

Efficacy of Conventional, Immune-Botanical and Egg Yolk Mixture on the Management of Diseases and Insect Pests of Tomato *Solanum lycopersicum* L. in Uganda

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Abstract

Vegetables are important for nutrition and health, however, production in sub-Saharan Africa is low, partly due to disease and pest damage. Three integrated pest management (IPM) packages: Conventional, Immune-Botanical and Egg yolk mixture were evaluated for control of tomato diseases and insect pests. During 2017A and 2017B seasons, there were no significant differences in severity of Bacterial wilt (*Xanthomonas campestris* pv. *solanacearum*), bacterial spot (*Xanthomonas campestris* pv. *Vesicatoria*), early blight (*Alternaria solani*), late blight (*Phytophthora infestans*) and Tomato yellow leaf curl virus disease (TYLCV) as influenced by the interactive effect of differences in variety and IPM package. Plots treated with conventional package had lower severity scores for TYLCV. Variety MT 56 and Pink-top were the best performers. There were significant differences in insect pest damage due to cutworms and Thrips in 2017A, and Aphids and Thrips in 2017B due to differences in variety and IPM package. Egg yolk significantly reduced thrips damage among different tomato varieties while conventional method significantly reduced aphid damage. Conventional package induced the highest fruit yield for MT 56 in 2017A and Pink-top in season 2017B. Both conventional and Egg yolk methods were cost effective and are therefore recommended for control of tomato insect pests and diseases.

Keywords: Diseases; Pesticides; Pests; Yield

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops cultivated worldwide [1]. However, productivity in sub Saharan Africa particularly Uganda is among the world's lowest. In Uganda, tomatoes are among the most important and prominent horticultural crops grown for both home consumption and the market [2]. About three million households in Uganda consume tomato in their sauce at every meal [3]. Recently, tomato production has been emphasized as a source of food security and income in Uganda [3]. It is a top priority for production, as the main income crop compared to other vegetables [4]. In Uganda, farmers harvest 1.5 to 14 t ha⁻¹ as compared to the world average of 27.5 t ha⁻¹ [5]. Production has intensified over the years with the introduction of high yielding varieties such as Asira F1 and Tengeru 2010; however, yields continue to be low due to several production constraints such as insect pests, diseases, and other environmental factors [6]. The major economically important insect pest species for tomato include whitefly (*Bemisia tabaci* Gennadius), leaf miners (*Liriomyza* sp.), thrips, (*Thrips tabaci* Lindeman), cotton aphids, (*Aphis gossypii* Glover), tomato fruit worm (*Helicoverpa armigera* Hubner. Major diseases include bacterial wilt (*Ralstonia solanacearum*), early blight (*Alternaria solani*), Bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*), Tomato yellow leaf curl virus and late blight (*Phytophthora infestans*) [6,7].

Tomato farmers in Uganda rely entirely on the use of pesticides to manage insect pests and diseases. However, the high susceptibility of

tomato cultivars to insect pests and diseases has caused farmers to obtain low yields in spite of the increased production cost [8]. According to Kagezi et al. [9], fresh tomato yield losses attributed to thrips are as high as 23.7% without the use of pesticides [10]. Even though insecticides have proven to be highly effective in protecting vegetable crops under extreme pressure from insect pests [11], the indiscriminate and widespread use of synthetic insecticides in vegetable cultivation usually results in development of insecticide resistance [12]. On the other hand, it has been established that farmers' limited knowledge on the appropriateness of pesticides to use, timely application, and the quantity to apply have led to low yield and undesirable accumulation of pesticides in food. Some pesticides are hormone disruptors, cancer-causing agents or neurotoxins that can have harmful effects on the brain and on the growth and development of babies. Little is known about how these pesticides, which we can't smell, see or taste on our produce, act in combination. Alternative earth-friendly solutions such as cooking oil+egg yolk mixture is urgently needed. Because of the critical role they play in vegetable production, there is a need to evaluate some of the most common pesticides used by farmers as well as test new ones on the market, together with non-harmful concoctions. This will generate useful information for effective management of diseases and insect pests for increased yield of tomato in Uganda.

The objectives of this study were to (i) determine the efficacy of three Integrated pest management (IPM) packages i.e., Conventional (Cypermethrin+Mancozeb), Immune-Botanical (Nimbecidine +Bacterimycin) and Egg yolk mixture (Egg yolk+Sunflower cooking

oil) against diseases and insect pests of tomato, and (ii) determine the effects of these IPM packages on the yield of tomato.

Materials and Methods

The study was conducted at the Horticulture and Oil palm program of the National Crops Resources Research Institute located at Namulonge, Wakiso district, 19 km north of Kampala. Mean daily temperatures were 28.5°C maximum, and 13.0°C minimum. Namulonge lies at an altitude of 1150 meters above sea level, with a bimodal rainfall (1196 mm annually) (Table 1) and red sandy clay loam soils of pH 4.9-5.0. The first study lasted from March to June 2017 (2017A) and a second season (2017B) from September to December 2017.

Season 2017A				Season 2017B			
Months	Rainfall (mm)	Temperature (°C)		Months	Rainfall (mm)	Temperature (°C)	
		Min	Max			Min	Max
March	93.3	16.3	29.6	September	200.7	17.7	27.5
April	160.3	17.4	28.9	October	83.8	18.5	28.4
May	64.3	17.2	27.7	November	206.4	17.9	28
June	2.9	16.8	28.9	December	12.9	17	30

Table 1: Mean annual rainfall and temperature at Namulonge during seasons 2017A and 2017B.

Field layout

Four tomato varieties were used for this trial namely: MT 56, Pink-top, Tengeru 97 and Ten-ten. Pink-top and Ten-ten are introductions from South Korea; Tengeru 97 was obtained from the local market but bred by world vegetable center (AVRDC). Variety MT56 was developed by Makerere University (Uganda) and Iowa State University (USA). These varieties were chosen because of their high tolerance to major pests and diseases of tomato in Uganda as confirmed from an adaptability study done earlier.

The seeds were nursed, and seedlings transplanted at a spacing of 0.9 m × 0.35 m on ridges 30 cm high. There were two rows of 18 plants in each treatment plot. The experimental field was laid in a randomized complete block design with two factors (Variety and IPM package) in three blocks. Each treatment plot measured 3 m × 3 m, with 0.6 m alley between treatment plot and 1.5 m alley between blocks. Fertilizer (200 g of poultry manure per planting hole) was applied once at planting. Weeds were controlled, and watering was done when necessary.

IPM treatments and their application

The treatments used were: (i) Conventional, containing a mixture of Cypermethrin-40 mL+Mancozeb-50 g per 20 liters of water, (ii) Immune-botanical: Nimbecidine-90 mL+Bacterimycin-10 g per 20 liters of water and (iii) Egg Yolk mixture: 1 local chicken Egg Yolk +Sunflower cooking oil-60 mL per 20 liters of water. A control plot (water application only) was also maintained. Application of treatments was done using separate knapsack sprayers (CP 20) at

weekly intervals, starting four weeks after transplanting, and continued up to end of harvesting.

Disease severity and Insect pest's damage assessment

A sampling of insect pests began four weeks after transplanting before treatments were applied. Among the 18 plants within each plot, ten were randomly selected and tagged for subsequent sampling and assessment of damage and disease severity. Pest damage assessment was done as according to Nagrare et al. [13] for Aphids, Lopez et al. [14] for leaf miners [15] for thrips, Bardner and Fletcher [16] for cutworms and, whiteflies damage. Disease assessment was as according to different scale: bacterial wilt [17] and bacterial spot [18], early blight [19], late blight [20] and Tomato yellow leaf curl virus disease [21].

Estimation of fruit yield

Yield (fruit weight) was taken from the ten tagged plants. Tomato fruits were harvested every three or four days when they reached maturity and then weighed in the field using a Switzerland-made Metler Toledo PB302 electronic weighing scale. The cumulative results obtained for each treatment were then extrapolated to kilograms per hectare (kg ha⁻¹). This yield was referred to as harvest yield. Furthermore, the fruits collected were divided into marketable and non-marketable (fruits with blemishes or injuries caused by insect and pathogen) yield.

Data Analysis

Disease severity and insect pest damage data were entered in an excel sheet before subjecting it to Analysis of Variance (ANOVA) using Genstat statistical software 4th Edition (2012). Treatment means were separated using Tukey at 5% probability.

Results

Diseases in season 1 2017A and season 2 2017B

For season 2017A, no significant differences ($P>0.05$) in the interactive effect of variety and treatment on the severity of Bacterial wilt, Early blight, Late blight, bacterial spot, and Tomato yellow leaf curl virus disease among the different varieties was observed. Significant difference ($P<0.05$) was observed in the severity of TYLCV among the treated plots. The control performed better than the other treatments with lower severity scores for TYLCV (Figure 1). Tomato variety MT 56 was the best performer with no disease at all (Table 2). In season 2017B, the interactive effect of variety and treatment followed a similar trend as in season 2017A.

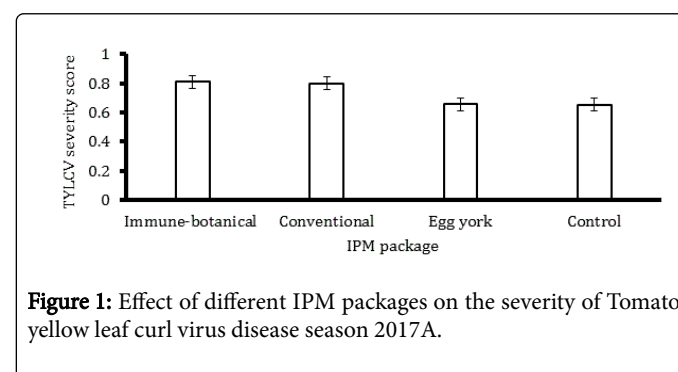


Figure 1: Effect of different IPM packages on the severity of Tomato yellow leaf curl virus disease season 2017A.

Season 2017A	Bacterial Wilt	Bacterial Spot	Early Blight	Late Blight	TYL CV
MT 56	0.00b	0.00c	0.00c	0.00d	0.00c
PINK-TOP	1.28a	2.04a	2.22a	2.06b	0.93b
TENGERU 97	0.93a	1.95a	2.08a	2.37a	1.08a
TEN-TEN	1.46a	1.41b	1.55b	1.40c	0.90b
Season 2017B					
MT 56	1.01b	1.37a	2.41a	1.32a	1.02a
PINK-TOP	1.30ab	1.27a	2.26a	1.21a	0.98b
TENGERU 97	1.02b	1.32a	2.38a	1.30a	1.06a
TEN-TEN	1.46a	1.25a	2.04b	1.26a	0.99b

Table 2: Mean severities score for the different diseases as expressed by different tomato under season 2017A and 2017B. Means followed by different letters are significantly different and means followed by a similar letter are not significantly different (P=0.05).

Insect pests damage in seasons 2017A and 2017B

There were no significant differences ($P>0.05$) observed for in the interactive effect of variety and treatment except for the level of damage caused by cutworms and thrips (Table 3). Egg yolk mixture induced lower cutworm damage among the different varieties (Figure 2).

Tomato Pests	Aphids	Cutworms	Leaf Miner	Thrips	Whitefly
Variety	0.68	0.062	0.576	0.389	0.339
Treatment	0.317	0.152	0.622	<0.001	0.786
Variety*treatment	0.473	0.031	0.824	0.011	0.133

Table 3: Source of variation for the effect of different varieties and IPM package (Conventional, Immune-Botanical and Egg York mixture on lowering the level of damage caused by some of the major insect pests of tomato within season 2017A).

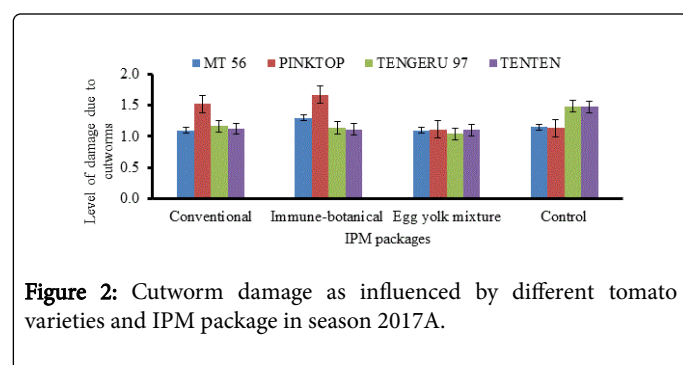


Figure 2: Cutworm damage as influenced by different tomato varieties and IPM package in season 2017A.

Ten-ten variety exhibited lower levels of thrip damage with the use of egg yolk mixture (Figure 3). Pest damage in season 2017B followed the same trend as in season 2017B except for damage caused by Aphids

which was found to be significantly different as influenced by the interactive effect of variety and IPM package. There was less pest damage on Pink-top variety and conventional package influence the greatest reduction in Aphid damage in season 2017B (Figure 4).

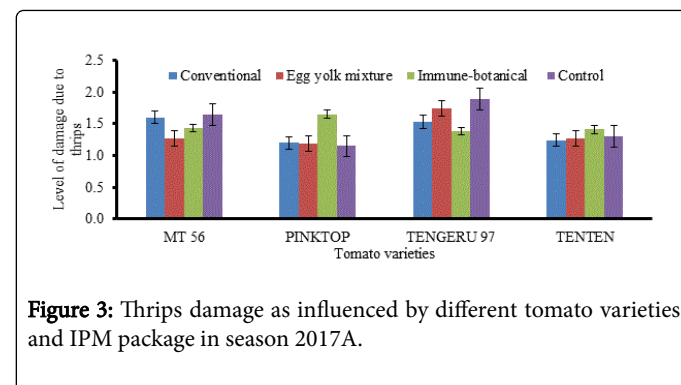


Figure 3: Thrips damage as influenced by different tomato varieties and IPM package in season 2017A.

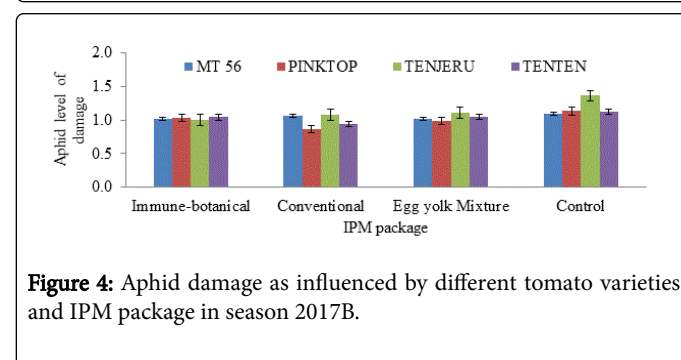


Figure 4: Aphid damage as influenced by different tomato varieties and IPM package in season 2017B.

Fruit yield as affected by various treatments in season 2017A and 2017B

The interactive effect of variety and treatment did not significantly ($P>0.05$) influence the total and marketable yield in season 2017A however conventional package influenced higher yields in 2017A among the different tomato varieties (Table 4).

Season 2017A	Immune-botanical	Convention al	Egg yolk	Contr ol
Total plant yield (Kg/ha)	19.5	28.6	20.2	18.3
Marketable weight (Kg/ha)	7.4	13.9	8.6	6.7
Season 2017B				
Total plant yield (Kg/ha)	2.4	3.1	2.2	1.6
Marketable weight (Kg/ha)	1.8	2.4	1.8	1.3

Table 4: Total plant yield (Kg/ha) and marketable yield (Kg/ha) for four different tomato varieties as affected by different IPM package in season 2017A and 2017B.

In the second season (2017B) there was a significant ($P<0.05$) interactive effect between variety and treatment for the total fruit yield. Plots treated with conventional package yield more than the rest while Pink-top was the best yielder under all treatment expects the control (Figure 5). The interactive effect of variety and treatment on

marketable yield was found not to be significant ($P>0.05$) however plots treated with conventional package had still higher marketable yield compared to the rest of the treatment (Table 4). Overall the yields in season 2017A were far higher than those obtained in season 2017B (Table 4).

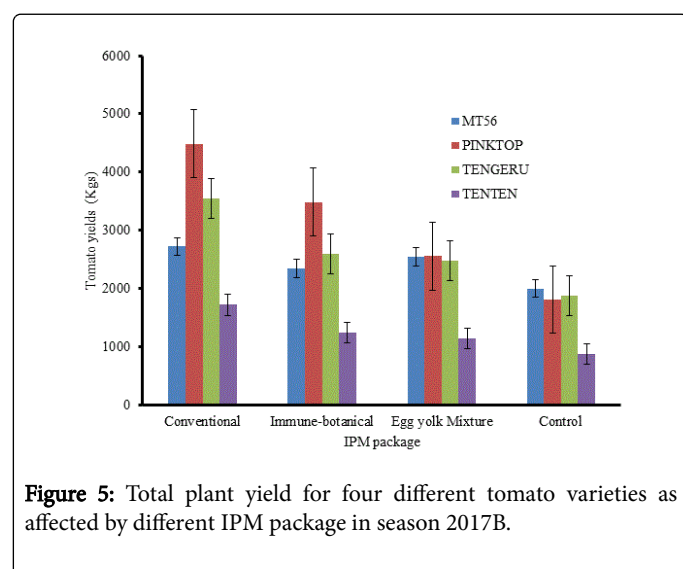


Figure 5: Total plant yield for four different tomato varieties as affected by different IPM package in season 2017B.

Cost estimations for pesticide usage

From the cost estimation of the amount of pesticides needed to spray a hectare, the cost for use of immune-botanical package was almost twice the cost of using conventional and egg yolk mixture (Table 5).

Treatment	Immune-Botanical	Conventional	Egg mixture yolk
Mixed together in a 20 liters Knapsack	Nimbecidine-90 mls+ Bacterimycin-10 gms	Cypermethrin-40 mls+ Mancozeb-50 gm	local egg yolk +60 mls of sunflower cooking oil
Application	Weekly		
Cost per ha per spray (\$)	38.7	22.6	24.7
Cost per season (\$) (6 times of spraying)	232.2	135.4	148.4
Exchange rate 1 \$=3650 Ushs			

Table 5: Cost of pesticides for the application for the different IPM package on a unit acreage.

Discussion

Tomato production in Uganda is an important enterprise most especially for the smallholder farmers. It has been shown that farmers choose different tomato varieties to grow depending on the production potential, market demand, regional adaptability, disease resistance and the end use of the fruits [22]. However, the major constraint they face is the crop pests and diseases which may require integrated pest and disease management options [23]. In Uganda, the majority of farmers rely on the use of pesticides to manage insect pests and diseases in

order to increase yield. However, the effectiveness of these pesticides depends on several factors namely their stability, physicochemical properties, the nature of the medium into which they are applied, the occurring organisms in the soil as well as the prevailing climatic conditions [24-26].

Generally, the severity scores of the different diseases observed within this trial were low. Bacterimycin, Mancozeb and egg yolk mixture were incorporated to control the diseases. There was no significant difference in between these treatments. Bacterimycin consists of binitro-dibromo propane 2-3 diol, an immune modulator that imparts resistance to plants against bacterial diseases such as canker in tomato and other vegetables. Furthermore, it was reported to inhibit the growth of *Verticillium lecanii* but accelerate the growth of *Trichoderma viride* [27]. Bacterimycin exhibits a unique mode of action which mimics the natural systemic activated resistance (SAR) response found in most plant species [28]. On the other hand, egg yolk destroys mycelia wall, distributes respiration and lipid metabolism of insects as well as repels insects and prevents fungal spore from germinating on the plant surface [29]. However, for this study, their effect on the insect pests was limited.

There was a significant difference in the level of damage caused by thrips among the treatments. The best treatment was conventional method containing Cypermethrin, a pyrethroid that has a greater knockdown effect and great photostability capability. Following in strengthen was Nimbecidine a neem-oil-based botanical insecticide containing *Azadirachtin* and other limonoids including Meliantriol, Salannin, Nimbin and a host of other terpenoids in the ratio as it occurs naturally in Neem. *Azadirachtin* has several effects on insect pests as it induces anti-feeding, regulates insect growth and causes sterility [30].

Due to seasonal variations, the effectiveness of the IPM packages varied significantly. In season 2017A there was less rain and temperatures were high. These climatic conditions enhanced the pest population and the severity of the different diseases in presence of the host plant since the pest population and inoculum build up was very fast [31]. However, the yield was not compromised since intensive watering was done. In the second season (2017B) there was enough rainfall in the month of September and November that favored the multiplication of pathogen spores thus more disease and insect damage on the plants resulting into lower yields as was the case observed by Aloysius et al. [32] in Ghana.

The different IPM packages significantly influenced the total yield among the different tomato varieties. Conventional package followed by egg yolk mixture influenced higher yields within MT56 and Pink-top varieties. Due to variation in climate within the two seasons, significant variation in yield was realized in the two seasons and this was attributed to changes in several climatic and soil factors: temperature, rainfall pattern humidity and soil fertility respectively [31,33].

Conclusion

The study showed that Bacterial wilt, *Xanthomonas campestris* pv *solanacearum*, Early blight, *Alternaria solani* Late blight, *Phytophthora infestans* and bacterial spot, *Xanthomonas campestris* pv. *vesicatoria* and Tomato yellow leaf curl virus disease were the major diseases, while aphids, *Aphis gossypii* (Glover), Whiteflies, *Bemisia tabaci* (Gennadius), thrips, *Thrips tabaci* Lindeman leaf miners, *Liriomyza* sp, and the tomato cutworm, *Agrotis* spp were the most important insect

pests observed to affect tomato in this study area (Namulonge). There was varying effect of the three IPM package on the severities of the different diseases found in tomato. None of the IPM packages had better control of the observed diseases. Tomato variety MT 56 was the best performer with almost no disease at all. Variety and IPM package significantly influenced the level of pest damage caused by cutworm and thrip damage. Egg yolk mixture had the greatest influence on reducing damage caused by tomato pests. MT 56 and Pink-top variety had the highest yield as well as the lowest level of damage by both pests and diseases. Conventional package influenced higher yields in among the different varieties. Variety difference has a significant influence on the level of damage and severity of disease expressed by the plant. From this study, we can conclusively recommend Egg yolk mixture for effective control of tomato insect pests and conventional method (Cypermethrin+Mancozeb) for managing tomato diseases. Both methods are cost effective as compared to the use of the immune-botanical package.

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