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COMBINING EFFECTS OF CULTURAL PRACTICES AND RESISTANT CULTIVARS ON REDUCING THE INCIDENCE OF *Meloidogyne* spp. AND *Thrips palmy* Karny ON POTATO

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ABSTRACT

Root-knot nematode (*Meloidogyne* spp.) and melon thrips (*Thrips palmy* Karny) are two serious pests on potato. These pests are conventionally controlled with synthetic pesticides. Cultural practices based on integrated pest management (IPM) are alternative methods to control these pests. The study aimed to determine the effectiveness of combined applications of cultural practices and potato cultivars in reducing the incidences of nematode and thrips. Treatments evaluated were methods of nematode and thrips control by implementing IPM and conventional practices. A split-plot randomized complete block design with four replications was used. The main plots were IPM or cultural practices (subsoiling, soil solarization and use of trap crop of marigold *Tagetes erecta*) and conventional practices using synthetic pesticides. The subplots were five potato cultivars, i.e. No. 095 (Herta x FLS–17), 720050/Kikondo, 676068/I.1085, Granola, and Atlantic. The results showed that applications of cultural practices in combination with potato cultivars reduced *Meloidogyne* spp. population and potato tuber damage by 53.70% and 61.36%, respectively, as well as a significantly decreased thrips population. In the cultural control plots, thrips populations were below the action threshold (10.0 nymphs per leaf), therefore no single application of pesticide was used. This was in contrast to the conventional control treatments where insecticide was spayed 10 times until harvest. The subsoiling and solarization cut off the life cycle of the thrips and any survive thrips were trapped by marigold plant. Population of *T. palmi* on the five potato cultivars differed significantly; the lowest population was found on the cultivars No. 095 (Herta x FLS-17) and 676068/I.1085. The cultural control practices combined with potato cultivar No. 095 (Herta x FLS–17) were the best treatment for controlling *Meloidogyne* spp. and *T. palmi* on potato and also produced the highest yield (31.01 t ha^{-1}). The study suggests that cultural control practices in combination with resistant cultivars are recommended as a suitable IPM to control nematode and thrips on potato crops.

[***Keywords***: Potato, *Meloidogyne* spp., *Thrips palmy*, *Tagetes erecta,* integrated pest management]

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important food crops in the world after wheat, rice, and maize. In Indonesia, potato areas are 64,151 ha, producing 1,071,543 t of tubers, but the average yield is still low (16.7 t ha^{-1}) (Statistics Indonesia 2009). Apart from other factors, the main cause for poor yield is a number of pests and diseases, including root-knot nematode (*Meloidogyne* spp.) and melon thrips (*Thrips palmy* Karny). These pests cause serious losses on potato, especially during the dry season.

Root-knot nematodes are small microscopic round-worm organisms grouped as a major pathogen of vegetable crops including potato throughout the world. The symptoms of haulm are similar to those caused by root damage. These nematodes reduce plant growth and cause fewer, small, pale green leaves which then tend to wilt in warm condition. Infected roots show variable-sized "knots" or galls. Infected tubers are deformed and have internal symptoms of nematode feeding. Severely infested plants may die prematurely and affect the quantity and quality of marketable vegetable yields (Kingland 2001). They infest plant roots by producing galls through their feeding habits (Nesmith 2000). Damaged population densities and potato yield losses due to *Meloidogyne* spp. in Indonesia were estimated to be around 15%. Yield losses of 50-80% in vegetable crops from this nematode have been common (Siddiqi 2000).

Thrips palmy is other major pest of potato and has been spread widely and rapidly in tropical or sub-tropical regions. In Indonesia, *T. palmi* was first described on tobacco in 1925 from Medan, North Sumatra (Sakimura *et al.* 1986; Nakahara 1994). Both nymphs and adults suck the cell contents from leaves, stems, flowers and fruits. Initial damage symptoms on potato are silvery feeding scars on the lower leaf surface, usually alongside the midrib and veins. Heavily infested plants show a silvered or bronzed appearance, deformed and stunted leaves and might be died. As described by Sastrosiswojo and Basuki (2002), infestation of *T. palmy* in Indonesia caused considerable damage by 40-50% and yield losses of

35-55% (Dibiyantoro 1996). Furthermore, *T. palmi* is difficult to manage due to a number of factors including high female reproductive capacity, rapid life cycle (egg to adult), residence in habitats such as unopened terminal buds that protect them from exposure to contact insecticide and resistance to various insecticides.

Indonesian potato farmers used very heavy pesticides (16-20 applications during one season) and most of farmers (63%) sprayed the crops twice a week (Rauf *et al*. 2000). Continuous application of pesticides might cause pest resurgence, secondary pest outbreaks, development of pest resistance, and also destroy natural enemies. Work by the Entomology Department of the Indonesian Vegetables Research Institute (IVEGRI) over the last three years has shown that *T. palmi* populations increased possibly as the result of uncontrolled broad spectrum insecticide use on potato crops. The pest becomes resistant to insecticides and reduced natural enemies of the thrips (Seal 1994; Tobing 2007).

Soil fumigation with methyl bromide (MB) was frequently used to control root-knot nematode. Fortunately, MB has been banned in Indonesia since January 2008, and in many countries MB has been restricted its use due to its hazardous effect on stratospheric ozone.

Cost-effective and safe strategies to control root-knot nematode and thrips are essential to maintain production efficiency and quality. There are good opportunities to reduce chemical inputs using integrated pest management (IPM). As in any IPM strategy, the primary strategies are using biological and cultural controls, supported by selective pesticides, only when necessary. Cultural controls are equally as important as the biological controls and include soil preparation, soil solarization to control nematodes and soil-borne diseases (Stevens 1990; Katan and DeVay 1991), intercrop with marigolds (*Tagetes* spp.) for nematode and insect pest management (Khan *et al.* 1971; Ploeg 1999), seed source and varietal selection. The basis of soil solarization is to increase soil temperature by covering the moist soil with a clear polyethylene sheet and to maintain this temperature for 4-6 weeks before planting (Kavalci 2007). Setiawati *et al.* (2005) reported that combined application of subsoiling, solarization, and cropping system between potato and marigold (*Tagetes erecta*) reduced population of pests and diseases on potato.

Marigold has long been known to possess nematicidal activity (Ploeg 2002). Nematodes are attracted to marigold roots but when they invade them, the root releases ozone containing substances which are toxic to them. Moreover, French marigold (*Tagetes patula*) was not only effective both in lowering root-knot nematode populations but also in altering the hatching behavior of *M. incognita* (Ibrahim *et al*. 2006).

Resistant cultivars may provide a useful component of integrated management of this pest and disease. However, development of host plant resistance to root-knot nematode and thrips is still incipient. Limited information is available on potato resistance to root-knot nematode and thrips. According to the Directorate General of Horticulture (2001), Atlantic potato variety is resistant to root-knot nematode. A simple cultural control practice that does not add to the cost of production was shown to be effective in minimizing damage from pests and diseases (Rich and Wright 2002). This study aimed to determine the effectiveness of combined applications of cultural practices and potato cultivars in reducing nematode and thrips incidence.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Station of the IVEGRI in Lembang-West Java (1250 m above sea level) from August to December 2006. The soil type was Andisols with a pH range of 5.0-5.5.

Treatments evaluated were two methods of nematode and thrips control by implementing IPM with a low pesticide input and by a conventional control with high pesticide input commonly practiced by farmers. A split-plot randomized complete block design with four replications was used. The main plots were IPM or cultural practices, i.e. subsoiling, soil solarization, and use of trap crop of marigold, and the conventional practices using synthetic pesticides commonly used by farmers. The subplots were five potato cultivars, i.e. No. 095 (Herta x FLS-17), 720050/Kikondo, 676068/I.1085, Granola, and Atlantic (Table 1). Parameters observed were population and severity of nematode and thrips incidence, soil temperature, as well as growth and yield of the five potato cultivars.

Prior to planting, horse manure of 20 t ha^{-1} was applied in bands at the bottom of each furrow. NPK (16:16:16) of 1 t ha^{-1} was placed over the horse manure and then covered with soil before the tubers were planted.

Extraction and nematode counts were performed as described by Ibrahim *et al*. (2004). Approximately 1 kg of soil samples was collected from each plot before subsoiling, after subsoiling-before solarization, after solarization, before planting, 30 days after planting (DAP), 60 DAP, and at harvest time. A two 250 g sub-

Table 1. Conventional and cultural control systems tested to control nematode (*Meloidogyne* spp.) and thrips (*Thrips palmi*) on potato, Lembang, West Java, 2006.

Treatment	Application
Conventional control	
Nematode	Carbofuran 50 kg ha^{-1} was applied in the furrow at 5 cm soil depth, covered well with soil and watered immediately before planting
Thrips	Imidacloprid 2 ml l^{-1} was sprayed weekly using a knapsack sprayer with cone nozzle during the growing season, started at 21 days after planting (DAP) to 84 DAP
Cultural control	
Subsoiling	The soil was cleared, ploughed by a tractor, harrowed by a dish harrow at a 25-30 cm depth, ploughed and then irrigated. Field plots were prepared by making furrows spaced 80 cm apart. Plant spacing within the row was 30 cm. The experimental unit was a plot of 3.6 m x 9.6 m. The following week, plots were moistened by irrigating with water. The total number of potato plants was 144 per plot
Solarization	Plots were covered manually with 100 µm clear polyethylene sheets for 6 weeks
Trap crop (*Tagetes erecta*)	*Tagetes erecta* seedlings were planted in line between potato plants at 30 cm x 40 cm distance
Selective insecticide	Spinosad 0.5 ml l^{-1} was applied when thrips population above the action threshold (10 nymphs/leaf)

samples were placed on tissue paper laid on the separate sieve (53 mm diameter). The sieve was put in a glass funnel and placed over a glass container. Distilled water was slowly filled to within 1 cm of the lip funnel and soil extract was collected. After 24 hours, the soil extract was transferred into a 250 ml cylinder and leaved for at least 30 minutes. The soil extract was gently agitated, and then 2 ml of the soil extract was transferred into a counting dish. Number of nematodes was counted in each soil extract sample. Reading of the nematode counting was repeated twice, and the final number of nematodes was converted into percent.

Soil temperature was recorded weekly at 8 and 12 AM using a soil thermometer placed at 10 cm soil depth in both the solarized and non-solarized plots. Thrips population was counted from randomly selected 10 plants in each plot. Number of the thrips was recorded from the top two leaves per plant in weekly interval. Assessments were conducted throughout the growing season. Numbers of insecticide sprays during growing season were recorded.

Percentage of plant damage was estimated by measuring 10 plant samples per plot with a formula as follows:

$$P = \frac{\sum n \times v}{N \times Z} \times 100\%$$

Note:
P = plant damage (%)
v = score of plant damage
0 = no symptoms of thrips damage
1 = less than 20% of plants show mild leaf curling of top leaves
3 = > 20 - <40% of the plants mild leaf curling of top leaves
5 = > 40 - <60% of the plant mild leaf curling of top leaves
7 = > 60 - <80% of the plant show leaf curling of top leaves
9 = all plants show severe leaf curling of top leaves
n = number of plant with the same score
Z = the highest score
N = total number of plants observed

At harvest time, potato tubers per plot were weighed then the data were converted to t ha^{-1} by a multiplication factor of 289.35. All rotten tubers were counted and weighed.

Data were analyzed with a split-plot analysis of variance to determine if the main factors (pest management strategy and potato cultivars) had a significant effect on nematode and thrip populations and potato yield. If it is significant, the analysis was continued with a duncan's multiple range test (DMRT).

RESULTS AND DISCUSSION

Soil Temperature

Solarization on plastic covered plots increased soil temperature significantly compared to non-solarized plots (Table 2). The highest temperature in the solarized plot was 50.4°C which was occurred at 6 weeks after soil solarization, whereas on the non-solarized plots the highest temperature was 39.3°C. According to Charles and Stapleton (1990), nematodes in the soil will be killed at temperature of above 48°C. Average soil temperature at 10 cm depth in the solarized plots was 11.1°C, higher than that in the non-solarized plots. The result found here was similar with that reported by Kavalci (2007) who showed that temperature of solarized soil increased 7-10°C at a 10-15 cm depth.

Effect of Treatments on Root-Knot Nematode

Split-plot analysis of variance confirmed that subsoiling, solarization, and potato-marigold intercropping treatments reduced root-knot nematode population in the soil. However, there was no interaction between the cultural practices and potato cultivars on the nematode counts (Table 3).

Before subsoiling, the number of *Meloidogyne* spp. in the soil was 106.67, indicating that nematode population was high and thoroughly spread within the plots. The subsoiling reduced 30% nematode population, higher than that found in the conventional plot (11%). Furthermore, soil solarization significantly reduced nematode population by 60.72-74.72% compared to that found in the conventional control. This result agreed with Ijoyah and Koutatouka (2009) who reported that soil solarization significantly reduced root-knot nematode on lettuce. Furthermore, Setiawati *et al.* (2005) showed that subsoiling, solarization, and mix cropping of potato and marigold reduced populations of *Meloidogyne* spp., *Rotylenchulus* sp., *Helicotylenchus* sp., *Tylenchulus* sp., *Xiphynema* sp., and *Trichodorus* sp. on potato. Marwoto (1992) also found that marigold suppressed development and pathogenicity of *Meloidogyne* spp. and the larvae did not develop normally to the adult stage in the roots of marigold plant. Nematode suppression by marigolds is thought due to biocidal agents such as thiophenes and heterocyclic sulphur abundantly found in this plant (Topp *et al*. 1998). Marigold roots also release alpha-terthienyl (Gommers and Bakker 1988) which acts as a nematicidal, insecticidal, antiviral, and cytotoxic (Arnason *et al*. 1989; Marles *et al*. 1992). Alpha-terthienyl inhibits the nematode egg hatching (Siddiqui and Alam 1988) and juvenile development (Ploeg and Maris 1999).

Based on the number of *Meloidogyne* spp. found at the conventional control plots where carbofuran was applied, carbofuran did not affect the nematode. As a result, number of the nematode extracted from the soil

Table 2. Soil temperature in the non-solarization (conventional control) and solarization (cultural control) treatments, Lembang, West Java, December 2006.

Treatment	Temperature (°C)						
	BS	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS
Non-solarization (conventional control)	29	30.3	34	35.7	36.2	37.1	39.3
Solarization (cultural control)	29	33.7	38.3	43	45.3	47.7	50.4

BS = before solarization, WAS = weeks after solarization

Table 3. *Meloidogyne* spp. population in the soil extracts of different cultivation practices of potatoes, Lembang, West Java, December 2006.

Treatment	*Meloidogyne* spp. counts in 100 ml soil extract						
	Before subsoiling	After subsoiling-before solarization	After solarization	Before planting	30 days after planting	60 days after planting	Harvesting
Pest management strategies							
Conventional control	106.67a	84.00a	116.00a	98.67a	134.00a	150.67a	166.67a
Cultural control	106.67a	74.67a	29.33b	14.67b	36.67b	52.00b	62.67b
Potato cultivars							
No. 095 (Herta x FLS-17)	80.00a	83.33a	66.67a	56.67a	83.33a	86.67c	103.33b
720050/Kikondo	110.0a	93.33a	90.00a	60.00a	86.67a	90.00bc	100.00b
676068/I.1085	80.00a	83.33a	76.67a	63.33a	90.00a	110.00ab	120.00b
Granola	76.67a	73.33a	66.67a	53.33a	88.33a	130.00a	150.00a
Atlantic	76.67a	63.33a	63.33a	50.00a	78.33a	90.00bc	100.00b

Means in the same column followed by the same letters are not significantly different at 5% DMRT.

samples during growing season was high. This result agreed with Thomas (1994), Choudhary *et al*. (2006), and Sarmai and Pandeyz (2009) who reported that carbofuran did not control nematode under field conditions; therefore its application may pose ecological problems (Li *et al*. 2008).

Number of *Meloidogyne* spp. extracted from the soils of potato cultivar plots ranged from 521.66 to 638.33 larvae, significantly higher than that in the cultural control plots (376.68 larvae), but lower than that of the conventional control plots (856.68 larvae) (Fig. 1). It means that the cultural control practices alone were able to suppress the build-up of *Meloidogyne* spp. in the soil, and further reduction was achieved when the cultural practices were combined with resistant potato cultivars.

Effect of Treatments on Thrips

In both the cultural and conventional control treatments, thrips population was steady below the action threshold until 35 DAP. However, the thrips population increased significantly above the action threshold (20-25 thrips per leaf) at 42 days onwards in the conventional control treatment (Fig. 2). As the consequent, imidacloprid insecticide was sprayed every week until the potato crops were harvested. Total insecticide

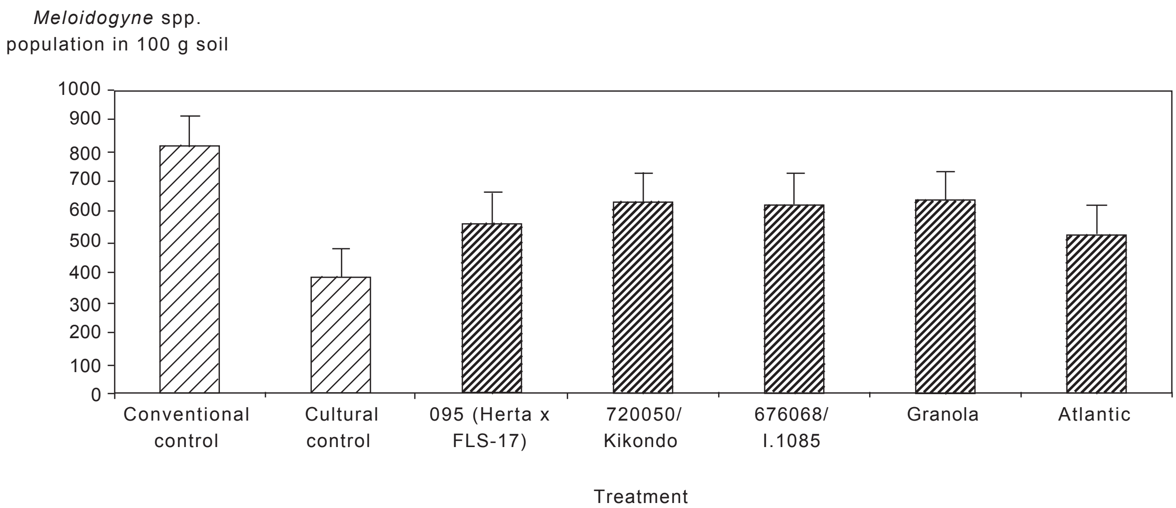

Fig. 1. Total population of *Meloidogyne* spp. in soil during potato growing season, Lembang, West Java, December 2006.

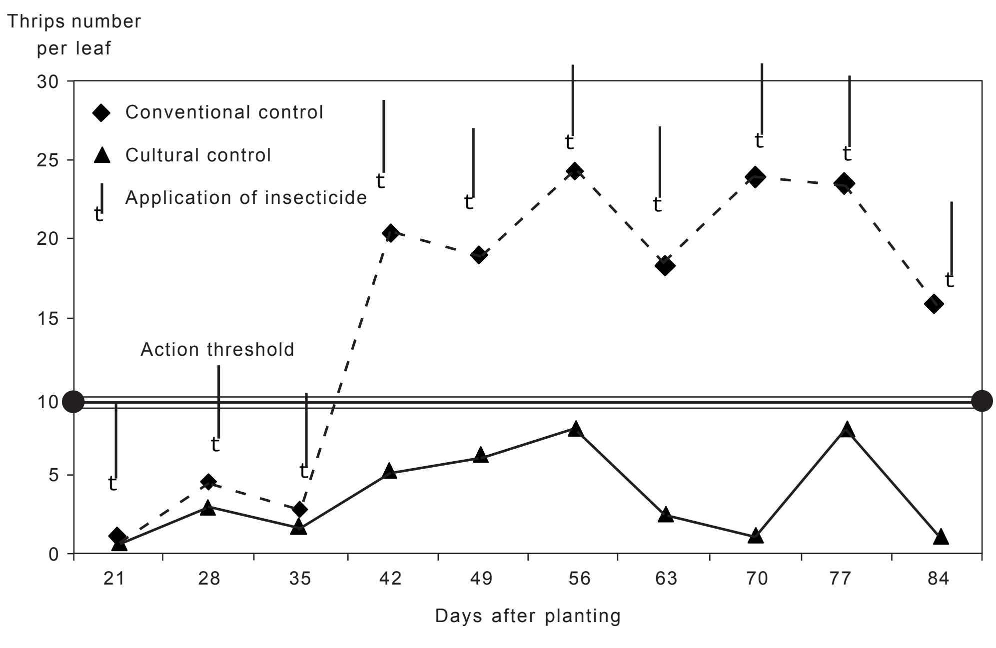

Fig. 2. Population fluctuations of *Thrips palmi* on potato during the growing season, Lembang, West Java, December 2006.

sprayings were 10 times equal to 15 l ha^{-1}. On the contrary, the thrips population on the cultural control treatments remained below the action threshold; therefore, no single insecticide application is necessary.

The possible reason for the ineffectiveness of imidacloprid in reducing thrips population is that only the nymphs and adults were being killed, whereas the eggs and pupae remained inside the plant tissues would not been killed (Etienne *et al.* 1990). Furthermore, the thrips may become resistant to imidacloprid because this insecticide has been used solely for many years for controlling the thrips on potato.

The study showed that the subsoiling and solarization treatments successfully cut off the life cycle of the thrips, and any survived thrips were then trapped by marigold plants intercropped with potato. Hooper and Pickett (1999) noticed that marigold contains chemicals such as linalool oxide (pyran) benzaldehyde, (±)-linalool, phenylacetaldehyde and (S)-(-)-limonene as attractant to the thrips. Our results suggest that cultivation of marigold as a trap crop on potato crop suppresses thrips population significantly; therefore, its application in the IPM program is justified.

Our experiment showed that *T. palmi* populations did not significantly differ among potato cultivars tested; and its population remained low (20-40 thrips per leaf) similar with that found in the cultural control plots (40 thrips per leaf) which was significantly lower than that of the conventional control plots (150 thrips per leaf).

T. palmi populations did not significantly differ among several potato cultivars tested (Fig. 3). This means that the contribution of resistant cultivars to the reduction of thrips population was significant. The reason for the lowest level of *T. palmi* infestation on the potato cultivars tested could be caused by antixenosis or antibiosis mechanism of plant resistance (Panda and Khush 1995). The resistant potato cultivars are possibly non-preferred for feeding and oviposition of the thrips, therefore, larval survival was low and life span of the adult was shorter. Resistant cultivars had an adverse effect on fecundity and oviposition rate of the thrips (Nugaliyadde and Heinrichs 1984; Brodbeck *et al*. 2001; Koschier and Sedy 2002).

Cultural control significantly reduced thrips population as shown at 49, 70 and 84 DAP. Analysis of variance showed that mean thrips number per leaf was significantly different between potato cultivars tested in the cultural and the conventional control treatments. It means that combined applications of cultural control and potato cultivars resulted in a significant reduction of thrips population. The five potato cultivars responded to the pest management practices. Number of thrips in the new potato cultivars was lower than that on control varieties Granola and Atlantic (Table 4).

Thrips number and thrip damage were positively correlated. Thrips damage did not significantly differ among potato cultivars tested at 84 DAP (Table 5). However, in the conventional control, the thrips damage was higher than that on the cultural control, and thrips damage on the cultural control was almost the same as that on the potato cultivars. It means that cultural control and potato cultivars in combination significantly affected thrips damage.

Yield Assessment

Potato yield from the conventional control treatment was significantly lower (54.94 kg plot^{-1}) than that of the cultural control treatment (58.51 kg plot^{-1}) (Table 6). However, its estimated yield per hectare was only slightly different, i.e. 22.89 t ha^{-1} for the conventional

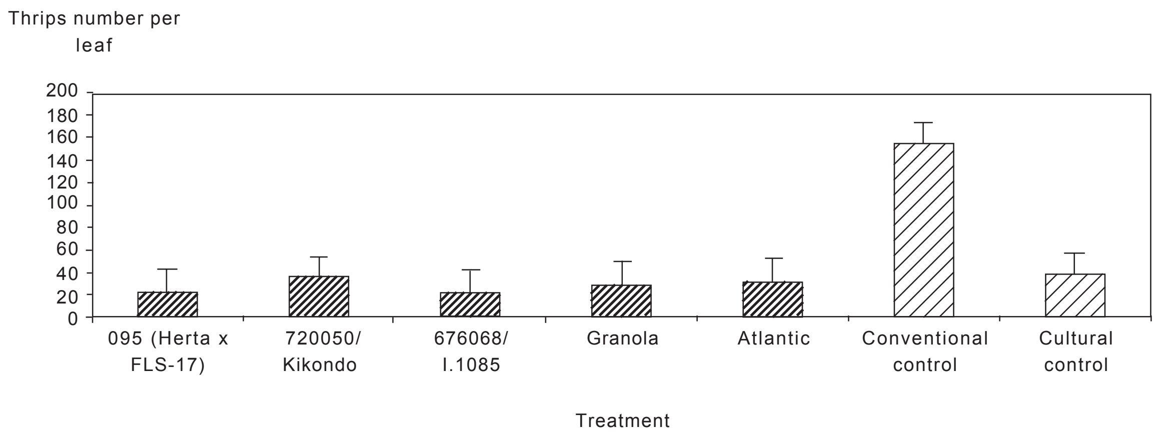

Fig 3. Total population of *Thrips palmi* on different potato cultivars, Lembang, West Java, December 2006.

Table 4. Interaction between pest management strategies and potato cultivars against *Thrips palmi* at 49, 70 and 84 DAP, Lembang, West Java, December 2006.

Pest management strategies	Potato cultivars				
	No. 095 (Herta x FLS-17)	720050/Kikondo	676068/I.1085	Granola	Atlantic
49 DAP					
Conventional control	1.17c	1.0c	1.07c	1.57b	2.03a
	A	A	A	A	A
Cultural control	0. 23ab	0.30ab	0.30ab	0.53a	0.37ab
	B	B	B	B	B
70 DAP					
Conventional control	0.93bc	1.27b	0.60c	1.30b	2.03a
	A	A	A	A	A
Cultural control	0.17a	0.17a	0.10a	0.17a	0.23a
	B	B	B	B	B
84 DAP					
Conventional control	2.67cd	4.00a	2.47d	3.47ab	3.27bc
	A	A	A	A	A
Cultural control	0.23a	0.30a	0.33a	0.30a	0.30a
	B	B	B	B	B

DAP = days after planting

Means followed by the same small letters are not significantly different horizontally at 5% DMRT while means followed by the same capital letters are not significantly different vertically at 5% DMRT.

Table 5. Interaction between pest management strategies and potato cultivars on plant damage due to *Thrips palmi* at 84 days after planting, Lembang, West Java, December 2006.

Pest management strategies	Cultivars				
	No. 095 (Herta x FLS-17)	720050/Kikondo	676068/I.1085	Granola	Atlantic
Conventional control	13.33bc	15.56b	12.22c	18.15a	14.44bc
	A	A	A	A	A
Cultural control	9.63a	8.52a	8.89a	10.71a	10.00a
	B	B	B	B	B

Means followed by the same small letters are not significantly different horizontally at 5% DMRT, while means followed by the same capital letters are not significantly different vertically at 5% DMRT.

control treatment vs. 24.38 t ha^{-1} for the cultural control treatment. These results demonstrated that suppression of the *Meloidogyne* spp. infections is important in increasing potato yield as also confirmed previously by Bélair *et al*. (2005). The study also indicated that tuber yields of a new unreleased potato cultivar, i.e. No. 095 (Herta x FLS-17) was significantly higher (31.01 t ha^{-1}) than that of the standard varieties (Granola and Atlantic), which could be the generation of potato variety.

In general, our study demonstrated that application of cultural control practices such as subsoiling, solarization, trap crop, and resistant cultivar reduced populations of *Meloidogyne* spp. and *T. palmy* below the action threshold therefore omit the use of synthetic insecticide application and increased potato yield (Fig. 4).

Table 6. Tuber yields of five potato cultivars treated with pest management, Lembang, West Java, December 2006.

Treatment	Percentage of tuber infested by nematode	Fresh tuber weight	
		kg plot^{-1}	t ha^{-1}
Pest management strategies			
Conventional control	5.90a	54.94b	22.89
Cultural control	2.28b	58.51a	24.38
Potato cultivars			
095 (Herta x FLS-17)	2.21c	74.42c	31.01
720050/Kikondo	3.87abc	43.98a	18.33
676068/I.1085	4.94ab	55.95b	23.31
Granola	6.28a	54.81b	22.84
Atlantic	3.14bc	56.78b	23.66

Means in the same column followed by the same letters are not significantly different at 5% DMRT.

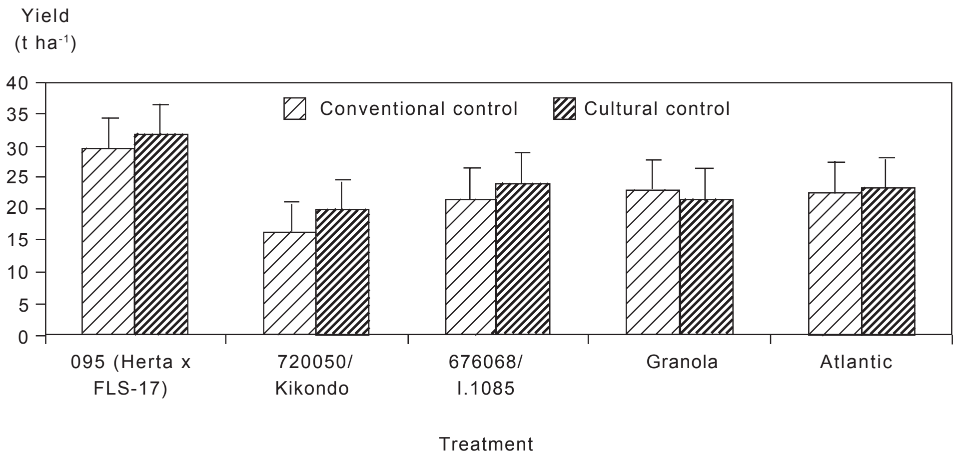

Fig. 4. Combining effect of cultural practices and potato cultivars on yield, Lembang, West Java, December 2006.

CONCLUSION

The cultural practices, i.e. subsoiling, soil solarization, and trap crop using marigold reduced the number of *Meloidogyne* spp. in the soil. Combined applications of cultural control and resistant potato cultivars further improved the nematode control. Thrips population in the cultural control treatments remained below the action threshold (10.0 nymphs per leaf), therefore no single application of synthetic insecticide was required. In contrast, thrips population in the conventional control treatment was above the action threshold, therefore insecticide was sprayed every week for 10 times until harvest, which was equally at 15 1 ha^{-1}. Application of the cultural practices cut off the life cycle of thrips and any survive thrips were trapped on the marigold intercropped with potato crops. Thrips populations in potato cultivar No. 095 (Herta x FLS-17) was the lowest amongst other five cultivars tested, and its yield was also the highest (31.01 t ha^{-1}). The use of cultural control practices in combination with resistant cultivars is therefore recommended as an integrated pest management system in controlling nematode and thrips on potato crops.

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