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Biological Efficiency of Polyethylen Plastics and Idefix (Cupric Hydroxid 65. 60%) in Injection Against Tomatoes bacterial wilt (*Ralstonia Solanacearum* (Smith, 1896) Yabuuchi *and al.*, 1996) and their Effects on Soil Microorganisms, in Burkina Faso

KAMBOU Georges*
email id: kambougeorges2000@yahoo.fr

HEMA S. Alain
email id: hemalain715@yahoo.fr

BORO Fousséni
email id: fousseniboro@yahoo.fr

OUEDRAOGO Léonard
email id: tinkoglega@gmail.com

*Corresponding author

Abstract **– A study of biological efficiency of polyethylene plastics and bactericide idefix (cupric hydroxid 65.60%) in injection into the root system against tomatoes bacterial wilt and their effects on soil microorganisms, have been done, at Kou Valley, in Burkina Faso. This tomatoes disease causes big damages to farmers. The number of bacteria (*R. solanacearum*) has been evaluated on SMSA media. The levels of infection development have been evaluated using AFANASSEVA and al. (1983) formula. The quantification of soil microorganisms have been done by counting their colonies on the different media. The white polyethylen implementation reduced the level of bacteria (*R. solanacearum*) from 34. 50% to 50. 00% in comparison with untreated control. The efficiency coefficients of polyethylen plastics varied from 0. 00 to 97. 93 and those of injection method from 0. 00 to 43. 45. At the complete maturation, the number of cellulolytic bacteria, microscopic fungies and ammonifying bacteria, was higher than the one of the tomatoes raising period. The polyethylen plastics have allowed two fold increase of yield in comparison with the untreated control. The injection method gave a yield increase of 87% in comparison with the untreated control. The use of black or white polyethylen plastics, as presented, gives prospect of a new integrated pest management method against tomatoes bacterial wilt without side effects on human health and environment.**

Keywords **– Bacterial Wilt, Cupric Hydroxid, Polyethylen Plastics, Tomatoes.**

I. INTRODUCTION

Tomato *(Lycopersicum esculentum* Mill) is one of the most produced vegetable speculations in the world as well as in the field in the gardens [1]. In worldwide, planted tomato area in 2001 was 3. 7 million hectares, with a production estimated at 100 million tons [2]. In 2013 this production was estimated at 159 million tones. Thus, in the global food context, tomato occupies a place of choice in the fight against food insecurity. Beyond its food virtues, it is a significant source of natural compounds with significant antioxidant potential [3] from which its contribution to the health plan. Africa occupied fourth place with 12% of the world tomato production after Asia (45%), Europe (22%) and America (19%) [1]. In Africa of the south of Sahara, the average yield of tomatoes is 10t / ha [4] against 25T / ha globally.

In Burkina Faso, tomato *(Lycopersicum esculentum)* is one of the pillars of vegetable sector. This sector remains the main source of rural activity during long dry periods. According to the ministry of agriculture [5], the tomato production occupies 23, 45% of the total market garden area with an estimated annual production of 50150 tons. However, the tomato production is subject to various infestations from biological pests, including *R. solanacearum* agent of tomato bacterial wilt. This situation leads to tomato low production and productivity, thus creating a structural deficit in the supply of tomato products.

Listed as one of the most harmful bacterial plant pathogens in the world [6], *R. solanacearum* has an invasive character to tomato in greenhouse and in open fields. The bacterium causes bacterial wilt of tomato which is a major constraint to tomato production in Burkina Faso and in the rest of Africa. In fact, the disease was reported in 21 countries in Africa including Kenya, Ethiopia, Nigeria, Mali, Cameroon, Cote d'Ivoire and Uganda. Its incidence can reach 45% to 63% or 80% depending on the agro-ecological area [7]. In Burkina Faso, the disease was reported in 1964 at Farako-Ba research station by Darondel of the Hayes. The strains were identified from Race1, biovar I (phylotype I). In 1998, Ouedraogo in his work has identified other strains belonging to the Race 1 biovar III and IV. In 2001, the disease was identified in the kou valley on tomato crops, in open fields. A mortality rate of over 90% has been observed on the tomato, on Rossol variety [8]. She is the main reason of crops abandonment, from many vegetable regions including that of Kou Valleys, of Toussiana, Nakagouana, Banakeledaga, and of Bazèga [9].

Aware of these economic losses caused by bacterial wilt of tomatoes, many control methods as prophylactic control [10], [11], chemical control [12], [13] biological control [14], [7], [15], genetic control [16] and cultural control [17], [18], [19] were surveyed. The impact of organic

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fertilization on bacterial wilt development on tomato has been showed by [9]. From this work, it appears that the rates of 24 to 30T / ha of organic manure, reduces the incidence of 30% bacterial wilt. Varietal selection which is the most effective control strategy [20] is often faced with the strong adaptability of bacteria due to its high genetic diversity. Chemical controls lead often to disastrous consequences on the environment and on human health, and have often unsustainable effects according to pests. It thus appears essential to explore new sustainable strategies for the protection of tomato, to achieve acceptable and quality yields.

II. Materials and Methods

A. Materials

The experimentation has been done on vegetable area of Kou valley about thirty kilometers from Bobo-Dioulasso. The soils are alluvial and ferruginous light-textured, sandy clay loam and PH acid [21]. The plant material was the tomato' variety Petomech, very sensitive to *Ralstonia solanacearum.* Cultivation technics consisted to an incorporation of well decomposed organic manure during the plowing, nitrogen mineral fertilizer NPK (15, 15, 15) at the rate of 300kg / ha during tomato plants rising and a mixture of urea (46. 2%) with NPK in equal proportion (75 kg / ha) was brought during the flowering stage. The insecticide K-optimal (Lambda – cyhalothrine + acetamepride) was applied at the rate of 1l / ha as a foliar treatment against pests including white fly (*Bemisia tabaci*) and the cotton bollworm (*Helicoverpa armigera*). The intake of water to the experimental plot was carried out as required. The fruits of tomatoes were harvested per treatment, counted and weighed with electronic scale accuracy.

B. Methods

After preparing the nursery, from seedlings were transplanted according to the experimental design which was a Fisher block of six (6) treatments in four (04) replications: untreated control, organic manure (20t / ha), organic manure (20t / ha) + IDEFIX (2 kg / ha), organic manure (20t / ha) + white polyethylen plastic solarization, organic manure (20t / ha) + black polyethilen solarization, organic manure (20t / ha) + injection into the soil near tomatoes roots system IDEFIX (18,09 ml / per plant). In the laboratory, colonies of *R. solanacearum* from the soil samples, from each treatment, were isolated and counted on the SMSA media. Some groups of soil microorganisms, playing an important role in soil fertility as cellulolytic bacteria, fungi, ammonifying bacteria and nitrifying bacteria were counted on agar culture media [23]. In the field, the rate of disease' development or epidemiology of bacterial wilt in tomato was evaluated on 20 plants of the useful plot, with the scale of severity from 0 to 5 and with the formula of [24].

$$R(\%) = 100 \times \sum (a \times b)/(N \times K)$$

Where

R: The epidemiology or the rate of disease development (%).

K: Note of the higher scale.

N: Total number of plants sampled per useful plot.

$\sum (a \times b)$: Sum of products of the severity of infestation (a) by the corresponding note (b).

An analyse of variance of data [25] was computed and means separations were done using Newman-Keuls test at 5% level using STAT-ITCF Version 5 software. The correlations between the studied' factors were computed using ORIGIN 3.0 software.

III. Results

A. Effects of different control methods on the dynamics of R. solanacearum in soil.

Before application of treatments, there are no significant differences between the various individual plots on the number of bacteria *R. solanacearum.* (Table I).

At the stage of recovery (14 th day after aplication), the average effect of different control methods (79, 26.10 ^{3} bacteria / 1g dry soil) on the dynamics of *R. solanacearum* is a decrease of 24, 51% compared to the untreated control. The untreated control presents more colonies of *R. solanacearum* (105.10 ^{3} bacteria / 1g dry soil). Between the different control methods, organic manure associated with IDEFIX (injection) displays more colonies (91, 30.10 ^{3} bacteria / 1 g of dry soil) corresponding to a decrease of 13, 04% compared to the untreated control. At the opposite, the lowest number of colonies is observed in organic manure associated with white polyethylene plastic solarization (68, 70.10 ^{3} /1g of dry soil) corresponding to a decrease of 34, 57% compared to the untreated control.

At the flowering stage (42 th day after application), the average effect of different control methods (69, 20x10 ^{3} bacteria / 1g dry soil) on the dynamics of *R. solanacearum* is a decrease of 32, 16% compared to untreated control. Between the different control methods, organic manure associated with white polyethilen plastic display fewer *R. solanacearum* (60, 00.10 ^{3} bacteria /1g dry soil) which is a decrease of 41, 20% in comparison with the control treatment, while organic manure associated with IDEFIX (injection) records the maximum colonies of *R. solanacearum* (81, 70.10 ^{3} bacteria / 1g dry soil) which is a decrease of 19, 90% compared to the untreated control. The single organic manure treatments and that associated with black plastic solarization did not differ significantly and have a deficit of 35, 30% and 37, 25% respectively, compared to the untreated control.

At the tomato full maturation (70 th day after application), the average effect of different control methods (63, 62.10 ^{3} bacteria / 1g dry soil) on the dynamics of *R. solanacearum* is a decrease of 38, 82% compared to the untreated control. The control treatment has more bacteria (104.10^3 bacteria/ 1g of dry soil) compared to other treatments. Among the different control methods, organic manure + IDEFIX (injection) got more colonies of *R. solanacearum* (73.10 ^{3} bacteria / 1 g of dry soil) wich is a decrease of 29, 80% compared to the control treatment. Organic manure combined with the white plastic solarization has the lowest number of bacteria (52, 00.10 ^{3} bacteria /1g dry soil) and it is a decrease of 50% compared to the control treatment. The single organic manure treatment and that associated with black polyethilen plastic solarization are not significantly different and show a decrease of 40, 38% and 41, 35% respectively compared to the untreated control.

Table I. Effects of different control methods on the density of R. solanacearum (1000 bacteria / 1g dry soil).

Treatment	Phenological stages			
	Before application	Raising	Flowering	Complete maturation
Untreated control	109,30 a	105,00a	102,00a	104,00a
Organic manure 20t / ha	109,70 a	79,00 d	66,00 d	62,00 d
Organic manure 20t / ha + Idefix 2,00 kg / ha	110,30 a	83,30 c	74,30 c	70,12 c
Organic manure 20t / ha + white plastic	110,00 a	68,70 f	60,00 e	52,00 e
Organic manure 20t / ha + black plastic	109,00 a	74,00 e	64,00 d	61,00 d
Organic manure 20t / ha + Injection Idefix (18,09 ml / plant)	109,30 a	91,30 b	81,70 b	73,00 b
Mean	83,56	74.67	70,39	70,39
CV (%)	1,90	2.00	1,70	1,7
ETR (df = 15)	1,57	1.53	1,18	1,18
ETM (Sx)	0,78	0.76	0,59	0,59

NB: means followed by the same letter are not significantly different at the level of 5% of the Newman Keuls test.

B. Effects of different control methods on the epidemiology of the disease

At the 7 th day after application, there's no significant difference between treatments on the level of disease development (Table 2).

At the 14th day after application, the average effect of the different control methods on the epidemiology of bacterial blight is 0, 04% / useful plot. The lower level of development is observed in the manure treatment (0.03%) while organic manure treatment + IDEFIX (injection) displayed the highest level of development.

At the 28th day after application, the average effect of different control methods on the development of the disease level is 0, 40% whish is a decrease of 72, 43% compared to the untreated control. Between the different control methods, organic manure associated with IDEFIX (spray), that associated with solarization black plastic and the unique organic manure are not significantly different and have a lower development rate of 79, 31%, 71, 03% and 81,40% respectively compared to the untreated control. Organic manure combined with the white plastic solarization has the lowest level of development (0, 03%) which is a decrease of 97, 93% compared to the untreated control. The organic manure treatment + IDEFIX (injection) displayed the highest level of development (0, 82%), a decrease of 43, 45% compared to the untreated control.

At the 36 th day after application, the average effect of different control methods on the development of bacterial blight rate (5, 00%) is a decrease of 33, 86% compared to the control treatment. Among the different control methods used, organic manure + white plastic solarization better reduces the level of the development of bacterial blight (2, 48%) which is a decrease of 67, 20% compared to the untreated control. The organic manure treatment associated with IDEFIX (injection) displayed the highest level (7, 40%) which is a decrease only of 2, 12% compared to the untreated control. This treatment was not significantly different from the untreated control.

Table II. Effects of different control methods on the development level of bacterial wilt (%)

Treatments	Periods of observations (DAA = Day After Application)						
	7	14	28	42	56	63	70
Untreated control	0,00	0,00c	1,45a	2,46a	7,56a	9,78a	14,43a
Organic manure 20t / ha	0,00	0,03b	0,30c	0,72d	4,60b	7,92c	11,40cd
Organic manure 20t / ha + Idefix 2,00 kg / ha	0,00	0,06b	0,42c	1,01c	6,24ab	8,88a	12,31bc
Organic manure 20t / ha + white plastic	0,00	0,00c	0,03d	0,16e	2,48c	5,56b	8,10e
Organic manure 20t / ha + black plastic	0,00	0,00c	0,27c	0,65d	3,94bc	6,45b	9,46d
Organic manure 20t / ha + Injection Idefix(18,09 ml/plant)	0,00	0,10a	0,82b	1,55b	7,40a	8,46a	10,44ab
Mean	0,00	1,18	3,18	4,51	10,25	12,67	15,26
CV (%)	0,00	9,30	8,70	7,00	4,80	5,60	3,40
ETR (df =15)	0,00	0,13	0,40	0,32	1,31	0,71	0,51
ETM (Sx)	0,00	0,07	0,02	0,16	0,65	0,35	0,25

At the 70 th day after application, the average effect of different control methods on the development of the disease level (10, 34%) is a decrease of 28, 34% compared to the untreated control. Between the different control methods, organic manure + white plastic solarization record the lowest level of development (8, 10%) is a decrease of 43, 87% compared to the control treatment. The highest level of development is observed in processing organic manure + IDEFIX (spray) (12, 31%) which is a decrease of 14, 70% compared to the untreated control.

C. Effects of different control methods on the dynamic of cellulolytic bacteria

Before application of the various treatments, analysis of variance shows no significant difference between the different plots on the number of cellulolytic bacteria (Table 3).

At the maturation (70 th day after treatment), the average effect of different control methods on the dynamics of cellulolytic bacteria (796, 84.10 ^{3} bacteria / useful plot) is an increase of 72.50% compared to the untreated control. Among treatments, organic manure shows the highest number of bacteria (bacteria 888, 32.10 ^{3} / 1g dry soil) an increase of 92, 30% compared to the control treatment; against a lower value at the organic manure + IDEFIX (injection) (728, 37.10 ^{3} bacteria / 1 g of dry soil); This corresponds to an increase of 57, 65% compared to the untreated control.

D. Effects of different control methods on soil microscopics fungies

Before the various treatments application, the analysis of variance didn't reveal significant difference between the various individual plots according to the number of fungies (Table 3).

At the full maturation (70 th day after treatment), the untreated control has the lowest number of fungi (244, 82.10 ^{3} fungies / 1g dry soil). Among the different control methods, organic manure associated with white plastic solarization shows more fungi (875, 20.10 ^{3} fungies/ 1g of dry soil) at the opposite of the lower value of organic manure associated with IDEFIX (spray) which is 490, 30.10^{3} fungies /1g dry soil).

E. Effects of different control methods on the soil ammonifying bacteria

Before the various treatments application, the analysis of variance shows no significant difference between the different plots according to the number of ammonifying bacteria (Table 3).

At the full maturity of tomato, the average effect of the different control methods on the dynamics of ammonifying bacteria (7527, 86.10 ^{3} bacteria / 1g dry soil) is an increase of 53, 77% in comparison with the untreated control. Organic manure combined with white plastic solarization shows the highest number of bacteria ammonifying (9345, 00.10 ^{3} bacteria / 1g of dry soil) while the lowest number of ammonifying bacteria occurs in organic manure + IDEFIX (spray) (4975, 14.103 bacteria / 1g dry soil). The single organic manure treatments and that associated with black plastic solarization are not significantly different.

F. Effects of different control methods on the soil nitrifying bacteria

Before the various treatments application the statistical analysis revealed no significant difference between the different plots on the number of fungies (Table 3).

At the full maturation (70 Th day after application), the average effect of different control methods (5648, 70.10 ^{3} bacteria /1g dry soil) is an increase of 181, 20% compared to the untreated control. The control treatment had the lowest number of nitrifying bacteria (2009, 00.10 ^{3} bacteria / 1g of dry soil). Among the different control methods, organic manure associated with black plastic solarization shows more nitrifiers (7612, 52.10 ^{3} bacteria / 1g of dry soil). At the opposite the lowest value was on the organic manure associated with IDEFIX (spray) (4208, 46.103 bacteria / 1g dry soil).

G. Effects of different control methods on yield components and yield

At the criteria of number of tomatoes, among the various control methods, the organic manure treatment associated with black plastic solarization records the highest number of tomato (1030 tomatoes / useful plot), an increase of 69% compared to the untreated control. This treatment does not differ significantly from the treatment of organic manure associated with white plastic solarization that displays a surplus of 65, 05% tomato compared to the untreated control. The treatment of organic manure associated with IDEFIX (injection) has the lowest number of tomatoes (744, 50 tomatoes / useful plot) between the different control methods which is only an increase of 22, 15% in comparison with the untreated control (Table 4).

According to tomatoes yield, the control treatment had the lowest yield (12, 16 T/ha / useful plot). Considering the different control methods, the organic manure treatment associated with white plastic solarization shows the highest yield (26, 07 T/ha / useful plot) which gives a surplus of 114, 40% compared to the control treatment. This treatment is not significantly different from the organic manure treatment associated with the black plastic solarization which gives an increase of 112, 10% compared to the untreated control. The lowest yield was observed in the manure treatment + IDEFIX (spray) (2kg/ha) which gives only an increase of 49, 20% compared to the control treatment. This treatment does not differ significantly from the single organic manure treatment which gives a surplus of 53, 63% in comparison with the untreated control.

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Table III. Effects of different control methods on soil microorganisms (1000/1g dry soil)

Treatments	Cellulolytics bacteria		Microscopics fungies		Ammonifying bacteria		Nitrifying bacteria	
	Before raising	**Complete maturation**	**Before raising**	**Complete maturation**	**Before raising**	**Complete maturation**	**Before raising**	**Complete maturation**
Untreated control	269,70 a	462,00 f	370,00 a	244,82 f	3355,67 a	4895,63 e	9570,00 a	2009,00 f
Organic manure (20T/ha)	268,70 a	888,32 a	371,30 a	660,30 d	3353,00 a	8434,52 b	9566,70 a	5815,10 c
Organic manure 20T/ha + IDEFIX (2,00 kg/ha)	267,70 a	789,34 c	365,00 a	490,40 e	3354,00 a	4975,14 d	9502,30 a	4208,46
Organic manure 20T/ha + white plastic	268,30 a	816,70 b	368,00 a	875,20 a	3353,70 a	9345,00 a	9508,30 a	5938,22 b
Organic manure 20T/ha + black plastic	266,70 a	761,45 d	369,30 a	843,60 b	3354,30 a	8429,30 b	9520,00 a	7612,52 a
Organic manure 20T/ha +IDEFIX (18,09ml/plant)	268,70 a	728,37 e	370,00 a	764,23 c	3353,30 a d	6455,37 c	9502,70 a	4669,20
Moyenne	268,28	741,03	368,94	646,43	3354,00	7089,06	9568,33	5042,15
CV (%)	1,50	7,10	1,30	3,10	1,10	1,80	1,10	1,10
ETR (df=15)	1,39	5,51	1,09	9,20	1,09	103,63	4,45	173,30
ETM (Sx)	0,69	2,75	0,69	4,60	0,91	51,81	2,22	86,65

Table IV. Effects of different control methods on tomato's yield

Treatments	Number of tomatoes (mean / useful plot)	Yield untreated (T/ha)	% to control
Untreated control	609,50e	12,16 d	-
Organic manure 20t / ha	772,50c	18,56 c	152,63
Organic manure 20t / ha + Idefix 2,00 kg / ha	882,75 b	18,10 c	148,20
Organic manure 20t / ha + white plastic	1006,00 a	26,07 a	214,40
Organic manure 20t / ha + black plastic	1030,50 a	25,80 a	212,10
Organic manure 20t / ha + Injection Idefix (18,09 ml / plant)	744,50 a	22,50 b	185,03
Mean	840,88	0,55	
CV (%)	2,20	5,3	
ETR (df = 15)	18,31	1,09	
ETM (Sx)	9,15	0,05	

H. Correlations between different studied factors

The correlation between yields and the level of bacterial wilt development at the 70 th day after application shows the following regression equation y = -2,34x + 46,43, with r = -0.98 and p = 0.001 (Figure 1). The other one at the full maturation shows the regression equation y = 0,03x – 2, 94 with r = 0, 85 and p = 0.03 (Figure 2).

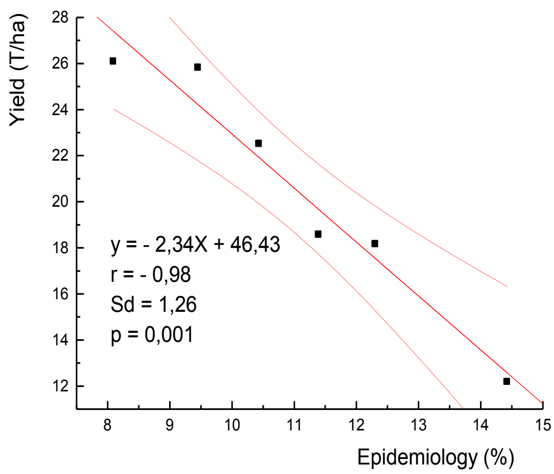

Fig. 1. Correlation between the epidemiology of bacterial blight and tomato yields at 70 th day after treatment

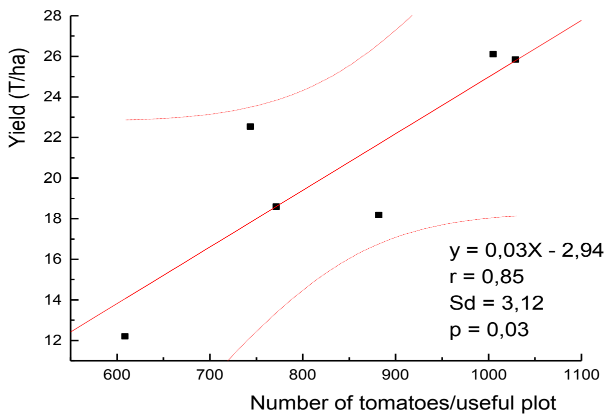

Fig. 2. Correlation between the number of tomato's fruits and tomato' yield

IV. Discussion

The various correlations between the level of bacterial wilt development and tomato' yield at the 70 th day after application (Figure 1) and the one established between the number of tomatoes and yield (Figure 2) show that the different control methods in place have influenced the epidemiology of bacterial wilt, tomato yield and consequently on the dynamic of *R. solanacearum* development. Indeed, these results, according to the effects of different control methods on the evolution of *R. solanacearum* in the soil, show that the organic manure treatment associated with the white plastic film solarization significantly reduced the bacteria' proliferation. This result is partly explained by the fact that the white plastic film, is able to capt the sun ultraviolet rays and transmit it into the soil depth. Under the action of soil moisture, it has increased temperature in the soil which could have inhibited the proliferation of *R. solanacearum*. This result is in adequation with the one obtained by [26], about the influence of temperature on stem, where he showed that the development of *R. solanacearum* is inhibited at temperatures above 43 ° C and that, the temperature optimum for the growth of bacteria is between 30°C and 35 ° C. The second explaination is that organic fertilize, has improved the total microbial activity, creating a competition between microorganisms and pathogens including *R. solanacearum*. This result is in adequation with the one of [9], when it has been established that organic fertilization at the doses of 24 to 32T / ha reduced the incidence of bacterial wilt from 23% to 32% respectively compared to the untreated control. This decrease in the proliferation of *R. solanacearum* could also be explained by the combined action of the organic soil and white plastic film solarization. Similar results were found in Japan by [27], on tomato and potato's crop. These authors showed that the combination treatment of the soil by burying residues *Geranium carolinianum* mixed with organic manure and in combination with solarization is effective in controlling *R. solanacearum*.

The black plastic film solarization associated with organic manure and the only organic manure have given satisfactory results according to the reducing of *Ralstonia solanacearum* colonies in soil. These results could be explained by the effectiveness of the combined action of organic manure solarization and the unique organic fertilizer against bacterial wilt, as described above. However it should be noted that the organic manure used alone reduced less proliferation *R. solanacearum* relative to that combined with solarization. This difference in efficacy could be explained by the fact that in the case of the single organic manure use, populations of *R. solanacearum* are subject only inhibitory action of certain microorganisms involved in the degradation of organic matter in the soil including actinomycetes. At the opposite, in the case of an association of organic manure and solarization, bacterial populations are subjected to the action of heat and that of the competition with microorganisms involved in the degradation of organic matter. This result has been confirmed by [28] on the agro-ecological management of bacterial wilt through plant services in combination with organic manure.

IDEFIX is a fungicide, bactericide which proved efficiency against vegetable foliar diseases including tomato crops. This fungicide-bactericide spray used in combination with organic manure injection and in combination with organic manure, reduced less the population density of *R. solanacearum* than the treatment of organic manure and organic manure combined with solarization. This could be explained either by the fact that the IDEFIX product contains chemicals whose action on the bacteria is antagonistic to that of microorganisms giving the organic fertilizer efficacy against bacteria and vice versa; either the dose of IDEFIX used in conjunction with organic manure is not sufficient to cause a synergistic action against the bacteria.

The results on the impact of different control methods on the dynamics of microorganisms in soil fertilization (cellulolytic bacteria, fungi, nitrifying bacteria and ammonifying bacteria) show that our different treatments did not affect the evolution of these beings. In fact an increasing number of each of these microorganisms, compared to control treatment was observed at our different treatments throughout the tomato development cycle. These results could be explained by the addition of organic manure to different treatments. Indeed, when the manure is applied to the land, a set of chemical reactions involving studied microorganisms, taking place in the transformation of mineral elements used by the plant. Cellulolytic bacteria and fungi provide degradation of the cellulose, while the ammonifying and nitrifying bacteria provide ammonification respectively (conversion of ammonia nitrogen) and nitrification (conversion of ammonia to nitrate). These results are in adequation with those of [20] where it was shown that the contribution of organic fertilizer stimulates the total soil microbial activity and promotes evolution of microorganisms involved in the dynamic developments of organic matter in the soil. However, it must be stressed that all treatments have not improved to the same degree, the microorganism's evolution. The organic manure treatments associated with white plastic film solarization, and that associated with black plastic film solarization longer stimulated the proliferation of microorganisms in the soil. This result could be explained by the pressure, that these treatments have on the populations of *R. solanacearum* which compete with soil microorganisms. The microorganisms are, then, in a setting where the action of their antagonist is low, hence their proliferation. This result fits in line with those obtained by [29]. These authors showed that solarization leads to an increase of the bacterial flora and promotes absorption of minerals in the soil solarized.

The effects induced by the various control methods on the dynamics evolution of *R. solanacearum* and on the microorganisms have had repercussions on the number of tomato plants attacked by bacterial wilt, the severity of attacks and the level of development of bacterial wilt, as well as yield components and yield of tomato.

Reducing the number of plants infested by these different control methods could be explained by some pressure from these technologies on the dynamics of *R. solanacearum*. In fact, the bacterium is telluric, any action caused or suffered by the soil bacterium occurs in the aerial parts of the host plant. The organic manure treatments associated with solarization and only organic manure reduced the density of *R. solanacearum* in soil, resulting in a reduction of the disease in these treatments. These same phenomena of *R. solanacearum* population's inhibition in soil by these technologies explain the weakness of the severity levels, the epidemiology of bacterial wilt and the yields observed in these treatments. These results are confirmed with those obtained by [30] according to the influence of solarization on yield components and yield. These authors found that the solarization associated with the organic amendment induces good vegetative growth by stimulation of total microbial activity in the soil, which promotes the release and absorption of mineral nutrients by the plant; it follows an increase of yields.

V. Conclusion

Fungicide-bactericide IDEFIX used in combination with organic manure and in injection into tomatoes root system also reduces the incidence of bacterial wilt and increased tomato yields compared to the untreated control. However the use of this fungicide - bactericide in combination with organic manure is less effective in comparison of that of the single organic manure and organic manure combined with solarization.

Organic manure combined with solarization of white plastic film and that associated with black plastic solarization reduced higher the epidemiology of bacterial wilt in comparison with the single organic manure respectively from 43, 87% to 97, 93% and from 34, 44% to 81, 37%. That led respectively to a yield increase of 114, 40% and 112, 10% in comparison with the untreated control. The injection method led to a yield increase of 85, 03%.

The different control methods did not generate a negative impact on the dynamics of soil microorganisms' development including cellulolytic bacteria, fungies, ammonifying and nitrifying bacteria. An increase of the population of these microorganisms was observed during tomato development cycle. The effectiveness of these technologies against tomato bacterial wilt could help vegetable farmers to recover the soil of some agricultural areas previously abandoned because of bacterial infestation due to *R. solanacearum.*

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AUTHORS' PROFILES

Dr. Georges KAMBOU was born at Ouagadougou, on August 30, 1955. He is Burkinabê and was the head of the vegetable, Fruit and Tuber crop Programme of INERA (Environmental and Agricultural Research Institute). He has a Ph.D in Ecotoxicology from the Stavropol State Agricultural Academy (USSR) in 1994 year. Fulbrighter Michigan State University (USA) in 2004 – 2005 year. He got an honorific award from IITA (International Institute of Tropical Agriculture) in 1997 for his scientific contribution in maize weeds management. He got two awards in 2010 from the UA/SAFGRAD institution in Burkina Faso and in 2016 from OUAGA II University during the National Forum of scientific Research and Technological innovations. He is member of IAPPS and has published the research paper in many national and international journals.
Email: kambougeorges2000@yahoo.fr

Dr Léonard S. OUEDRAOGO was born in Tinkoglega/Passoré, on December 31, 1954. He is Burkinabê and has been the Chief of vegetables, fruits and Tuber Programme of INERA (Environmental and Agricultural Research Institute). Dr Léonard S. OUEDRAOGO got his PH.D at Agricultural Academy of Kiev (Ukraine) in 1988. He has been in UK at the international Mycological Institute (IMI) for many courses on plant pathology and then in Denmark in 1997-1998 for seed pathology course. He was decorated by Burkina Faso Government in 2011 for his contribution in the development of science in Burkina Faso. Dr Léonard S.OUEDRAOGO is author or co-author of more than 35 scientific papers. Email : tinkoglega@gmail.com

Mr. Hema S. Alain was born on September 9, 1987 at Bobo-Dioulasso in Burkina Faso. He is a Burkinabê and Master II's student at the Rural Development Institute of NAZI BONI University (IDR/UNB).
Email: hemalain715@yahoo.fr

Mr. BORO Fousséni was born on May 25, 1977. He is a Burkinabê and is working at INERA vegetables, fruits and tubers programme since 2002. He got the M.Sc diploma of Matourkou Agricultural Polyvalent Center in 2014.
Email : fousseniboro@yahoo.fr