COMPARISON OF EFFICIENCY AND SELECTIVITY OF THREE BIO-INSECTICIDES FOR THE PROTECTION OF TOMATOES IN BURKINA FASO

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SUMMARY

The search for less toxic products and alternative methods is a need to elaborate integrated control strategies for growing tomatoes in Burkina Faso to reduce the dependence of farmers on pesticides. A trial was carried out in the village of Kouka, from December 2015 to March 2016, to assess the effectiveness and action spectrum of biopesticides on several key pests of tomato (*Solanum lycopersicum* L.) in Burkina Faso, namely two Lepidoptera caterpillars (*Helicoverpa armigera* (Hub.) and *Utetheisa pulchella* L.) and whiteflies (*Bemisia tabaci* (Genn.)). The effectiveness of the three products already sold in the country has been evaluated: BIO K 16 (1.5 kg/ha), H-N (3 L/ha) and PiOL (3 L/ha). In the aim to cover the spectrum of pests, and thus coming closer to Integrated Pest Management practical conditions, each biopesticide has been applied in association with abamectine, an insecticide-acaricide (ACARIUS 18 EC, 1 L/ha). In general, all treatments resulted in significant protection of the tomato fruit against caterpillars of moths, but had no effect on *Bemisia tabaci*. The combination *Bacillus thuringiensis*-abamectine has provided both the best protection of the fruits and the highest yield (19.6 T/ha). This combination could be recommended as part of IPM in tomato cultivation.

Key words: Tomato, biopesticides, *Bacillus thuringiensis*, *Helicoverpa armigera*, *Utetheisa pulchella.*

INTRODUCTION

In Burkina Faso, the tomato production is in second place after the onion. The production obtained during the 2011/2012 campaign was 185.700 tons (MAH, 2012). However, this production is still fragile because of strong pressure of pests (especially the caterpillars of moths) and some areas can no longer produce tomatoes in sufficiency (IFDC, 2007). To reach economically viable production levels, chemical pesticides are still the most used control method by the producers, sometimes with the use of non-recommended pesticides in vegetable products (such as cotton pesticides and obsolete pesticides) (Toé, 2010, Congo 2013; PAFASP, 2014).
Furthermore, we observe that for the vegetable productions in Burkina Faso, the doses used and the frequency of spraying exceed the recommendations (PAFASP, 2014). This intensive use of pesticides generates high exposure for the producer during application and for the consumers via pesticide residues in harvested products, the emergence of resistance and environmental contamination. To limit the impact of these pesticides on human health and the environment, the search for less toxic products and alternative methods is a priority in Burkina Faso. Therefore, it is necessary to develop integrated pest management (IPM) strategies, efficient and profitable, for the tomato cultivation in Burkina Faso to reduce farmers' dependence to pesticides when tomato is the most treated speculation in this country. To test some IPM

strategies, a trial was carried out to assess the efficacy and the spectrum of action of three biopesticides used in combination with a pesticide.

MATERIALS AND METHODS

Field trial

A field trial was carried out in the village of Kouka, from December 2015 to March 2016, to evaluate the efficiency and the spectrum of action of several biopesticides on the main pests of tomato (*Solanum lycopersicum* L.) in Burkina Faso: the caterpillars of two Lepidoptera (*Helicoverpa armigera* (Hub.) and *Utetheisa pulchella* L.) and whiteflies (*Bemisia tabaci* G.). To follow the apparition of the major pests on tomato, the yellow traps of van Moericke (Ø = 27 cm, h = 10 cm) have been used. This model is frequently used in entomology fauna of agricultural environments (Mignon *et al*., 2003). Traps were located in the untreated plots (T0).
The trial was set up at the vegetable production site of Lièkonon (N = 11°55' 09.2" W = 4°17' 26.3") approximately 8 km from the village of Kouka. The trial took place during the dry season (end of December 2015 to March 2016). The soil is a sandy clay type. The climate is of Sudanese type. During the trial, a thermo-hygrometer has been measured on site with an average temperature of 31.3 °C and an average relative humidity of 32%. The experimental plots were prepared by land clearing, plowing and flattening of boards.
The plant material used is the tomato cv. “Roma VF”, having a cycle from 120 to 160 days and a potential yield of 40 T/ha (FAO, 2008). This cultivar is one of the most popular in Burkina Faso, but it is very sensitive to attacks from carpophageous Lepidoptera like moths (FAO, 1999 cited by Gouba, 2002; FAO, 2008; RECA/Niger, 2014). Plants were produced in a nursery 25 days before transplanting (January 16, 2016).
The experimental design was in 4 Fisher blocks completely randomized, with 5 objects; each block was installed at a different producer. The size of elementary plots was 50 m². They were separated by bunds of 100 cm wide. Plants inside the plots were spaced at 40 cm x 80 cm. The 5 objects (4 repetitions by object) were: the control (T0: no treatment), the 3 biopesticides combined with an insecticide (T1: BIO K 16+ACARIUS 18 EC; T2: H-N+ACARIUS 18 EC; T3: PiOL+ACARIUS 18 EC) and the pesticide (insecticide-acaricide) used alone (T4: ACARIUS 18 EC).

Characteristics and origins of the products

The effectiveness of three “biopesticides” products already produced and/or marketed in Burkina Faso (BIO K 16, H-N and PiOL) was evaluated in comparison to a control (untreated plot) and a reference (plot treated with an insecticide-acaricide also available locally).
To control all pests, including mites, as well as to be closer to an integrated pest management strategy, each of these 3 biopesticides was used in association with ACARIUS 18 EC (1L/ha), an insecticide with 18 g of abamectin per liter. Abamectin is an active substance produced by fermentation from an actinomycetes fungus living in soil. It acts as an insecticide-acaricide by contact and ingestion and is recommended in IPM (iFlex, 2010) against biting and chewing pests. The characteristics of the commercial products are described in Table 1.

The spraying of these plant protection products was performed with 4 OSATU sprayers with a capacity of 1 L (one sprayer was used for each product).

Table 1. Names, origins and characteristics of the 3 biopesticides and the insecticide ACARIUS 18 EC used for the trial on tomatoes.

Commer-cial name	Firm	Composition	Formulation (code and dose/ha)	Area of use
BIOK 16	Pro-phyma	*Bt* var. Kurstaki: 2-4% (16.000 UI/mg)	Wettable powder (WP, 1,5 kg/ha)	Authorised against *Pieridae, Leaf miners, Noctuidae, Leafrollers and moths.*
H-N	Biopro-tect (Burkina Faso)	H-N essentially made of neem oil. Both a foliar fertilizer and a biological insecti-cide.	Liquid solution (SL, 3 L/ha)	Authorised against thrips, mites, the cotton bollworm, whitefly, leaf min-ers, aphids, etc.
PiOL	Biopro-tect (Burkina Faso)	Extracts of chilli, garlic and onion. Both repellent and cu-rative effect.	Liquid solution (SL, 3 L/ha)	Authorized against aphids, leaf-eat-ing caterpillars.
ACARIUS 18 EC	Pro-phyma	Abamectin (18g/l) Acts by contact and in-gestion.	Emulsifiable concentrate (EC, 1 L/ha)	Insecticide allowed against insects and mites on vegetables.

Dosage, periods and conditions of use of the plant protection products are shown in Table 2.

Table 2. Dosage, periods and conditions of use of the PPP in the trial

Commercial name	Dosage for 50m²	Volume of mixture sprayed	Interval between 2 treatments	Number of treatments
Bio K16	10 g	2 L	14 days	3
H-N	24 ml	2 L	14 days	3
PiOL	24 ml	2 L	14 days	3
ACARIUS 18 EC	4 ml	2 L	14 days	2

The first treatment was on November 02, or 26 days after transplanting. An interval of two weeks between the treatments (alternatively a biopesticide and ACARIUS 18 EC) was respected leading to 5 sprayings at the total on each plot.

Assessment of damage

On each plot, from the 15th day after transplanting, the population of *Helicoverpa armigera* caterpillars was evaluated on 10 randomly chosen plants. Since a larva can be found or perforate several fruits, they are eliminated to avoid any double counting. The interval between 2 observations, being 7 days, a correlation between the dynamic evolution of the insect and the product's protective activity was observed.
The number of fruits perforated by the caterpillars is also evaluated on the ten plants. To prevent data loss before harvest since the perforated fruit fall faster, they are collected for observation (for opening) and larval counting, and then destroyed after each observation.
At maturity, 24 fruits were randomly harvested, in each block and for each treatment. The average fruit weight was then determined to assess performance, and the number of healthy fruits or damaged ones by the larvae was recorded.

Attacked bodies and parts of plants with abnormalities (necrosis, burns, rots, etc.) that can be signs or symptoms of disease or phytotoxicity of products applied were also taken and analyzed at Plant Pathology Laboratory (“Clinique des Plantes”) of the “Institut du Développement Rural” (UPB/Burkina Faso) to determine the causal agent.

Statistical analysis of data

The collected data were entered using the Excel software and the analysis was executed with the IBM SPSS.22 software. The average number of larvae as well as the average number of fruit healthy or damaged by the caterpillars, were determined and subjected to an ANOVA analysis with one factor (Product X Pressure of the larvae). The Newman-Keuls test and Ducan test were associated to the previous analysis to gather objects whose effects are similar to the 5% (or 10%) threshold(s).

RESULTS

Health outcomes plots

For all producers, we observe that plots were damaged by pest attacks and various diseases. The whiteflies (over 50% of plots), Lepidoptera (*Helicoverpa armigera* and *Utetheisa pulchella*) and locusts were the most often seen pests in fields. *Fusarium oxysporum* and *Alternaria* (blight) were responsible of over 50% of the observed attacks (dryness of the plants' collets or even whole plants). This pressure of pests and diseases, representative of usual conditions in Burkina Faso, has strongly affected the development of plants and fruit production.

Pests collected in yellow traps

Three main pests (locusts, *Helicoverpa armigera* and *Utetheisa pulchella*), on top of whiteflies (*Bemisia tabaci*), were collected in the yellow traps. Figure 1 shows the evolution of insect populations collected in the untreated plots.

Locusts have reached their peak outbreak on the 19th day after transplanting before undergoing a decrease on the 47th day after transplanting. *Helicoverpa armigera* recorded its peak outbreak on the 40th day after transplanting with a total of four insects trapped. Regarding *Utetheisa pulchella*, two peaks were observed in the 26th and 40th day after transplanting, each time with 10 individuals observed in the traps.

Evolution of the caterpillar populations in untreated and treated plots

Figure 2 shows the evolution of Lepidoptera larvae populations (*Helicoverpa armigera* and *Utetheisa pulchella*) in treated plots compared with the control (T0).

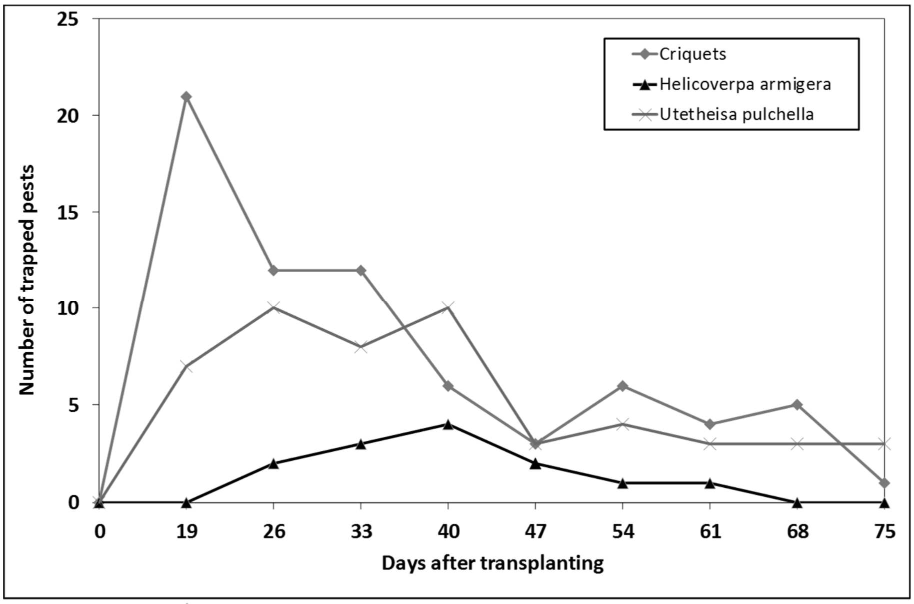

Figure 1: Evolution of pest populations on untreated plots

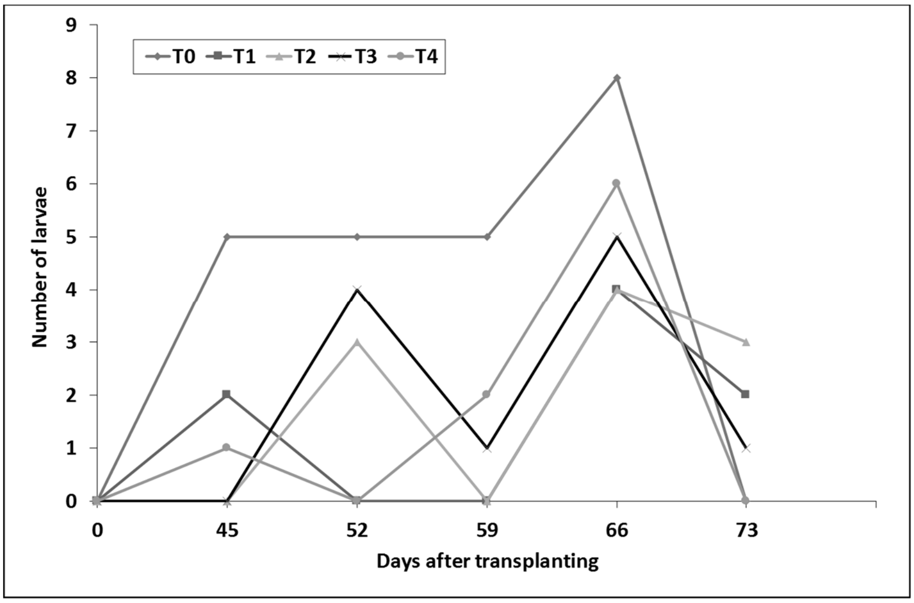

Figure 2: Evolution of caterpillar populations (T0 = control plots)

We observe two outbreak peaks in all treatments. In T0, T1 and T4 treatments, the first peak was reached on the 45th day after transplanting and the second on the 66th day. In T3 and T2 treatments, the outbreak peaks were reached on the 52nd day after transplanting and on the 66th day respectively.

Treatment effects on the caterpillar's population and on fruits protection

Figure 3 compares the average number of perforated fruits and the average of caterpillars collected by type of treatment.

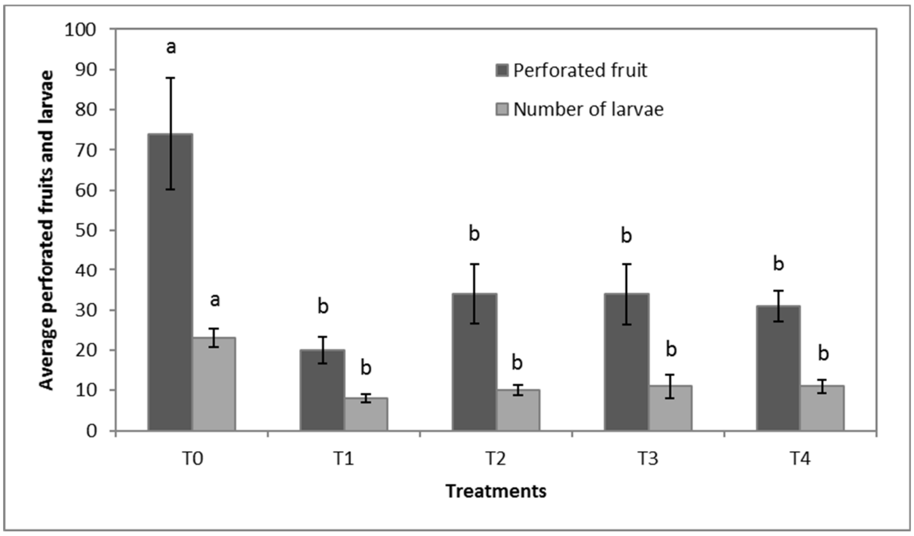

Figure 3: Average number of perforated fruit and number of larvae collected per treatment

Variance analysis shows no significant difference between treatments regardless of the biopesticide used (T1, T2, T3) nor between the associations or the insecticide alone (T4). However, according to the Newman-Keuls test, there is a significant difference between the untreated control (average of 16 fruits perforated and 4.75 larvae collected) and all treatments. Nevertheless, we can observe that the combination BIO K 16+ACARIUS 18 EC would present a higher efficacy in terms of fruit protection than the other biopesticides (H-N and PiOL) or the insecticide alone (ACARIUS 18 EC), because it has allowed to register the lowest average number of perforated fruits (5 perforated fruits and an average of 1.5 caterpillars collected). A higher number of repetitions would no doubt have demonstrated significant differences between this treatment and the other biopesticides.

Treatment effects on fruit yield

Table 3 below summarizes the yields obtained from different treatments.

Table 3. Average weight of healthy and perforated mature fruits, yield (Tons of tomatoes/ha), net yield/ha, yield loss (in %), depending on treatments.

Treatments	Average weight of healthy fruit (kg/50 m²±)	Average weight of perforated fruit (kg/50 m²±)	Yield (T/ha ±)	Net yield (T/ha ±)	% Yield loss
T0	85.57±9.82 [a]	8.77±5.17 [a] (10,2%)	18.48±2.69[a]	17.11±1.96 [a]	9,47
T1	98.05±5.60 [b]	2.74±1.85 [b] (3,0%)	20.16±1.23[a]	19.61±1.12 [b]	2,73
T2	87.77±6.44 [ab]	4.66±4.12 [ab] (5,3%)	18.87±2.04[a]	17.55±1.29 [ab]	4,93
T3	91.20±9.99 [ab]	4.66±4.14 [ab] (5,1%)	19.17±2.77[a]	18.24±2.00 [ab]	4,85
T4	96.13±6.10 [b]	4.25±2.12 [ab] (4,4%)	20.07±0.94[a]	19.23±1.22 [ab]	4,24

In the same column, the results followed by the same letter are not significantly different at the 10% threshold (Duncan test).

The variance analysis (Duncan test, 5% threshold) doesn't show any significant difference between treatments. But at the 10% threshold a significant difference appears between treatment T1 (BIO K 16+ACARIUS 18 EC) and the control (T0) in terms of protecting the fruits against the Lepidoptera caterpillars and in terms of net yield, indicating the effectiveness of the protection of this combination. No significant difference was observed between treatments combined with ACARIUS 18 EC.

DISCUSSION

Throughout the trial, yields observed are below expectation for this cultivar (40 Tons/ha). This lower efficiency is due to the pests (moths, locusts and whiteflies) and *Alternaria* present on the plants. This observation confirms the pressure that pests and diseases exert on the tomato and the vegetable crops in general in Burkina Faso.

The infestation levels of moth caterpillar populations have varied according to the phenological stage of the plants. Comparison of pest populations collected in yellow traps showed that adults of both Lepidoptera (*H. armigera* and *Utetheisa pulchella*) reached their peaks on the 40th day after transplanting, period that corresponds to the flowering-fruiting of the tomato. Adults (butterflies) are attracted by the flowers and that explains the large outbreaks. Our results are in agreement with those of Adje *et al*., (2009) who also observed that *H. armigera* peaked outbreak at the same date.

Utetheisa pulchella, especially harmful to crotalarias, also attacks cowpea, the tomato and eggplant (Appert and Deuse, 1982). It was reported in Senegal (Djiba, 1986). The strong outbreak of this pest in our trial may be due to rising temperatures from February to March in Burkina Faso. Indeed, this insect flies better in dry and sunny conditions.

In terms of protection of the fruits against the larvae of caterpillars and yields, we observe a weaker moth attack in the treated plots, especially during the first and sensitive 45 days. All associations do not show equal effectiveness, but in all cases, the number of caterpillars observed in treated plots is still lower than the control plots. This shows that the biopesticides used, associated with ACARIUS 18 EC, can protect with a real efficiency the tomato fruits despite the severity of the attacks.

The insecticide application (ACARIUS 18 EC) and the biopesticide made of *Bacillus thuringiensis* (BIO K 16) has achieved the best protection and the best yields. This is due to the effectiveness of *Bt* against the moth of tomato (Sanchis, 2016; Sanchis *et al*., 2016). Indeed, it is at the 2nd larval stage that the caterpillar *H. armigera* enters the fruits and perforates them in galleries making them unmarketable (Mazollier, 2001). The Kurstaki strain of the *Bacillus thu-*

ringiensis is a contact product, acting only by ingestion, specific to the Lepidoptera young larvae (L1 and L2 stages) able to eliminate them by poisoning after consumption of treated foliage (Mazollier 2001).

However, associations of abamectin with biopesticides have failed to protect plants against the whitefly whose presence is observed from the second week after transplanting (from end of January until end of March) on most of the plots. This strong outbreak of whitefly populations could result from a part of the test set-up period (January to March) which is favorable to its development. Thus N'zi *and al*., (2010) have found that planting in June allowed a lower proliferation of *Bemisia tabaci* compared to seedlings produced from December. On the other hand, the proper development of plants in the field has allowed them to outbreak. The works of Burban (1991), Adje *et al*. (2009) and N'zi *et al*. (2010) showed that the whitefly populations were especially important on the young leaves and on plants in the vegetative development stage. And indeed, their population was particularly important after the 2^{nd} week of transplanting up until flowering.

Finally, acrididae being essentially leaf-eating, their populations were higher in the vegetative phase, with a peak observed on the 19th day after transplanting, but the damage was not significant.

CONCLUSION

In conclusion, the use of biopesticides (BIO K 16, H-N and PiOL) in combination with abamectin allowed to protect the fruits of tomatoes against the larvae of moths, even if these associations have not had a significant effect on the whitefly. The Integrated Pest Management scheme will have to be completed to control outbreaks of this pest especially resistant to pesticides.

Plots treated with *Bacillus thuringiensis* and abamectin have recorded significant lowest losses in tomato fruits and have resulted in a better yield, close to 20 Tons/ha which is the average yield in tomato production in Burkina Faso.

The protection of human health and environment against the misuse of pesticides, is a hot topic, the use of biopesticides otherwise appears as an effective way, at least as a way to explore to reduce the use of pesticides in vegetable crops and avoid all the known disadvantages of a non-rational chemical control. Developing production of itineraries with IPM strategies, it will be possible to reduce the impact of chemical treatments and therefore protect human health of users and consumers and the environment.

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