Potato Tuber Moth, *Phthorimaea operculella* (Zeller) Management using Selected Cultural Practices in West Shewa Zone, Ethiopia

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ABSTRACT

Potato Tuber Moth, *Phthorimaea operculella* amongst the insect pest of potato (*Solanum tuberosum* L.) is the major production constraints in Ethiopia which causes damage both under field and storage conditions and results economic lose. So that, this experiment was conducted to evaluate the effect of phonological stages of potato vine clearing and times of tuber harvesting on PTM infestation using RCBD factorial experiment with three replications. Results indicates that, during the pre vine clearing monitoring period, the larvae and damages on the potato leaves showed significant increase from the initial monitoring to the start of vine clearing made at vine senescence period. Furthermore, number of larvae, damaged tuber and galleries created by the mining of PTM larvae in tubers were also significantly increased from senescence period to the complete death of vines. On the other hand, comparing harvesting practices at vine clearing periods revealed that, the highest number of larvae and damage in tuber were recorded on harvests taken after 45 days. It can be concluded that, using vine clearing at completely yellow stage and harvesting after 15 days of vine clearing is recommended to reduce the effect of PTM infestation of tubers in the soil.

Keywords: Potato Tuber Moth, *Phthorimaea operculella*, Vine Clearing Stage, Carved Galleries..

INTRODUCTION

Among the major insect pests were identified in Ethiopia by Bayeh and Tadesse (1992) Potato Tuber Moth (*Phthorimaea operculella*) (Zeller), (Lepidoptera: Gelechiidae) is the most economic important pest of potato and caused damage both under field and storage (Herman *et al*., 2005). A study conducted at Alemaya, Eastern of Ethiopia in potato growing areas in 2001 revealed that, over 42% of potato tubers were infested by Potato Tuber Moth (PTM) and on the average, 8.7% of the potato tubers were lost due to field infestation by PTM. Field infested tubers are primary source of infestation in storage and later on in the field and the most critical period in the dynamics of PTM damaged lies between the tuber setting and harvest, exposure of tuber during this period is known to increase PTM infestation elsewhere (CIP, 1988).

To reduce field damage and further infestation in storage, minimization of practices that increase exposure of tubers from one place to another, use of different management methods that are economical and selected appropriately suitable to the environment, as well as which does not have significant adverse effect on non target organisms are strongly recommended (Sileshi and Teriessa, 2001).

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PTM infestation and damaging of potato had been controlled using insecticides for the past years and has rapidly developed resistance to a wide variety of insecticides. Hence, effective controlling foliage attack with current insecticides have not prevented occurrence of high level of tuber infestation (Clough *et al*., 2008). In Ethiopia, there are a limited works done on management of PTM infestation in the field through cultural practices.

Therefore, the objective of this study is to evaluate the effect of phonological stages of potato vine clearing and times of tuber harvesting in reducing PTM infestation.

MATERIALS AND METHODS

Study Area

The experiment was conducted during 2011 to 2012 under irrigation condition at Ambo University research farm in Gudar. Distance from Addis Ababa about 125km and 12km from the Ambo town to the west. The site is located an altitude of 2396 m.a.s.l. with average annual temperature and rainfall of 19.5^{o}c and 900 mm respectively (Agricultural Office, 2002).

Vine Clearing Stage and Harvesting Time

Potato tubers were planted in 3.75m x2.4m plot size with three replications and recommended agronomic practices were followed. There were 4x3 factorial in the experiments (stage of vine clearing and time of tuber harvesting): four stages of vine clearing were corresponds with the start of vine senescence, when the vines turned completely yellow, when the vines started dying and when vines completely dead and three times of tuber harvesting were carried out on 15 day's interval (15, 30, 45 days). The vines turning completely yellow and harvesting after 15 days were used as standard cheeks. 60 days after planting monitoring was also carried out to see the trends developed due to PTM infestation on potato growing plants before the time of vine clearing practices were started and data's were collected for the damaged leaves in plants and PTM larvae presents in two weeks interval. Fifteen days after vines were cleared 50 potato tubers were randomly taken per plot and dissected to take presence and/or absence data of tuber infestation, larvae feeding in each tuber and number of galleries created on tubers, this were also repeated after 30 and 45 days of the vine clearing made. The data of yield per hectare at time of harvesting were also collected.

Statistical Analysis

Collected data were subjected to the analysis of variance (ANOVA) with JMP IN (2000) version: 5.1 and SAS (2002) version 9.00 program software. Before to run ANOVA the different parameters were checked for normality and required transformation using logarithmic methods. Data collected on damaged leave and numbers of larvae per plant counted on leaves were adjusted the percent reduction of population before to run ANOVA. Their differences among treatments were determined with a Tukey-kramer test at 5% probability level.

RESULTS

Monitoring of Pre-vine Clearing

Experimental Results on monitoring number of larvae and damaged leaves counted on potato plants in the field before the vine cleared at two weeks interval highly significant differences were observed between the monitoring times. In general the number of larvae recorded per plant was significantly different between the three pre vines clearing monitor done. Correspondingly the level of leaves damage caused by PTM on potato plants in plots assigned for the different treatments (vine clearing stage and harvesting time) were also significantly different between the three pre vine clearing monitoring done. The number of larvae and damaged leaves increased more or less when they goes from monitoring time one to three significantly (Figure 1).

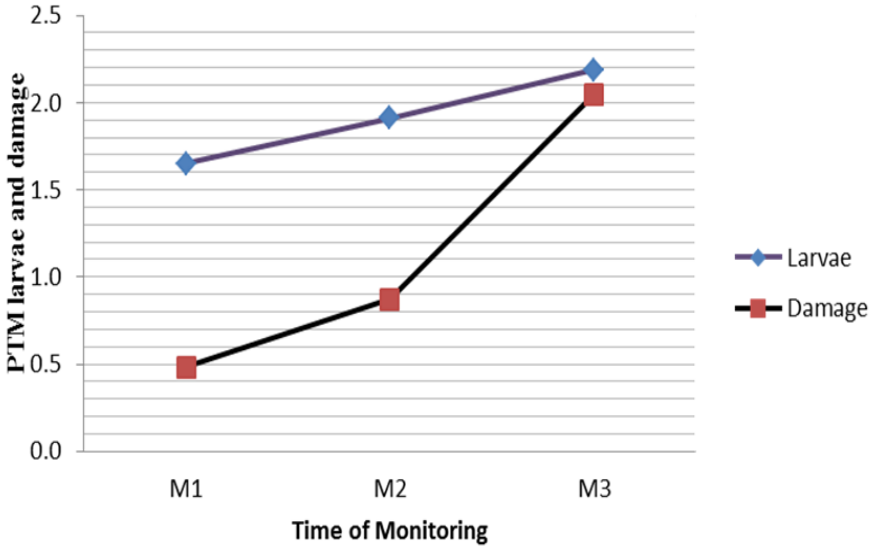

Figure1. PTM larvae and damaged leaves monitored before the treatments applied.

Effect of Vine Clearing on PTM Larvae, Damaged Levels and Carved Galleries in Tubers

During the vine clearing stage practices the significantly difference were observed between the treatments for the numbers of larvae counted on damaged tubers by PTM. The vine clearing at completely dead had the highest number of larvae in tubers was recorded than the other three stage of vine clearing significantly. In general the number of larvae was significantly increased as the vine clearing stage goes from at senescence to completely dead (Table 1).

The effect of vine clearing stage on percent damaged per tuber recorded by PTM was presented in Table 1. The main factor of vine clearing stage did affect percent damage tubers significantly. The highest percentage of tuber damaged was recorded in the last stage of vine clearing (at completely dead) and the lowest percentage was in first stage of vine clearing (at senescence). Therefore as vine stage increased from first to the forth, the damaged percent in tubers was also significantly in analogous (Table 1).

The data of carved galleries in tubers during the managing of PTM by four stage of vine clearing are summarized in Table 1. The number of galleries per tuber counted was significantly exaggerated by the vine clearing stage practice conducted. The vine clearing stage at senescence was highly significantly different by recorded of the lowest mean number of galleries than the other stage of vine clearing. The highest mean number of galleries created was recorded at vine clearing stage of completely dead (Table 1).

Effects of Vine clearing on Yield of Potato

The tuber yield harvested per hectare was significantly affected by the stage vine clearing. The maximum of yield (40 tone/ha) of tuber was recorded from vine clearing stage at senescence, but not significantly differ from the vine stage at completely yellow. The vine clearing stage at completely dead was gave the lower yield (28.9tone/ha) which was significantly lower than the first, second and the third stage vine clearing (Table 1).

Table 1. Effect of vine clearing stage against Potato Tuber Moth in potato tuber

Vine Clearing stage	Parameter (Mean±SE)			
	LPT	DT	GPT	YPH
Senescence	0.25±0.01[d]	29.7±[d]	0.3±0.04[d]	40.7±2.7[a]
Completely yellow	0.5±0.01[c]	33.6±[c]	1.07±0.05[c]	38.4±1.5[a]
Start dying	0.65±0.013[b]	29±1.7[b]	1.5±1.03[b]	33.4±0.9[b]
Completely dead	0.932±0.02[a]	47±[a]	1.9±0.063[a]	28.9±11[c]
F-ratio	219.3	50.6	54.56	55.8
P-value	<.0001	<.0001	<.0001	<.0001

* Means ± SE followed by the same letter (s) within column (lower case letter) are not significantly different from each other at P< 0.05. **LPT**= Number of larvae per Tuber, **DT**= Damaged tuber (%), GPT= Number of galleries per tuber, **YPH**=Yield per Hectare (tone),

Effects of Harvesting time on PTM larvae, Damaged levels and Carved Galleries in Tubers

The PTM larvae counted in tubers for the three level of harvesting time are presented in Table 2. There was highly significantly difference between the three levels of harvesting on number of larvae counted in tubers. The harvesting time after fifteen (15) days was significantly reduce the number of larvae over the time of harvesting after thirty (30) and forty five (45) days.

PTM damaged on potato tuber was recorded from each three level of harvesting time are presented in Table 2. Statistically significantly differences were observed between the three levels of harvesting time on percent damaged of tuber by PTM. The highest percent damage of tuber was recorded in harvesting time after 45 days and tuber damage was reduced as the harvesting time from 45 to 15 days.

The carved galleries created in tubers during the three harvesting time of tuber for the management of PTM are summarized in Table 2. There are significant differences were observed on number of galleries per tuber counted in three level of harvesting time there. The harvesting time after 15 days was highly significantly differ by recorded of the lowest mean number of galleries than the harvesting after 30 and 45 days (Table 2).

Effects of Harvesting time on Yield of Potato

There were significantly differences in potato tube yield per hectare at harvest between the three levels of harvesting time. The highest yield of potato tuber was harvested from the plot harvested after 15 days (44.5tone/ha) and the lowest yield tuber was after 45 days (21.2 tone/ha) of harvesting. In general as the harvesting time of tube was from 15 days to 45 days of harvesting the yield per hectare was decreased significantly (Table 2).

Table 2. Effect of harvesting time against Potato Tuber Moth in potato tuber

Harvesting time	Parameters (Mean±SE)			
	LPT	**DT**	**GPT**	**YPH**
Harvesting after-15 days	0.3±0.01^{c}	28.675±0.8^{c}	0.99±0.03^{c}	44.5±1.3^{a}
Harvesting after-30 days	0.4±0.01^{b}	36.5±1.5^{b}	1.06±0.05^{b}	34.7±1.3^{b}
Harvesting after-45 days	0.5±0.02^{a}	47.5±2.45^{a}	1.3±0.06^{a}	21.15±2.35^{c}
F-ratio	191.3	90.56	90.05	309.9
P-value	<.0001	<.0001	<.0001	<.0001

* Means ± SE followed by the same letter (s) within column (lower case letter) are not significantly different from each other at P< 0.05. **LPT**= Number of larvae per Tuber, **DT**= Damaged tuber (%), GPT= Number of galleries per tuber, **YPH**=Yield per Hectare (tone),

During harvesting of tubers in the plot of field applied the cultural practice of vine clearing and time of harvesting, the damage of symptoms created on tubers by PTM infestation for the delayed of vine clearing and delayed time of harvesting can be observed severe damage (Fig. 2).

Figure 2. PTM damage and galleries created on tubers.

Effect of Vine Clearing by Harvesting Time on PTM Larvae, Damaged levels, Carved Galleries in Tuber

The interaction of vine clearing stage by harvesting time for PTM larvae in tubers, damaged tubers, galleries carved created and yield of tuber harvested are shown in Table 3. The number of larvae counted per tuber was affected significantly by the factorial interactions of vine clearing stage with harvesting time ($F_{6, 22} = 4.8$, P<.002). The numbers of larvae counted per tuber harvested after 15 days to vine clearing at senescence, start of dying and completely dead are significantly and by recording the lowest larvae per tuber (Table 3). The larvae counted after 15 and 30 days to the vines were cleared at the completely yellow were not significantly different from each other and significantly differ from harvesting after 45days. I general the number of larvae per tuber was increased when from first stage of vine to the fourth stage of vine clearing and when from the 15 to 45 days of harvesting in each combination of the treatments (Table 3).

The interaction of stage of vine clearing and time of tuber harvesting were significantly affect the percent damaged tubers by PTM ($F_{6, 22} = 22$, P<.002). The percent damaged tuber recorded when tubers were harvested 15 days after vines clearing were made at the senescence significantly different from the harvesting after 30 and 45 days. The vine clearing made when potato plants were completely yellow, start dying and

completely dead the damaged tuber percentage at harvesting after 30 days was not significantly different from harvesting after 15 days, but the harvesting after 45 days in recording the highest of percent damaged tuber significantly different from both lower of harvesting levels in each three vines cleared stage of at completely yellow, start dying and completely dead (Table 3).

Galleries counted in tubers harvested at 45 days after vine clearing done at the stage when they were at senescence were significantly different from harvesting after 30 and 45 days and the harvesting after 30 days was not significantly differ from 15 days. In the stage when vines clearing stage at completely yellow, started dying and completely dead, the harvesting after 15 days was significantly different from harvesting after 30 and 45 days by recording the lowest number of carved galleries per tuber, but the harvesting after 30 and 45 days was not significantly different on number carved galleries created on tubers.

Effect of Vine Clearing Stage by Harvesting Time on Yield of Potato

The yield of tuber per hectare were also affected by the factorial interaction of vine clearing stage with harvesting time ($F_{6, 22} = 61$, $P<.0005$). Yield harvested per hectare in vine clearing stage at senescence, completely yellow and at completely dead the yield of tuber harvested after 45 days was recorded the lowest yield when compared with harvesting after 15 and 30 days to the vine clearing, but after 15 and 30 days of harvesting the yield there were not significantly difference observed between each other in the corresponding to the vine stage at senescence, completely yellow and at completely dead. In vine clearing stage at start of dying the yield harvested per hectare was significantly lowest in the after 45 days than the after 15 and 30 days to vine clearing (Table 3).

Table 3. Vine clearing stages by harvesting time interaction on Potato Tuber Moth management

Vine clearing stage	Harvesting time	Parameter (Mean±SE)			
		LPT	**DT**	**GPT**	**YPH**
Senescence	H-15days	0.2±0.01^{c}	20±0.7^{c}	0.55±0.03^{c}	52± 3^{a}
	H-30days	0.25±0.01^{b}	29±1.3^{b}	0.6±0.03^{bc}	46±3^{a}
	H-45days	0.3±0.01^{a}	40±2.4^{a}	0.9±0.06^{a}	24±2.3^{b}
	F-ratio	44.6	32.7	18.7	26.6
	P-value	0.0003	0.0006	0.003	0.001
Completely yellow	H-15days	0.3±0.01^{b}	24.7±0.3^{c}	0.6±0.03^{b}	48.6± 0.7^{a}
	H-30days	0.3±0.01^{b}	32±0.3^{bc}	1±0.06^{a}	44±0.7^{a}
	H-45days	0.4±0.01^{a}	43.7±4.1^{a}	1.25±0.06^{a}	23.1±3.2^{b}
	F-ratio	63.7	15.9	45.1	46.8
	P-value	0.0004	0.004	0.0002	0.0002
Start dying	H-15days	0.3±0.01^{c}	32±2.4^{c}	0.7±0.03^{b}	40.5± 1^{a}
	H-30days	0.4±0.01^{b}	38.7±1.8^{bc}	1.1±0.1^{a}	39±1^{b}
	H-45days	0.5±0.02^{a}	48±0.9^{a}	1.3±0.06^{a}	20.8±0.8^{c}
	F-ratio	36.3	19.4	17.3	144.7

Vine clearing stage	Harvesting time	Parameter (Mean±SE)			
		LPT	**DT**	**GPT**	**YPH**
	P-value	<.0001	0.002	0.003	<.0001
Completely dead	H-15days	0.4±0.01^{c}	38±0.7^{c}	0. 9±0.03^{b}	36.9±0.5^{a}
	H-30days	0.5±0.0^{b}	45±2.9^{bc}	1.4±0.08^{a}	33±0.5^{a}
	H-45days	0.6±0.02^{a}	56.7±2.4^{a}	1.7±0.08^{a}	16.7±3.1^{b}
	F-ratio	74.8	18.5	28.1	30.1
	P-value	<.0001	0.002	0.0009	0.0007

* Means ± SE followed by the same letter (s) within column (lower case letter) are not significantly different from each other at P< 0.05. **LPT**= Number of larvae per Tuber, **DT**= Damaged tuber (%), GPT= Number of galleries per tuber, **YPH**=Yield per Hectare (tone),

Correlations

Number of larvae per tuber counted was highly significantly and positively correlated with percent damage of tuber and negatively correlated with yield per hectare. Percent damage of tuber also shows significant and negative correlation with yield per hectare (Table 4).

Table 4. Correlation among PTM damages, number of larvae and yield harvested per hectare

	LPT	**DT**	**YPH**
LPT	1.00	--	--
DT	0.95***	1.00	--
YPH	-0.85**	-0.8**	1.00

* **LPT** = Larvae per Tuber, **DT** =Percent of Damage Tuber, **YPH** = Yield per Hectare. * P ≤ 0.05, ** P ≤ 0.01, *** P≤0.001

DISCUSSIONS

In this study the monitoring of PTM, *P. operculella* larvae and damage caused on leaves infestation were conducted in field as pre vine clearing showed that number of larvae and leaves damage were significantly increased with time of monitoring increased to until the vine clearing practices at the vine of senescence in the all stages of vine clearing and time of harvesting. Shelton and Wyman (1979) also reported that on time of tuber infestation, foliar larval populations, and tuber damage by monitoring the PTM, which was found to increase substantially prior to vine senescence and most tuber damage occurred after the vines senesced. They also showed that larval counts in the foliage were significantly correlated with tuber damage, but if vines were killed before complete senescence and tubers were harvested soon thereafter, tuber infestation would be reduced.

Number of larvae presents in tubers, damage level of tubers and number of carved galleries during harvesting period showed that as the vine clearing stage from the senescence to vines completely dead; larvae, damaged tuber and galleries were significantly increased. Number of larvae, percent damage of tuber and number of carved galleries were also increased when the tubers harvesting after 15 days of vine clearing to 45 days of harvesting after the vine was cleared. In Tunisia by (Fuglie *et al*., 1991) and by (Regev, 1989) demonstrated the importance of harvesting tubers in date in reducing PTM infestation in the field to a minimum but, two primary reasons may preclude farmers from completing their potato harvesting before the PTM begins to pose a substantial threat to the crop due to insufficient crop

maturity that results in potato skins not to be fully mature before harvesting may suffer from more skin damage, resulting in easier infection by fungal and bacterial pathogens and as well as improperly cured potatoes will have higher storage losses from transpiration and shrinkage. Similar studies of report also in Canada by Delanoy, *et al*., (2004) to describe the importance of vine killing in potato for production seed and time of harvesting after the vine was killed, vine killing is to reduce the risk of late season virus transmission by winged aphids, to stop tuber growth to obtain a desirable tuber size profile and promote skin set, prevent bruising and as well as developed skin resists damage during harvest, which reduces the potential for infection to enter the tuber causing rot. After the vines were killed harvesting should be after 10 to 14 days to achieve maximum resistance to bruising and skinning. But, the time or stage at which the vines were killed/ cleared not recommended from the previous studies. Based on the above discussion with previous finding on the purpose of vine killing and on the result of trial in the present studies the stage of vine clearing of potato plant in the field before harvesting and time of harvesting after the vine killed was recommended in the part recommendation.

This result was agreed with Hanafi (1999), Von Arx (1999) and by Shelton and Wyman (1979) who reported that the extent and time of damage to tubers were determined largely by time of harvest and, thus, foliage larval populations and pheromone trap counts would also not always give an accurate prediction of tuber damage.

SUMMARY AND CONCLUSIONS

PTM, *P. operculella* is a major threat to potato production worldwide as well as in Ethiopia because of its close relationship with its host, high adaptability of *P. operculella* has become a major pest of seed potatoes either in the field or in storage. Therefore, it is important to find ways to manage PTM better by minimizing economic losses, by reducing harm to the environment or people working with the crop.

In this study the management of PTM experiments conducted in field was the effect of stage of vine clearing and time of harvesting on PTM infestation and damage in tubers. These studies also showed that it is possible to minimize the damage of potato tuber by PTM in the field.

The vine clearing stages have an effect on *P. operculella* infestation, vine clearing at senescence greatly reduced the infestation on tubers in soil than the other stages. The time of harvest at 15 days and the vine clearing at senescence in separate as well as in combination significantly reduced the tuber infestation but, those treatment on the tuber skin of potato was not well structured and allowed to by pest damage further in storage. Vine clearing at completely yellow and harvesting after 15 days of vine clearing were recommended for reducing PTM infestation and improves tuber skins structure or hardiness which also reduces or tolerates pest damage during storage.

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مكافحة عثّة درنات البطاطا *Phthorimaea operculella (Zeller)* (حرشفية الأجنحة: Gelectidae) باستعمال ممارسات زراعية مختارة في منطقة غرب شيوا، إثيوبيا

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ملخص

عثة درنات البطاطا *Phthorimaea operculella (Zeller)* (حرشفية الأجنحة: Gelectidae) (PTM) هي من ضمن الآفات لمحصول البطاطا (*Solanum tuberosum* L.) وتعدُّ عائقاً رئيساً يُسبب أضراراً في الحقل وفي ظروف التخزين وينتج عنها خسائر اقتصادية. تم القيام بهذه الدراسة لتقييم مراحل العمر التتابعي لنبات البطاطا ووقت الحصاد على العدوى بحشرة (PTM) وذلك باستعمال التصميم الكامل العشوائي في ثلاث مكررات، أظهرت النتائج أنه خلال فترة ما قبل ظهور النبات فإن اليرقات والضرر على الأوراق أظهر زيادة معنوية عن التقييم الأولي لفترة نهاية عمر النبات، إضافة إلى ذلك فإن عدد اليرقات والدرنات المصابة والأنفاق المصنوعة من يرقات العثة في الدرنات ازدادت معنوياً مع قرب نهاية المحصول إلى الموت الكامل للنبات. وفي المقابل، بمقارنة ممارسات الحصاد عند ظهور النبات كشفت أن العدد الأعلى من اليرقات وإصابة الدرنات تم تسجيلها للمحصول بعد (45) يوماً من الحصاد، وبناء عليه، فإنه يمكن الاستنتاج أنه بإزالة المحصول عند الاصفرار الكامل ثم الحصاد بعد (15) يوماً من قلع النبات يوصى به للإقلال من تأثير إصابة الدرنات بالعثة في التربة.

الكلمات الدالة:*Phthorimaea operculella* ، العمر التتابعي، الأنفاق المحفورة، مكافحة، إثيوبيا.

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