Farmers Initiated Learning on Improving Strategies for Controlling Potato Late Blight Disease *Phytophthora* sp. in Sembalun Highlands Indonesia

Baiq Nurul Hidayah, Sudjudi, Lia Hadiawati, Kunto Kumoro, Dwi Praptomo Sudjatmiko, Peter Dawson, Terry Hill, Julie M. Warren

***Abstract*—** Potato production in Sembalun highlands - Nusa Tenggara Barat (NTB) Province of Indonesia occurs in the Rinjani Valley 1,050 – 1,250 m above sea level. Farmers grow the Atlantic variety for a crisp processing company. One of the main constraints of growing potato in the tropical conditions are optimum development of pests and diseases of potato crops, especially potato late blight (PLB) disease. Over-application of potato late blight disease (PLB) fungicides is common practice in farmers level. This research aimed to help farmers develop and put into use a less costly potato late blight controlling technique that will significantly reduce the cost of fungicides and less impact for the environment. Another aim was to see whether the farmers could undertake a simple but rigorous experiments appropriate for on-farm testing of new management technique. This is important because potatoes are a new crop in NTB and specific management suited to local conditions has not yet been developed. The research was conducted at five farmers' fields and involving five Farmer Field School (FFS) groups. Each treatment was replicated five times by having five different farmer groups repeat the same experimental design in their fields. The replication meant that the results could be statistically analysed. We called the technique where FFS groups cooperate to plan and undertake simple but rigorous experiments Farmer Initiated Learning (FIL). The results of improved PLB management technique such as yield was significantly higher (19.47 t/ha) compared to farmers existing practices (17.97 t/ha), Percentage of plants infected by PLB was significantly lower (10%) compared to farmers existing practices (17%) and gross margin was significantly higher for the improved management techniques which is Rp. 4.04 million/ha higher than existing practices**.**

***Keywords*—** Farmer Initiated Learning, Potato Late Blight, Sembalun Highlands.

I. Introduction

POTATO (*Solanum tuberosum*) is an important vegetable commodity in Indonesia that has good market prospects, both as a vegetable as well as raw material for the food processing industry. Because of this potatoes are expected in future to be the choice for diversification of carbohydrate sources that can increase sustainability and overcome poverty in Indonesia.

In Indonesia, potatoes are produced in 21 provinces, the biggest are Sumatra and Java with a cropping area around 64,148 ha. Demand for table and processing potatoes shows growth. The value of imported processing potatoes to Indonesia in 2007 was US$ 40 million from 43,477 tonnes. For the year 2008 up to September processing potato imports reached 29,187 tonnes valued at US$ 28 million. In 2009 Indonesia still imported 48,000 tonnes with a value of US$ 33 million. Indonesian domestic potato production has increased steadily at over 3% per annum since 1997 and reached 1,176,304 tonnes in 2009 [1].

Potato production is generally still conventional and traditional or passed down from previous the generations, so that yields are still low from 14.9 – 16.4 tonnes/ha (average yield in Indonesia). Constraints to increasing potato production in Indonesia include: (1) low quality and quantity of seed potatoes, which forms the main concern in the effort to increase potato production in Indonesia [6], (2) current conventional cultivation techniques [8], (3) topographic factors, where high areas with suitable temperatures for growing potatoes are very limited [8], (4) the tropical conditions are optimum for the development of pests and diseases of potato crops [8].

NTB potato production occurs in the Sembalun sub-district on the slopes of Mt Rinjani, at a height of around 1,050 metres to 1,250 m asl. Potatoes are now the most important horticultural commodity for the Sembalun community. The potato variety that is grown by Sembalun farmers is Atlantic with a yield of 18.2 tonnes/ha [2] which is still relatively low because in several potato studies in Indonesia the yield has been 35 tonnes/ha [2]. Sembalun farmers can grow potatoes in the dry season as well as the wet season. In the wet season potatoes are planted in dryland that has a potential area of more than 1,500 ha and in the dry season potatoes are planted in paddy fields after the rice harvest in the months of June and

Baiq Nurul Hidayah, Sudjudi, Lia Hadiawati, Kunto Kumoro, and Dwi Praptomo Sudjatmiko are with Assessment Institute for Agricultural Technology (AIAT) Nusa Tenggara Barat Province – Indonesia, Jalan Raya Peninjauan Narmada 83371 Mataram Indonesia, phone +62 (370) 671312, fax +62 (370) 671620, e-mail: nurul.hidayah@yahoo.com

Peter Dawson, Terry Hill, and Julie M. Warren are with Department of Agriculture and Food – Western Australia (DAFWA), 3 Baron-Hay Court South Perth WA 6151.

July with a potential area of 1,105 ha. In 2010, the percentage of the paddy area used to produced potatoes was just 15 %.

The main constraint to development of Atlantic potatoes in Sembalun is sub-optimal application of integrated crop management (ICM). Farmers still predominantly use chemical fertiliser and do not yet apply the use of organic fertiliser although there is a potential to produce and develop local organic fertiliser. Farmers also are accustomed to controlling pests and diseases with chemical pesticides without observing threshold levels that indicate whether control is required or not, and also apply mixtures of various pesticides together without paying attention to the active ingredients which causes an impact on the important natural predators. The dominant use of chemical fertilisers and pesticides is the reason potato enterprises have high costs, in fact the constant use of chemical fertilisers will damage the soil structure and cause the soil to become hard [9]. Further, the excessive use of chemical pesticides will destroy the insect biodiversity and lead to the death of insects and other microorganisms antagonistic to pests and pathogens [9].

The constant practising of conventional potato production systems will reduce the profitability of farmers [2], and in the long term will cause environmental damage and loss of biodiversity in this region [2]. Because of this, a sustainable and environmentally friendly plan to support agricultural development through the study of environmental friendly of fungicides application to control potato late blight in the Sembalun highlands is needed. Sembalun is a small, isolated potato production area without specialist potato support services and therefore research will have to be carried out by the farmers themselves with local extension workers.

To ovecome the constraint of over-application of potato late blight disease (PLB) fungicides was required that enabled farmers to become their own researchers. The technique used was a modification to the FFS methodology. The aim was to investigate demonstration plots that allowed the impact of single management changes to be measured by farmers. Previously the potato FFSs had compared an ICM plot versus a conventional plot. This resulted in a range of management changes between the plots which made it difficult to identify the cause of improvements in profits between the treatments. We call this improved methodology Farmer Initiated Learning (FIL).

This research aimed to help farmers develop and put into use a less costly potato late blight controlling technique that will significantly reduce the cost of fungicides and less impact for the environment. Another aim was to see whether the farmers could undertake a simple but rigorous experiments appropriate for on-farm testing of new management technique on controlling potato late blight.

II. MATERIALS AND METHODS

A. Experimental set-up

Simple FIL experiments to test one variable were introduced to Sembalun Farmer Field Schools in 2010. The research was conducted at five farmers' fields and involving five Farmer Initiated Learning groups. At Sembalun five farmer groups compared farmer's conventional practices and FIL treatments. The plots were around 1000 m^2 and all had a 50 m^2 yield assessment sub-plot pegged in the center. This meant that the yield measured by each farmer group came from the same size plot. The results from each farmer group were used as replicates. Results were presented on a t/ha basis. The experiment was located at the Sembalun highland of NTB. The FIL groups were all members of the overarching farmer group Kelompok Horsela.

B. Cultural practices and conditions

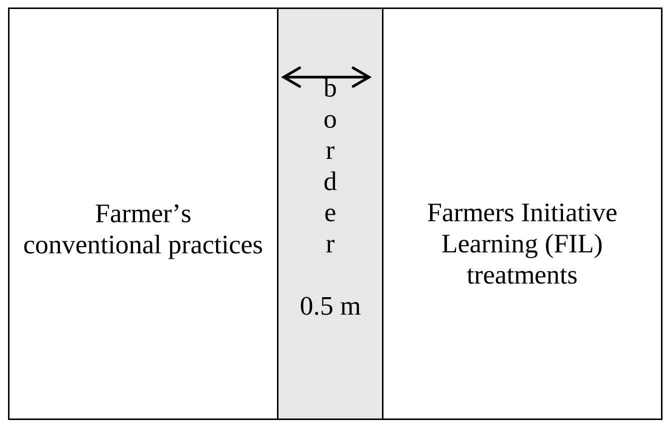

Fig 1. Example of experimental plot design. Plots varied in size according to individual. Yield was determined by harvesting a 50 m^2 sub-plot in the centre of each treatment.

C. Pest and disease control

Integrated Pest Management (IPM) treatments for Demplot FIL

- Disease control used the IPM concept as recommended by Australian Centre for International Agricultural Research (ACIAR) for example not using METALAXYL or MEFENOXAM (such as Ridomil Gold MZ).
- For applying fungicides threshold already established for IPM were used.
- The first spray used was a Curzate Victory mix or Equation at 80% emergence if emergence was even or at 50% emergence if it was uneven.
- After the first spray, a repeated progam was followed as follows:
  contact ---- systemic --- contact ---- systemic --- etc.
- If rainfall, spray in each 3 days
- If no rainfall, spray in each 5-7 days
- Application of fungicides minimum 4 hours before rainfall.

The use of fungicides, based on monitoring, that were applied to control PLB is shown in Table I.

TABLE I. TYPE OF FUNGICIDES USED IN CONTROLLING POTATO LATE BLIGHT IN THE FARMER INTITATED LEARNING PLOTS.

No	Farmer Existing Practices		IPM ACIAR FIL	
	Fungicides	Active Ingrediants	Fungicides	Active Ingrediants
1.	Apsa	Alkil aril alkoksilat asam oleat	Apsa	Alkil aril alkoksilat asam oleat
2.	Besmor	Poli Oksietilen Alki Aril Eter	Besmor	Poli Oksietilen Alki Aril Eter
3.	Cozene	Mankozeb & Karbendazim	Cylotex	Siromazin
4.	Cyrotex	Siromazin	Dhytane	Mankozep
5.	Dhytane	Mankozep	Equation	Simoksanil & Pamoksadon
6.	Equation	Simoksanil & Pamoksadon	Jose	Sipermetrin
7.	Indostik	Tendensat Nonil Tenol Etilen Oksida	Industik	Tendensat Nonil Tenol Etilen Oksida
8.	Jose	Sipermetrin	Revus	Mandipropamid
9.	Klopindo	Imidacloprid	Satgas	Propineb
10.	Metindo	Metamil	Sidamec	Abamectin
11.	Nemispor	Mankozeb	Tracer	Spinosad
12.	Pentacron			
13.	Pentacur			
14.	Revus	Mandipropamid		
15.	Rovral	Iprodion		
16.	Sidamec	Abamectin		
17.	Satgas	Propineb		
18.	Topsindo	Tiofanat Metil		
19.	Winder	Imidacloprid		
20	Victory	Mankozeb		

D.Statistical Analysis

All the data were statistically analysed using analysis of variance (ANOVA). The significance of treatment effect was determined using F-test, and to determine the significance of the difference between the means of the two treatments, least significant differences (LSD) were estimated at the 5% probability level.

III. RESULTS AND DISCUSSION

PLB was the disease with the highest incidence recorded by baseline agronomic survey enumerators (Table II). Therefore efficient and sustainable management techniques for PLB are required.

TABLE II. INCIDENCE OF DISEASE (% OF SITES) IN THE FIELD REPORTED BY SURVEY ENUMERATORS* IN SEMBALUN HIGHLANDS NUSA TENGGARA BARAT (NTB)

No	Diseases	Percentages
1	Potato Late Blight	100
2	Bacterial Wilt	11
3	Blackleg	100
4	Nematode	0
5	Virus	0

* trained crop monitors from Local Agriculture Agency

It is not surprising PLB was ranked the major issue as it is considered the major biotic constraint to potato production worldwide [5], with yield reductions estimated from 15% [3] to 20% [4]. With highly suitable weather conditions for the development of PLB epidemics [3], the use of the susceptible varieties Granola [3] and Atlantic [3], short or no crop rotations [7] and use of high generation seed, controlling the disease is a constant requirement for Indonesian potato farmers. It is for these reasons that control of PLB was ranked the highest priority of needs for the improvement of potatoes in developing countries [5].

Controlling PLB in Indonesia revolves around farmers using multiple applications of fungicides applied with either a simple backpack sprayer or motorized hand sprayer. Applications of up to 22 fungicides per potato crop have been recorded previously (Table I) [10], with an average of 18 being used specifically to control PLB [3]. The baseline agronomic survey showed chemical usage by NTB farmers comprised between 4 and 20 sprays per crop specifically for PLB (data not shown). This adds significant costs to the production of potatoes in Sembalun highlands Indonesia with conservative estimates of fungicide costs of US$ 224/ha and a total cost nationwide for PLB at US$180 million [3]. Excessive and inefficient use of fungicides to control PLB in Indonesia has been reported in the past [10].

No positive correlation for fungicide expenditure and yields was found. Fungicide expenditure represents between 3% and 14% across the province averages. There is often no correlation between these inputs and yields and gross margins. Farmers are over-applying agro-chemicals in the hope of controlling diseases such as PLB. To combat the high use of fungicides used to control PLB resistant cultivars have been released in Indonesia but adoption has not occurred. This is a common in developing countries with CIP resistant varieties amounted to only 6% of potato area in 1997; a fall from the 40% which occurred in the 1990's [11]. Market forces, the slow multiplication rate of potatoes, breakdown of resistance and poor or informal seed schemes have lead farmers to favour susceptible varieties [4]. Better management of PLB disease will benefit farmers through reduced input costs while maintaining or increasing yield.

ACIAR PLB treatments

Five farmer groups planted LBD plots; two groups planted in paddy fields and these LBD plots were severely affected by the wet weather, the third was damaged by herbicide. Results from the two remaining sites, Koang Londe and Mentagi, where crops grew well, are examined in table III.

TABLE III. PLB INFECTION, YIELD, INCOME AND COSTS FROM TWO PLB MANAGEMENT TECHNIQUES TESTED BY TWO FARMER GROUPS AT KOANG LONDE AND MENTAGI IN SEMBALUN HIGHLANDS DURING THE WET SEASON OF 2010.

Potato late blight		**Yield**	**Income**	**Costs**		**Gross**
Treatment	Infection (% plants infected at flowering)	(t/ha)		Total	Fungi cide	margin /ha
			(Rp. 000 000/ha)			
Farmers' Practice	16.9	18.0	48.5	41.7	8.9	6.8
ACIAR	10.0	19.4	52.4	41.6	8.5	10.8
n	2	2				2
Significance (P = 0.05)	ns	*				*
LSD (P=0.05)	9.8	0.4				1.0
Significance (P = 0.1)	*					
LSD (P=0.10)	4.9					

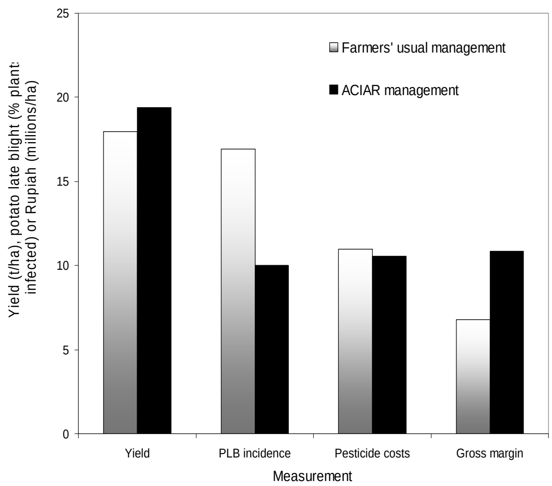

Fig 2. Effects of improved PLB management at Sembalun highlands. Yield was significantly higher for the ACIAR management (LSD P < 0.05 = 0.4 t/ha), % plants infected by PLB was significantly lower for the ACIAR management (LSD P < 0.1 = 4.9%) and gross margin was significantly higher for the ACIAR management (LSD P < 0.05 = 2 million Rp/ha).

Yields for both late blight treatments were similar with the farmers' management producing 17.97 t/ha while the ACIAR recommended treatment yielded significantly higher with 19.47 t/ha (Table 3). This shows that the new ACIAR PLB control method may have had better efficacy than the farmers' usual method. PLB infection data backs this up with the farmers' management plot recording 17% of plants infected at flowering while the ACIAR recommended treatment only had 10% of plants infected. This was significant at P < 0.10 but not at P < 0.05 (Table 3).

The PLB also differed in profitability as shown by gross margin. The farmers' management included average pesticide costs of Rp 10.95 million per ha while the ACIAR method was slightly lower at Rp 10.56 million per ha. This is a 39% higher than found in the economic baseline survey where average pesticide expenditure was Rp 7.9 million per ha. The fungicide component of costs under farmers' management was Rp 8.9 million per ha while the ACIAR method was slightly lower at Rp 8.5 million per ha. Farmers' management fungicide costs were 59% higher than shown in the baseline survey probably because of the very wet season. The ACIAR treatment produced a gross margin of 10.83 million Rp/ha which was significantly greater by 4.04 million Rp/ha than the farmers' treatment gross margin.

These results show that the FIL methodology of LBD demonstration plots is an effective way for farmer groups to do their own research on crop management. The results also show that the ACIAR recommendations for PLB management are effective and produce greater profits than the farmers' usual disease management.

IV. CONCLUSION

The FIL groups within Kelompok Horsela demonstrated that these farmers and their agricultural extension workers now have the capacity to plan and coordinate a series of simple though specialized potato experiments. Sub-group results could be analyzed as replicates in an ANOVA of the combined results. This means that this isolated group of farmers can now undertake their own objective testing of new management techniques.

ACKNOWLEDGMENT

We would like to thank the Australian Centre for International Agricultural Research (ACIAR), Indonesian Vegetables Research Institute (IVEGRI) Balai Pengkajian Teknologi Pertanian (BPTP) Nusa Tenggara Barat Province and the Department of Agriculture and Food, Western Australia (DAFWA) for funding this project. The assistance of collaborator farmers from Kelompok Horsela and extension workers from Dinas Pertanian, Kecamatan Sembalun, is gratefully acknowledged.

REFERENCES

[1] Badan Pusat Statistik, 2011. Produksi Sayuran di Indonesia http://www.bps.go.id/tab_sub/view.php?tabel=1&daftar=1&id_subyek=55&notab=15 Accessed 9 March 2011.

[2] BPTP NTB, 2009. Sosial Ekonomi Kentang Sembalun. (Balai Pengkajian Teknologi Pertanian NTB, Narmada) English translation attached to *ACIAR Final Report AGB/2005/167 Appendix 2 Economic Baseline Survey of Potatoes*. http://aciar.gov.au/publication/FR2011-24

[3] de Vries S.C., 2004. Country report on the late blight in Indonesia. *In* Proceedings regional workshop on potato late blight for East and Southeast Asia and the Pacific Eds: Lizárraga C.

[4] Forbes G.A., 2009. Late blight in developing countries and the role of the Global Initiative on Late Blight (GILB). *In* Proceedings of the eleventh Euroblight workshop, Hamar, Norway, 28-31 October 2008. PPO-Special report No. 13. Schepers HTAM (Ed).

[5] Fuglie K.O., 2007. Priorities for Potato Research in Developing Countries: Results of a Survey. *American Journal of Potato Research* 84: 353-365.

[6] Fuglie, KO, W Adiyoga, R Asmunati, S Mahalaya and R Suherman. 2006. Farm demand for quality potato seed in Indonesia. *Agricultural Economics* 35: 257-266

[7] Jayasinghe U., 2005. Potato seed system in Indonesia: A baseline survey. *In* Supply and demand for quality potato: Farmers' perspectives and policy options. Eds: Fuglie KO, Adiyoga W, Asmunati R, Mahalaya S, Suherman R. UPWARD working paper series No.8. CIP-UPWARD, Los Bańos, Laguna, Philippines pp 70-78.

[8] Kuntjoro, A.S., 2000. Produksi Umbi Mini Kentang G0 Bebas Virus melalui Perbanyakan Planlet secara Kultur Jaringan di PT. Intidaya Agrolestari (Inagro) Bogor – Jawa Barat. Skripsi. Jurusan Budidaya Pertanian Fakultas Pertanian, Institut Pertanian Bogor. Pp 62.

[9] Nurmayulis and Maryati, 2008. Content of Nitrogen and Yield of Potato Supplied with Fermented Organic Matter, Azospirillum sp., and Nitrogen Fertilizer in Cisarua, Lembang, West Java. Jurnal Tanah Trop., Vol 13, No. 3, Pp 217-224

[10] van de Fliert E, Warsito and Lagnaoui A., 1999. Participatory needs and opportunity assessment for potato IPM development planning: the case of Indonesia. *In*: *Impact on a Changing World.* CIP Program Report 1997-98. Lima, Peru. pp 171-178

[11] Walker T, Y Bi, JH Li, PC Gaur & E Grande, 2001. CIP's Contribution to Varietal Change in Potatoes in Developing Countries. CIP Program Report 1999-2000. pp 219-224.