmers applied more systemic fungicides than in Garut independent of the variety. Most frequently used fungicides were cymoxanil, dimethomorph and propamocarb.

Table 3.8 Average, minimum and maximum fungicide and sticker use and costs for Granola and Atlantic potato farmers in Garut and Pangalengan.

			average	min	max
Contact fungicides, active ingredients (kg/ha)	Atlantic	Garut	57.6	22.6	138.0
		Pangalengan	30.9	22.0	45.4
		all Atlantic farmers	49.4		
	Granola	Garut	23.1	6.2	73.2
		Pangalengan	37.7	13.3	92.5
		all Granola farmers	35.5		
	All Atlantic and Granola farmers		40.2		
Systemic fungicides, active ingredients (kg/ha)	Atlantic	Garut	1.2	0.6	1.8
		Pangalengan	3.2	2.6	3.9
		all Atlantic farmers	1.8		
	Granola	Garut	1.3	0.4	2.2
		Pangalengan	3.8	0.6	10.0
		all Granola farmers	2.8		
	All Atlantic and Granola farmers		2.5		
Mancozeb (kg/ha)	Atlantic	Garut	35.2	6.9	86.7
		Pangalengan	10.8	0.0	24.5
		all Atlantic farmers	27.7		
	Granola	Garut	16.2	0.0	56.0
		Pangalengan	21.8	0.0	62.7
		all Granola farmers	19.7		
	All Atlantic and Granola farmers		22.3		
Chlorothalonil (kg/ha)	Atlantic	Garut	22.4	7.5	51.2
		Pangalengan	13.2	0.0	38.0
		all Atlantic farmers	19.6		
	Granola	Garut	6.1	0.0	17.2
		Pangalengan	21.0	0.0	49.2
		all Granola farmers	15.3		
	All Atlantic and Granola farmers		16.7		
Total costs fungicides (million IDR/ha)	Atlantic	Garut	8.1	3.2	16.8
		Pangalengan	5.4	4.8	5.9
		all Atlantic farmers	7.3		
	Granola	Garut	4.4	2.3	10.6
		Pangalengan	9.6	4.0	22.6
		all Granola farmers	7.6		
	All Atlantic and Granola farmers		7.5		
Costs stickers (million IDR/ha)	Atlantic	Garut	0.3	0.0	1.0
		Pangalengan	0.2	0.0	0.6
		all Atlantic farmers	0.2		
	Granola	Garut	0.1	0.0	0.8
		Pangalengan	0.2	0.0	1.4
		all Granola farmers	0.2		
	All Atlantic and Granola farmers		0.2		

Costs of fungicides. Figure 3.8 shows the costs of fungicides and stickers among farmers. These costs vary from 2.3 to 22.6 million IDR/ha and account for 4 to 35% of the total production costs. For reason of comparison, Figure 3.8 also shows the fungicide costs of the vegIMPACT late blight demo conducted

in Garut in the same wet season as part of the farmer's training (Schepers et al., 2014). Fungicides costs of over 50% of the farmers were higher than in the demo. The spraying interval in the demo and the (average) farmers was the same, 4 days. In the farmer's practise of the demo (Farm P in Fig. 3.8) 16.8 kg contact fungicides and 1.1 to 1.7 kg systemic fungicides per ha were applied, which was much less than used by farmers, i.e. on average 40.2 kg contact fungicides and 2.5 kg systemic fungicides per ha. In the demo also an optimal control strategy based on the latest knowledge of late blight control (vegI in Fig. 3.8) was included. Also the costs of this treatment were much lower than the costs of late blight control on many farmer's fields.

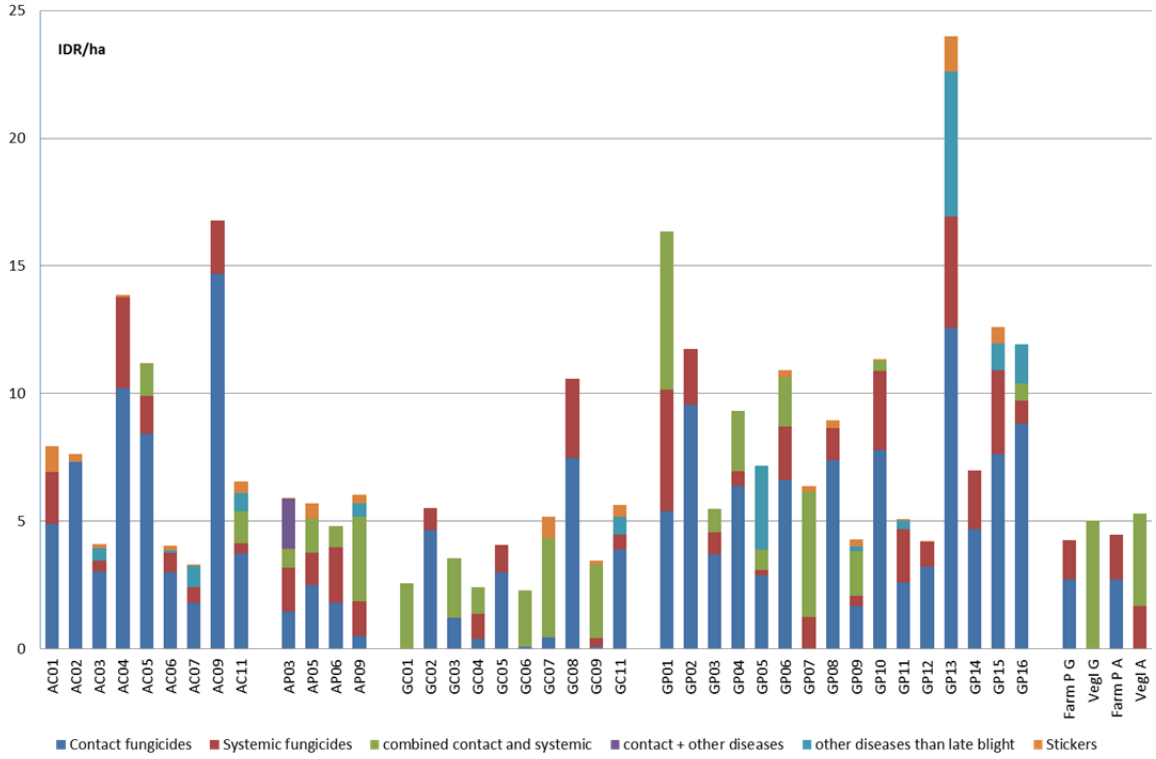

Figure 3.8 *Costs of fungicides and stickers in Granola and Atlantic of farmers (in million IDR/ha) in Garut and Pangalengan and in the demo of Garut wet season 2013/2014 (in million IDR); AC= Atlantic in Garut, AP=Atlantic in Pangalengan, GC= Granola in Garut, GP = Granola in Pangalengan, Farm P G = Farmer's practise Granola, VegI G= vegIMPACT Granola, Farm P A = Farmer's practise Atlantic, VegI A= vegIMPACT Atlantic (see text for explanation).*

Table 3.9 presents the percentage of farmers applying specific insecticides.

Soil insecticides. In Garut 53% of the farmers applied a soil insecticide (78% of Atlantic farmers and 20% of Granola farmers). In Pangalengan 35% of the farmers used a soil insecticide (none of Atlantic farmers and 44% of Granola growers). There was no registration of the type of insect that was controlled. In the soil

Foliar insecticides. Almost all farmers (97%) sprayed foliar insecticides with an average frequency of 6.7 times per season (Table 3.6). There are no clear differences between varieties and regions, but among farmers there are very large differences: one farmer did not spray insecticides, while other farmers

sprayed 17 times. Most farmers applied abamectin (63% of farmers in Garut and 75% of farmers in Pangalengan). In Pangalengan a relatively high percentage of farmers applied carbosulfan, profenofos, cypermethrin, while in Garut chlorantraniliprole was more used. There was no registration of the insect that was controlled.

Hazard risks of insecticides. Two of the used soil insecticides are classified by the WHO as highly dangerous, i.e. cadusafos and carbofuran. In Garut, 44% of Atlantic farmers applied one of these insecticides, while none of the Granola farmers. In Pangalengan, 38% of Granola farmers applied carbofuran, while this insecticide was not used by Atlantic farmers. Many moderately hazardous insecticides were applied: fipronil, metaldehyde, acephate, carbosulfan, chlorfenapyr, chlorpyrifos, cypermethrin, deltamethrin, dimetoate, imidacloprid, lambda cyhalothrin, permethrin and profenofos across varieties and regions.

Table 3.9 Use of different insecticides in Granola and Atlantic by farmers in Garut and Pangalengan (expressed as % farmers).

	Atlantic			Granola			All farmers	
	Garut	Pangalengan	All farmers	Garut	Pangalengan	All farmers	Garut	Pangalengan
# farmers:	9	4	13	10	16	26	19	20
Applied in the soil:								
cadusafos	22	0	15	0	0	0	11	0
carbofuran	22	0	15	0	38	23	11	30
fipronil	33	0	23	20	6	12	26	5
metaldehyde	11	0	8	0	0	0	5	0
Applied after emergence:								
abamectin	67	50	62	60	81	73	63	75
acephate	0	25	8	0	0	0	0	5
acetamiprid	0	0	0	10	0	4	5	0
carbosulfan	0	75	23	0	44	27	0	50
chlorantraniliprole	78	0	54	10	6	8	42	5
chlorfenapyr	0	0	0	0	6	4	0	5
chlorfluazuron	22	0	15	0	0	0	11	0
chlorpyrifos	0	25	8	0	6	4	0	10
cypermethrin	0	50	15	0	25	15	0	30
cyromazine	22	25	23	10	25	19	16	25
deltamethrin	11	50	23	0	6	4	5	15
diafentiuron	0	0	0	30	0	12	16	0
dimehypo	11	25	15	0	13	8	5	15
dimetoate	0	0	0	0	6	4	0	5
fipronil	0	0	0	0	6	4	0	5
imidacloprid	33	25	31	10	6	8	21	10
kartap hydrochloride	0	25	8	0	0	0	0	5
lambda cyhalothrin	11	25	15	10	25	19	11	25
metamidophos	11	0	8	0	0	0	5	0
pentamidophos	11	0	8	0	0	0	5	0
permethrin	11	0	8	0	0	0	5	0
profenofos	22	25	23	20	63	46	21	55
thiamethoxam	11	0	8	0	0	0	5	0

Use and costs of insecticides. Table 3.10 shows the average, minimum and maximum use and costs of insecticides. Various farmers did not apply soil insecticides, while other farmers applied up to 4,499 grams active ingredient/ha. Similarly, insecticide spraying was not used by some farmers but some

applied up to 4,606 gram active ingredient/ha. Therefore, costs of insecticide use differed greatly from 0 to 5.8 million IDR/ha across farmers. On average insecticide costs were much lower than the fungicide costs, i.e. 2.3 million IRD/ha *vs* 7.5 million IRD/ha (Table 3.8).

Table 3.10 Average, minimum and maximum use and costs of insecticides for Granola and Atlantic potato in Garut and Pangalengan.

			average	min	max
Total insecticide use active ingredients (g/ha)	Atlantic	Garut	1529	30	3780
		Pangalengan	1344	283	3051
		all Atlantic farmers	1472		
	Granola	Garut	684	0	3436
		Pangalengan	3067	390	7313
		all Granola farmers	2151		
	All Atlantic and Granola farmers		1925		
Insecticides as soil treatment active ingredients (g/ha)	Atlantic	Garut	870	0	1968
		Pangalengan	0	0	0
		all Atlantic farmers	602		
	Granola	Garut	8	0	48
		Pangalengan	915	0	4499
		all Granola farmers	566		
	All Atlantic and Granola farmers		578		
Insecticides spraying (g/ha)	Atlantic	Garut	659	30	1880
		Pangalengan	1344	283	3051
		all Atlantic farmers	870		
	Granola	Garut	676	0	3436
		Pangalengan	2152	13	4606
		all Granola farmers	1584		
	All Atlantic and Granola farmers		1346		
Costs soil insecticides (million IDR/ha)	Atlantic	Garut	0.3	0.0	0.8
		Pangalengan	0.0	0.0	0.0
		all Atlantic farmers	0.2		
	Granola	Garut	0.1	0.0	0.3
		Pangalengan	0.2	0.0	1.0
		all Granola farmers	0.2		
	All Atlantic and Granola farmers		0.2		
Costs insecticides spraying (million IDR/ha)	Atlantic	Garut	1.9	0.6	4.6
		Pangalengan	1.8	0.5	5.3
		all Atlantic farmers	1.9		
	Granola	Garut	1.7	0.0	3.5
		Pangalengan	2.5	0.2	5.8
		all Granola farmers	2.2		
	All Atlantic and Granola farmers		2.1		
Total costs insecticides (million IDR/ha)	Atlantic	Garut	2.2	0.6	5.4
		Pangalengan	1.8	0.5	5.3
		all Atlantic farmers	2.1		
	Granola	Garut	1.8	0.0	3.5
		Pangalengan	2.7	0.2	5.8
		all Granola farmers	2.4		
	All Atlantic and Granola farmers		2.3		

Figure 3.9 presents the costs of insecticides per farmer. It clearly illustrates that the highest costs are related to the use of insecticides applied by spraying.

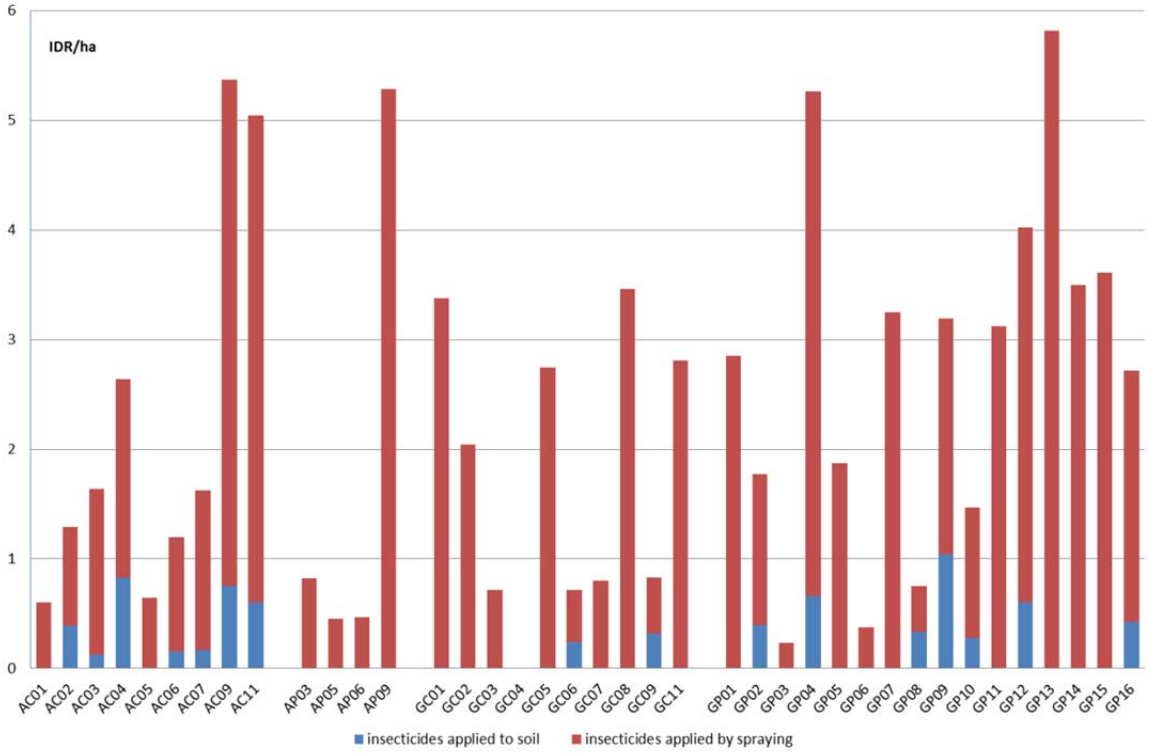

Figure 3.9 *Costs of insecticides (in million IDR/ha) by Granola and Atlantic farmers in Garut and Pangalengan; AC= Atlantic in Garut, AP=Atlantic in Pangalengan, GC= Granola in Garut, GP = Granola in Pangalengan.*

3.5 Labour

Table 3.11 presents information about the labour input during the growing season. On average, the labour requirements per hectare were 3,164 hours (male + female) within a range from 1,575 to 5,446 labour hours/ha.

On average, 44% of the total labour requirements were fulfilled by women with no clear differences between regions and varieties. However, also here was a large variation between individual farmers, ranging from 11 to 73%.

On average, 665 labour hours (lh) per hectare were used for crop protection with more hours (720) in Granola and less (556) in Atlantic. Labour requirements for crop protection in Pangalengan were higher (734) than in Garut (558). Labour requirements for crop protection varied across all fields between 116 and 2,294 lh/ha. Low labour input for crop protection may point at the use of contract (hired) labour.

On average, 688 lh/ha were needed for the harvest within a range of 186 and 2,294 lh/ha. Also, here low labour requirements may be associated with the use of contract work, but also labour input for transport. Obviously, also the yield level influences labour requirements for harvesting.

On average, labour costs were 15.6 million IDR/ha within a range of 5.8 to 28.9 million IDR/ha.

Figure 3.10 shows the male and female labour input per activity.

Table 3.11 Average, minimum and maximum labour input per gender (in lh/ha) excluding hired labour for Granola and Atlantic potatoes in Garut and Pangalengan.

			average	min	max
Total male hours	Atlantic	Garut	1478	773	3116
		Pangalengan	1513	1046	2343
		all Atlantic farmers	1489		
	Granola	Garut	2022	1026	3405
		Pangalengan	1804	517	3766
		all Granola farmers	1888		
	All Atlantic and Granola farmers		1755		
Female hours	Atlantic	Garut	1846	866	2969
		Pangalengan	863	337	1567
		all Atlantic farmers	1544		
	Granola	Garut	1087	192	2160
		Pangalengan	1500	644	2438
		all Granola farmers	1341		
	All Atlantic and Granola farmers		1409		
Total hours	Atlantic	Garut	3324	2011	5312
		Pangalengan	2376	1475	3909
		all Atlantic farmers	3033		
	Granola	Garut	3109	1774	5446
		Pangalengan	3304	1882	5037
		all Granola farmers	3229		
	All Atlantic and Granola farmers		3164		
% female hours	Atlantic	Garut	56	41	71
		Pangalengan	34	21	44
		all Atlantic farmers	49		
	Granola	Garut	34	11	52
		Pangalengan	46	25	73
		all Granola farmers	42		
	All Atlantic and Granola farmers		44		
Total labour costs (IND*1,000,000)	Atlantic	Garut	18.4	11.1	28.9
		Pangalengan	11.0	5.8	21.4
		all Atlantic farmers	16.1		
	Granola	Garut	13.5	8.1	21.3
		Pangalengan	16.5	16.5	24.8
		all Granola farmers	15.4		
	All Atlantic and Granola farmers		15.6		
Crop protection hours (male + female)	Atlantic	Garut	499	279	942
		Pangalengan	684	438	1014
		all Atlantic farmers	556		
	Granola	Garut	617	318	965
		Pangalengan	784	116	2294
		all Granola farmers	720		
	All Atlantic and Granola farmers		665		
Harvest hours (male + female)	Atlantic	Garut	730	387	1291
		Pangalengan	437	215	822
		all Atlantic farmers	640		
	Granola	Garut	709	336	1482
		Pangalengan	715	186	2294
		all Granola farmers	713		
	All Atlantic and Granola farmers		688		

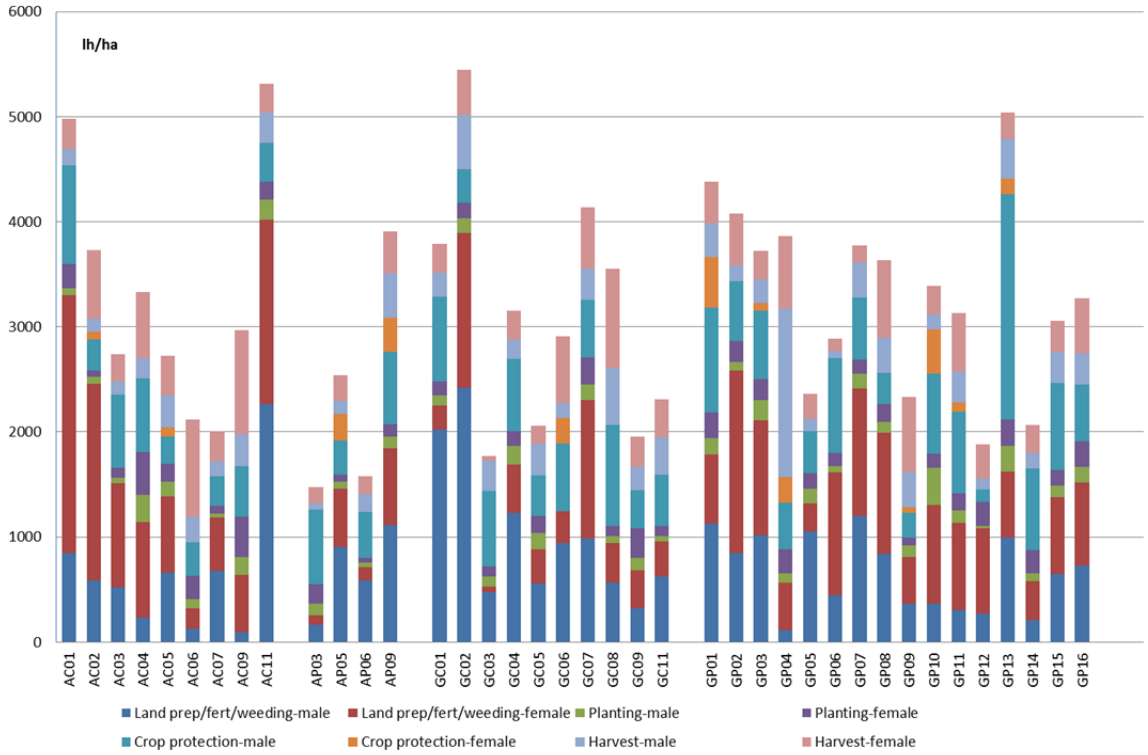

Figure 3.10 *Male and female labour hours per ha for different activities of Granola and Atlantic farmers in Garut and Pangalengan. AC= Atlantic in Garut, AP=Atlantic in Pangalengan, GC= Granola in Garut, GP = Granola in Pangalengan.*

3.6 Physical and financial potato yields

Table 3.12 shows information about the the physical and financial potato yield. Various farmers (54% Atlantic farmers and 62% Granola farmers) kept part of the yield for next season's seed potatoes. Figure 3.11 shows the physical yield data and Figure 3.12 the financial yield data of individual farmers.

Table 3.12 Average, minimum and maximum physical (t/ha), financial yield (million IDR/ha) and prices of Granola and Atlantic potatoes (IDR/kg) in Garut and Pangalengan.

			average	min	max
Yield (ton/ha)	Atlantic	Garut	17.5	7.5	24.0
		Pangalengan	10.6	5.9	19.3
		all Atlantic farmers	15.3		
	Granola	Garut	15.8	8.8	29.1
		Pangalengan	23.1	6.7	41.9
		all Granola farmers	20.3		
	All Atlantic and Granola farmers		18.7		
Financial yield (IDR*1.000.000/ha)	Atlantic	Garut	97	44	135
		Pangalengan	57	25	114
		all Atlantic farmers	85		
	Granola	Garut	94	40	194
		Pangalengan	154	31	320
		all Granola farmers	131		
	All Atlantic and Granola farmers		115		
Price of potatoes (IDR/kg)	Atlantic	Garut	5380	5108	5559
		Pangalengan	5154	4147	6299
		all Atlantic farmers	5310		
	Granola	Garut	5657	4400	6727
		Pangalengan	5788	4220	7182
		all Granola farmers	5738		
	All Atlantic and Granola farmers		5595		

The average potato yield was 18.5 ton/ha across both locations and varieties. In Pangalengan, the average Granola yield was much higher than the yield of Atlantic (22.9 *vs* 10.6 ton/ha). In contrast, in Garut the average Granola yield was lower than the yield of Atlantic (15.8 *vs*.17.5 ton/ha). Variation in yields across farmers ranged from 5.9 t/ha to 41.9 t/ha.

The average financial yield was 115 million IDR/ha. In Pangalengan, Granola farmers had much higher financial yields than Atlantic farmers (152 *vs* 57 million IDR/ha) associated with higher yields and higher prices for Granola. In Garut, there was hardly any difference between Granola and Atlantic farmers. Overall variation among farmers ranged from 25 to 320 million IDR/ha, so more than a factor 12. Some farmers in Pangalengan had a very high financial yield, because they stored a substantial amount of the potato yield as seed potatoes with a relatively high price.

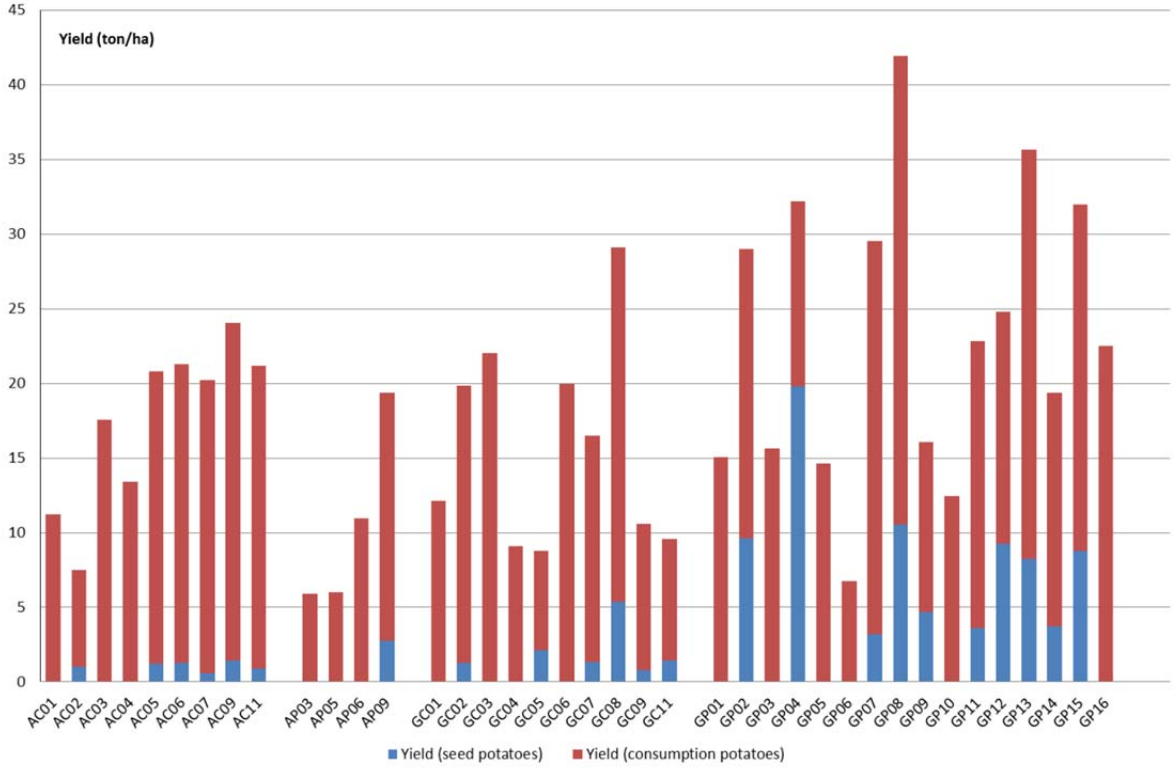

Figure 3.11 *Yield (in ton per ha) of Granola and Atlantic farmers in Garut and Pangalengan; AC= Atlantic in Garut, AP=Atlantic in Pangalengan, GC= Granola in Garut, GP = Granola in Pangalengan.*

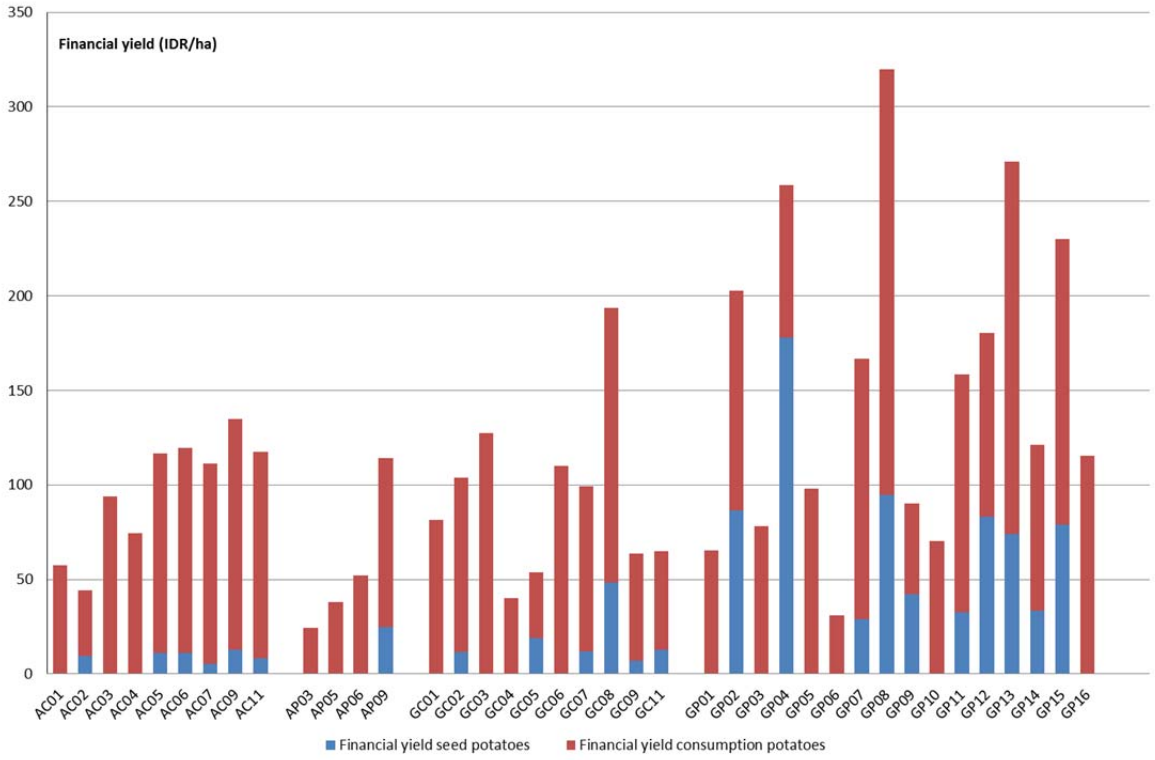

Figure 3.12 *Financial yield (in million IDR/ha) of Granola and Atlantic farmers in Garut and Pangalengan. AC= Atlantic in Garut, AP=Atlantic in Pangalengan, GC= Granola in Garut, GP = Granola in Pangalengan.*

3.7 Economic profit

Table 3.13 shows the crop balance sheet for both locations and varieties. Profits with Granola were much higher than with Atlantic in both locations mainly because of the higher yield. Figure 3.13 shows the variation in costs and profits of farmers. Seven farmers made more costs than income, with a highest loss of 25.5 million IDR/ha. The majority of the farmers made a profit and one farmer realized even a profit of 246.3 million IDR/ha, related to a high selling price.

Table 3.13 *Average crop balance sheet (million IDR/ha) of Granola and Atlantic potatoes in Garut and Pangalengan.*

	Atlantic		Granola	
	Garut	Pangalengan	Garut	Pangalengan
# farmers:	9	4	10	16
Financial yield	96.7	57.3	93.8	153.6
Costs	77.4	48.0	53.2	68.6
Seed potatoes	21.0	15.7	17.0	22.6
Fertilizers	17.1	8.8	14.4	11.6
Fungicides (incl. stickers)	8.4	5.6	4.5	9.8
Insecticides	2.2	1.8	1.8	2.7
Labour	18.4	11.0	13.5	16.5
Other costs	10.3	5.2	1.9	5.4
Profit	19.3	9.3	40.6	84.9

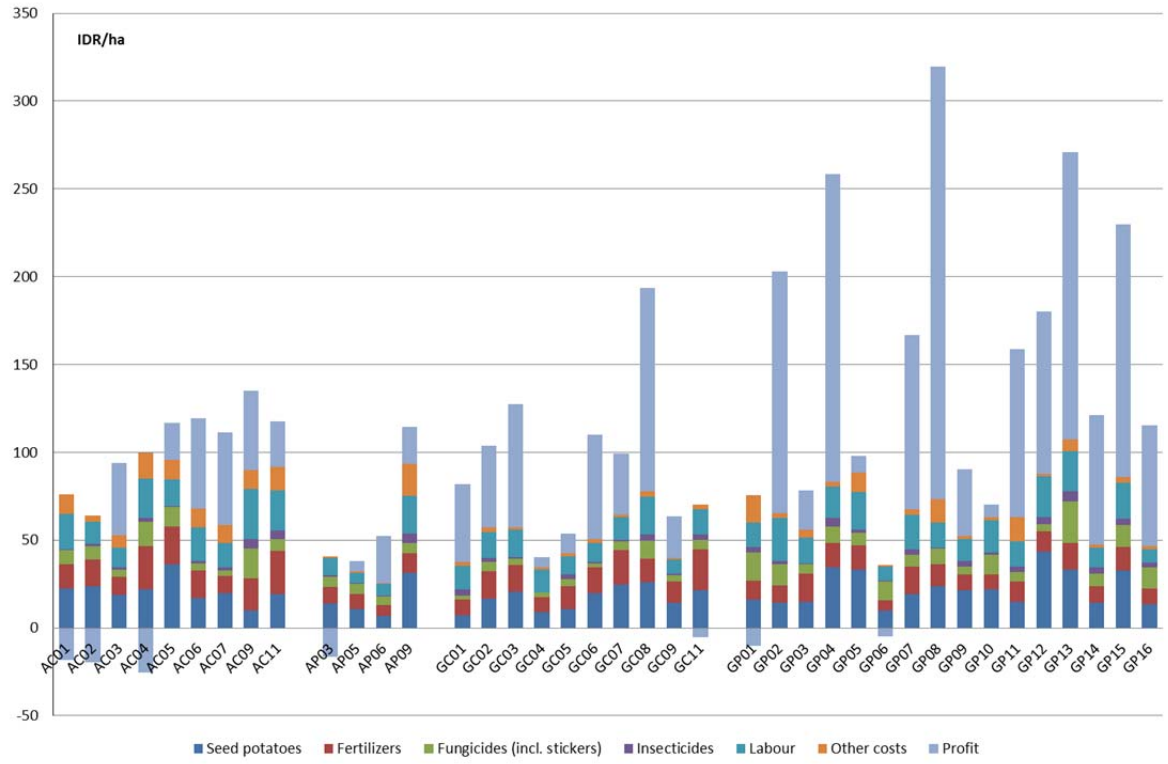

Figure 3.13 *Costs of seed potatoes, fertilizers, fungicides, insecticides and labour, other costs and profit (calculated as financial yield minus total costs in million IDR/ha) of Granola and Atlantic farmers in Garut and Pangalengan. AC=Atlantic in Garut, AP=Atlantic in Pangalengan, GC= Granola in Garut, GP = Granola in Pangalengan.*

Table 3.14 shows the average, minimum and maximum cost price per kg potatoes produced. Granola in

Pangalengan has the lowest average cost price associated with high yield levels.

Table 3.14 Average, minimum and maximum cost prices per kg potato produced of Granola and Atlantic variety in Garut and Pangalengan.

			average	min	max
Cost price IDR/kg	Atlantic	Garut	4859	2812	8522
		Pangalengan	4798	2334	6919
		all Atlantic farmers	4840		
	Granola	Garut	3526	2449	6645
		Pangalengan	3264	1752	6045
		all Granola farmers	3365		
	All Atlantic and Granola farmers		3857		

4. Discussion and conclusions

Large differences in management and inputs across Granola and Atlantic farmers resulted in large physical and financial yield differences in Garut and Pangalengan. Differences in management characteristics, input use and performance indicators (e.g. physical yield) are larger between potato varieties Granola and Atlantic than between both locations Garut and Pangalengan. In general, use and costs of most inputs varied a factor 2 to 6 times among farmers. Here, we first discuss the different inputs and associated management in more detail as they are important determinants of the final yield and financial performance of a potato crop.

4.1 Crop management and input use and costs

Seed potatoes

In terms of production costs, seed potatoes are most costly, followed by the costs for labor, fertilizers and fungicides.

Large differences existed among farmers in seed potato use, ranging from 1.4 to 2.9 ton/ha for Atlantic and from 0.8 to 2.3 ton/ha for Granola. Associated with the differences in the use of seed potato also the number of planted tubers per m^2 differed strongly from 2.7 to 5.5 for Atlantic and from 3.3 to 5.3 for Granola. On 12.5% of the fields planting density was less than 3.5 plants per m^2, which is very low. However, there was no clear relationship between yield and plant density (Fig. 3.1).

With the large differences in seed potato use also the costs differed widely from 6.7 to 36.2 million IDR/ha for Atlantic and from 7.4 to 43.4 million IDR/ha for Granola (Table 3.3). Also the costs for seed potatoes differed greatly from 7,000 to 25,000 IDR per kg (Table 3.3). Some of the farmers with low seed potato costs (lower than ca. 12.5 million/ha) achieved very low yields (Fig. 3.4).

Labor

Total labor costs varied between 5.8 and 28.9 million IDR/ha among farmers. These differences are mainly due to differences in labor requirements for soil preparation, fertilization and weed control and, for example relate to the use of plastic mulch, amount of organic fertilizers and the preceding crop. For example, if the preceding crop leaves more residues or weeds in the field more labor will be needed for soil preparation.

Fertilization

Costs for fertilization were the third largest cost component which varied between 5.8 and 24.6 million IDR/ha among farmers.

The majority of the farmers (59%) applied more organic manure per ha in terms of weight than the yield of potatoes. Many farmers (38% of the Atlantic farmers and 50% of the Granola farmers) applied more than 20 ton organic manure per ha, which resulted in high labor and transport costs. Also remarkable was that potato farmers in Garut applied much more N and P fertilizers than in Pangalengan.

Based on a nitrogen content of organic manure (1%) and 50% availability, farmers applied on average 100 kg N/ha with organic manure in addition to an average of 178 kg N/ha inorganic fertilizers. About 50% of the farmers applied more than 250 kg available N/ha, with extreme N rates of 455 kg N/ha. High

N rates are costly and generally result not in higher yields. In contrast, high nitrogen inputs may reduce potato yields as it results in abundant leaf development and delayed in tuber initiation. Moreover, high N inputs result in lower dry matter content which negatively affects the processing quality, especially of Atlantic. Within vegIMPACT experimental demo fields with different amounts of organic and inorganic fertilizers are carried out to show farmers the effects of lower N rates on potato yields. The first demo conducted in the dry season of 2014 indicated that nitrogen fertilization could be reduced from 20 ton organic manure and 200 kg inorganic N/ha (farmer's practice) to 10 ton organic manure and 150 kg inorganic N/ha without reducing yield (Van den Brink et al., 2015). However, Figure 3.6 showed a weak relationship between available nitrogen and yield in the wet season 2013/2014 also beyond 250 kg available N/ha. Although this relationship was weak it indicates that further monitoring of farmers in other seasons is required to assess the robustness of this relationship. Important in this respect is to know the nutrient content of the applied organic manure. Both in Van den Brink et al. (2015) and this report it is based on the nutrient composition of organic manure as determined in De Putter et al (2014), who showed, however, a large variation in the few manure samples analyzed. Exact information on the manure composition supports better-informed and practical fertilizer recommendations for farmers. In addition, quality characteristics of manure are also helpful to understand the observed differences in observed manure prices (> factor two different). The timing of manure and fertilizer applications is further an important factor for better estimating the available N from manure and fertilizers for crop uptake. Some farmers applied manure 3 or 4 weeks before planting, which increases the risk of N leaching, especially in the wet season.

Related to the high use of organic manure, P use is very high ranging from 222 to 808 available P_2O_5/ha. Approximately one third of the farmers applied more than 500 kg available P_2O_5/ha. It should be realized that the actual P input with manure is even 30% higher as we assumed that only 70% of the P is available for crop uptake in the season of application. It is unknown why farmers use such high phosphate rates, but maybe it relates to phosphate fixing properties of the soils in Garut and Pangalengan.

Also K_2O applications were very high across farmers, 33% of farmers applied more than 400 available kg K_2O/ha, while the minimum was 134 and the maximum 743 kg K_2O/ha. .

Related to the high inputs of both organic and inorganic fertilizers, average fertilizer costs were 13.3 million IDR/ha, within a range of 5.8 and 24.6 million IDR/ha. Considering the potentials to reduce nutrient inputs there are also good possibilities to lower the production costs.

Crop protection

Late blight was the most important disease during the wet season. Costs for fungicides ranged from 2.3 till 22.6 million IDR/ha among farmers. On many fields (64%) costs of fungicides were higher than the costs of fungicides in the late blight vegIMPACT demo fields during the wet season of 2013/2014 (Schepers et al., 2014). Farmers used very high spraying volumes, ranging from 481 to 2,687 liter/ha in the full grown crop, while recommended volumes are 400-600 liter/ha. High volumes increase the risk that fungicides run off the leaves. Several farmers started too late with late blight control, 33% of the fields were sprayed for the first time more than 20 days after planting. There are large differences among farmers in spraying interval. All farmers applied both contact fungicides and systemic fungicides. Some farmers applied very high amounts of contact fungicides, ranging from 22 to 138 kg/ha. Per spraying 2-3 kg is recommended, hence, with a spray frequency of 17 per season less than 50 kg/ha

should be applied. So, there are several possibilities to improve late blight control. Optimal control strategies should be tested and demonstrated in demo fields.

4.2 Physical and financial potato yield

It is of no surprise that physical and financial yields varied a factor 6 to 7 among the farmers in Garut and Pangalengan considering the variation in production costs (Figs. 3.11 and 3.12). It is more difficult to identify those management practices that have determined physical and financial yield differences.

Potato yields tended to be higher with higher costs for the planted seed potatoes, especially for Granola (Fig. 3.4). Granola yields tended to increase with higher seed potato prices (Fig. 3.2). Therefore, quality of seed potatoes seems an important yield-determining factor. About 60% of Granola growers and 40% of Atlantic growers planted farm-saved seed. Most of these farmers obtained low yields (lower than 15 ton/ha). There are possibilities to improve the quality of farmer-saved sees potatoes. Until now farmers are taking tubers from the harvested potato lot after harvest. Selection of healthy plants during the growing season and harvesting only tubers from these plants for seed potatoes may improve the quality of the farm-saved seed.

Another important yield-determining factor is the length of the growing season. Table 3.1 showed that the length of the growing season of Atlantic potatoes in Garut was 14 days longer than the same variety grown in Pangalengan. While conditions between both locations were not much different, the average yield of Atlantic was 7 ton/ha higher in Garut than in Pangalengan (Table 3.12). The relationship between the length of the growing season and yield for the four location x variety combinations is shown in Figure 4.1. Because of the limited number of data and the large variation in data the R^2 is low in all cases, but they all show an increasing yield trend with increasing number of growing days: The data indicate at daily yield increases of about 100 to 500 kg/ha. This implies that it is crucial to keep the foliage of the potato crop in a healthy and productive condition as long as possible. The control of late blight in this respect is crucial. Section 4.1 describes several issues that may improve the current way of controlling late blight, ranging from using a lower spray volume to starting control measures at an earlier stage of crop development.

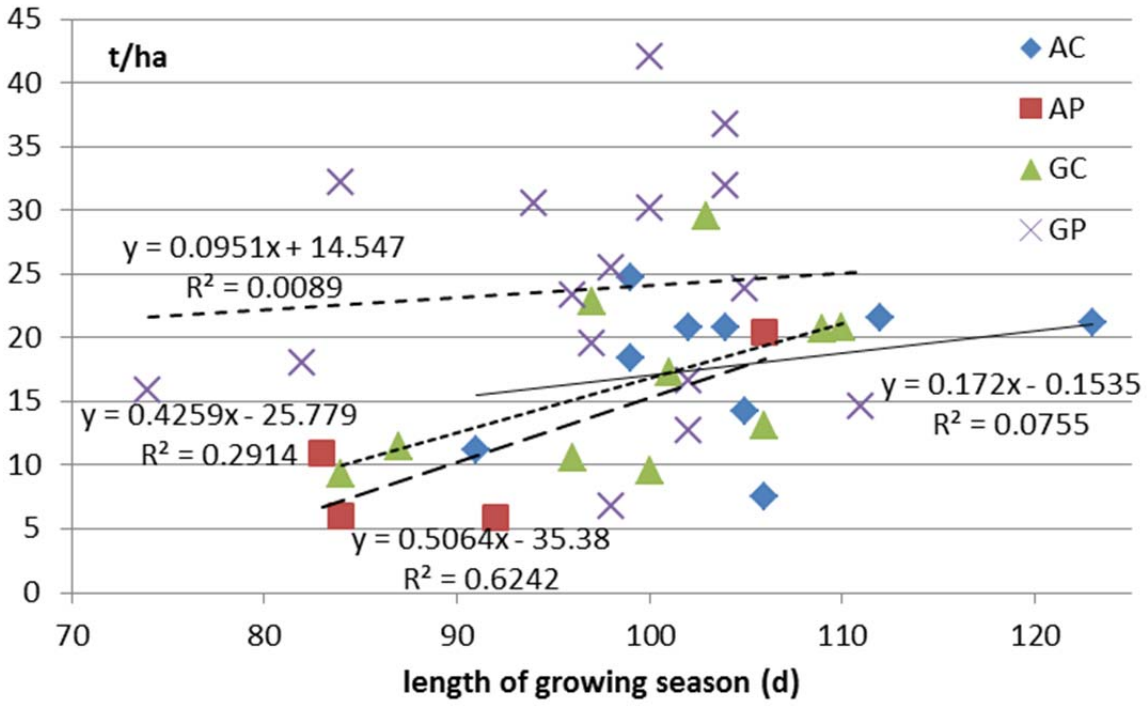

Figure 4.1 *Relationship between the length of the growing season and potato yield of Granola and Atlantic farmers in Garut and Pangalengan. AC=Atlantic in Garut, AP=Atlantic in Pangalengan, GC= Granola in Garut, GP = Granola in Pangalengan.*

4.3 Final remarks

This report describes the results of potato farmers in Garut and Pangalengan during one production cycle/season. The performance of the same farmers in the dry season of 2013 also has been documented (De Putter et al. 2014), and reports of other seasons will follow providing potentially a rich database on potato management in Indonesia. Since the farmers have received specific trainings in fertilizer management and late blight control the sequence of reports also provides insight in the effect of these trainings. The observed reduction in N use in the wet season 2013/2014 compared to the dry season 2012 is promising in this respect (section 3.3) but needs to be confirmed in future registration campaigns.

5. References

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