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Effect of organic amendments and fungicide application on potato late blight, bacterial wilt and yield in Cameroon

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Abstract

The effect of three types of organic amendments, mineral fertilizer NPK (11-11-22) + 5.5% MgO and fungicide treatment with Ridomil Gold Plus 66 WP was evaluated on late blight severity, bacterial wilt incidence and potato yield in a split plot experimental design at the research and application farm of the Faculty of Agronomy and Agricultural Sciences, University of Dschang. The aim of the study was to control the two main diseases which impede potato cultivation in Cameroon. Ridomil Gold significantly reduced ($P < 0.05$) the severity of late blight expressed as values of standard area under disease progress curve in plots amended with compost made of garden waste (CGW) and mineral fertilizer (12.59 and 11.14%) compared to the other types of fertilization, and increased by 76% the marketable tuber yield compared to the control on the other hand. The CGW also reduced significantly ($P < 0.05$) the intensity of bacterial wilt compared to the other types of amendments. Loss in marketable tuber yield was about 24% and 18% due to late blight and bacterial wilt in non-treated sub plots, respectively. Mineral fertilization yielded the highest marketable tuber in treated plots with 12.98 t/ha and was comparable to that of poultry manure and CGW. The study showed that the use of the fungicide Ridomil Gold Plus and CGW can be integrated in a program to control late blight and increase potato's yield, and that CGW could be associated in bacterial wilt control.

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Introduction

Potato (*Solanum tuberosum* L.) is the most important plant of the Solanaceae family, cultivated for its tubers for consumption (FAO, 2010). Its tubers are rich in starch, vitamin B, C and mineral salts, glycoalcaloides, alphasolanine and alphachaconine (Maga, 1980; FAO, 2010). In Cameroon, potato is mainly cultivated in the highland plateau of the West, North-west and South-west regions and constitutes an important economic crop at the level of producers, traders and the country at large (Njualem *et al.,* 2001; Fontem *et al.,* 2004).

In the polycultural traditional system which predominates in the high plateau of West Cameroon, average yields are very low (1.5 – 3.2 t/ha) and exceeds 20 t/ha in monoculture (Njualem *et al.,* 2001; FAO, 2010). With annual production of 325.3 million tonnes (FAO, 2010), potato comes ahead of other root and tubers. These low yields are principally due to fungal and bacterial diseases, especially late blight caused by *Phytophthora infestans* (Mont.) de Bary and bacterial wilt caused by *Ralstonia solanacearum* (Smith) Yabuuchi (CIP, 1987; Fontem and Aighewi, 1993; Fontem, 1995; Njualem *et al.,* 2001). The use of synthetic fungicides and crop rotation are the recommended means for controlling late blight and bacterial wilt respectively. However, chemical control is costly, toxic, polluting and ineffective against bacterial wilt. Some decades ago, it was reported that the use of compost in crop production not only helps to improve the physicochemical properties and soil fertility, but also to control some soil borne diseases and increase crop yields (Adebayo *et al.*, 2001 ; Abassi *et al.*, 2002 ; Remade 2006 ; Yadessa *et al.,* 2010). The efficiency of compost in controlling diseases is attributed to its contain in antagonistic microorganisms such as bacteria and actinomycetes (Yadessa *et al.,* 2010). These previous research works constitute motivation of the present study.

The aim of this study was to evaluate the use of organic amendments in association with a synthetic fungicide on the control of late blight and bacterial wilt of potato.

Materials and methods

Experimental site

The study was conducted at the research and application farm of the Faculty of Agronomy of the University of Dschang situated at latitude 5.5° North and longitude 10.05° East with an altitude of 1470 m characterized by a cold altitude climate with two seasons: a long rainy season (from mid-March to mid-November) and a short dry season (from mid-November to mid-March). Average annual precipitation varies from 1800 – 2000 mm. Average temperature fluctuates between 21 and 24°C. Relative humidity is generally above 70%.

Composition of composts and fabrication technique

The two types of composts were made up of the following elements:

Compost based on garden waste (CGW)

Euphorbia pulcherima leaves and flowers, *Allamanda cathartica* branches, leaves and flowers, *Bougainvillia spectabilis* branches, leaves and flowers, *Canna indica* stems, leaves and flowers, *Hibiscus rosa-sinensis* stems leaves and flowers, *Mimosa spp* leaves, guava, pear and banana leaves, *Brachiaria ruziziensis; Emilia coccinea*; *Erigeron floribundus; Ageratum* spp *(A. conyzoïdes* and *A. haustonianum)*; *Gallinsogan siliata* and Bryophytes (mousses and lichens).

Compost based on kitchen waste (CKW)

Plantains, cocoyam, potato, yams, sweet potato, cassava, banana and pineapple peelings, maize spathes and stems, chicken feathers, egg shells, cabbage leaves, carrots, onion and garlic scales, tea filter and various fruits.

The heap composting technique was used in making the composts. The compost heaps were regularly turned watered and covered with a tarpaulin to avoid leaching due to rainfall. Weekly temperatures were collected at the level of a ventilation hole created to this effect. Composting ends when the temperature remains constant. It is said to be matured (Yadessa *et al.,* 2010).

Analysis of soil and organic matter samples

Soil samples were collected at a depth of 20 cm from each block before planting, using an auger. These soil samples as well as compost and poultry manure were taken to the soil and environmental chemistry laboratory of the University of Dschang for analysis. These samples were dried in an oven at 40°C for 48h and carefully grind and filtered using a 2 mm mesh filter. The granulometric analysis was carried out after sedimentation according to Skock's law, using a Robinson Köhn pipette so as to separate the different granulometric fractions such as sand clay silt and fin silt. The textural classes of the soils were then determined using the FAO textural triangle. Chemical and physical analysis of the soil and organic matter samples were carried out according to Walkey, de Bray II and de Black's method (CEAEQ and MINAPAQ, 2003; CIRAD, 2004).

Experimental design and application of amendments

The trial was conducted in a split plot experimental plan comprising 6 treatments repeated three times and randomly distributed in the experimental units. The main plot was represented by the organic/mineral manure and the secondary plot by fungicide treatment. Treatments were compost based on garden waste (CGW) at a dose of 15t/ha, compost based on kitchen waste (CKW) at 15 t/ha, a mixture of CGW and CKW (at a ratio of 1:2) at 15 t/ha, poultry manure at 15 t/ha, mineral fertilizer 11-11-12 (NPK) + 5.5 MgO (400 kg/ha) as recommended for potato and the control treatment. Compost, poultry manure and mineral fertilizer were mixed with soil at each stand before planting tubers at a distance of 30 x 80 cm corresponding to a density of 41 666 plants/ha. Chemical control against late blight was realized by the application of Ridomil Gold Plus 66WP (6% metalaxyl-M + 60% copper oxide) at the recommended dose of 2.5 kg/ha twice a month until maturity. The experimental units that were treated with fungicide were surrounded with plywood before the application. The potato variety CIPIRA was used in the trial due to its high productivity, early maturity and its availability in the locality. Wilted plants were rogued together with soil and buried out of the plot; a peg was used to note the rogue wilted plant so as to facilitate data collection of bacterial wilt incidence (Fig. 1).

Data collection

Data collection diseases incidence and severity started 30 days after sowing (DAS), at the first appearance of disease symptoms and continued weekly. The late blight severity was noted using a modified Horsfall Baratt scale (Berger, 1980). The severity values were used to calculate the standardized area under disease progress curve (SAUDPC) using the formula suggested by Campbell and Madden (1990):

$SAUDPC = \sum_{i-1}^{n-1} \frac{(yi+yi+1)(ti+1-1)}{2(tn-t1)}$ where y_1 is the severity at time t_1 in days after planting and $t_n - t_1$, the duration of the epidemic in days. Yields (total and marketable tubers) were evaluated on the 77th DAS. Observations were made on 4 plants at the center of each plot.

Data analysis

Data collected such as bacterial wilt incidence, number of infected tubers, total yields, marketable yields as well as SAUDPC (values calculated from severity) went through an analysis of variance using the program GENSTATS. Means were separated using the Duncan multiple comparison test at a probability level of 5%.

Results

Composting and physicochemical composition of the different organic matter

Four months after composting, mature compost with constant temperature was obtained. Compost of garden waste had very fine particles compared to that of kitchen waste (Fig. 2).The physicochemical analysis of the different organic matter (OM) showed that their composition varied with the nature of compost. The pH of the soil was 5.99. The pH of composts and poultry manure varied from 7.06 to 7.30 and 7.02 to 7.41, respectively. Composts were rich in organic matter with very high total nitrogen content. The soil was rich in organic matter (6.92%), with very poor quality since C/N > 20. The available phosphorous content was very low. The sum of exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}) was very high (217.52 meq/100g) in poultry manure (Table 1).

Table 1. Physicochemical characteristics of soil, poultry manure and compost.

Physico chemical characteristic	Soil	Poultry manure	CGW	CKW	CM
Depth (cm)	0-20	-	-	-	-
Texture					
Sand	28,69	-	-	-	-
Large silt	10,38	-	-	-	-
Fine silt	38,13	-	-	-	-
Total silt	48,38	-	-	-	-
Clay	22,93	-	-	-	-
Textural Class	L	-	-	-	-
Soil Reaction					
pH-water	5,99	7,02	7,06	7,30	7,18
pH-KCL	5,46	7,41	6,88	6,85	6,86
Organic matter					
CO (%)	4,03	9,02	5,51	6,46	5,98
OM (%)	6,92	15,6	9,49	11,13	10,31
NH_4+ (g/kg)	0,38	18,79	-	-	-
NO_3 (g/kg)	1,97	3,64	-	-	-
Total Nitrogen (g/kg)	1,89	4,38	14,4	10,5	12,8
C/N	21,35	20,6	3,82	6,15	4,67
Exchangeable cations					
Calcium (meq/100g)	5,84	57	19,20	24,50	86,80
Magnesium (meq/100g)	1,62	142,60	77,3	62,8	99,3
Potassium (meq /100g)	0,63	12,06	-	-	-
Sodium (meq/100g)	0,3	5,86	-	-	-
Sum of exchangeable bases (meq/100g)	8,39	217,52	96,50	87,30	186,10
Effective CEC (meq/100g)	8,39	9,10	-	-	-
S/CEC (%)	100.00	100.00	-	-	-
CEC pH7 (meq/100g)	14,42		-	-	-
Base saturation (%)	58,5		-	-	-
P available :Bray II (mg/kg)	1,17	130,13	-	-	-
P soluble in water (mg/kg)	-	7,10	-	-	-
% Humidity of poultry manure	-	11,35	-	-	-

Effect of organic amendments and mineral fertilization on late blight severity

Symptoms of late blight disease were the first to be recorded on potato plants, 30 DAS. There were no significant differences of SAUDPC (P > 0.05) between the treated plots nor the type of amendment in plots with non-treated control plots. In treated plots with fungicide and amended with CGW and mineral fertilizer, SAUDPC values were the lowest (12.59 and 11.14%) compared to the other types of fertilization (Table 2).

Table 2. Late blight expressed as SAUDPC (%) values subjected to different types of amendments.

Fertilisation	SAUDPC (%)	
	Untreated	Treated
Control	28,23 [a*]	18,97 [a]
Compost Garden waste (CGW)	30,12 [a]	12,59 [b]
Compost kitchen waste (CKW)	32,55 [a]	20,08 [a]
CM (CGW + CKW)	33,75 [a]	19,21 [a]
Poultry manure	34,9 [a]	22,17 [a]
NPK + MgO	31,17 [a]	11,14 [b]

*Means on the columns followed by the same letter are not significantly different according to Duncan test (P = 0.05).

Effect of organic and mineral amendments on bacterial wilt incidence

The bacterial wilt incidence was the highest in the control and in plots amended with poultry manure. The intensity of bacterial wilt was significantly ($P < 0.05$) reduced in the experimental unit (EU) amended with CGW compared to other types of amendments. Moderate values of bacterial wilt intensity were recorded from EU amended with CKW, compost mixture and mineral fertilizer (Table 3).

Table 3. Bacterial wilt incidence (%) in plots that were not treated with fungicide and amended with organic and mineral matter.

Fertilization	Wilt incidence
Control	59,13 [a*]
Compost garden waste (CGW)	19,11 [c]
Compost kitchen waste (CKW)	52,16 [ab]
CM (CGW + CKW)	40,35 [b]
Poultry manure	61,23 [a]
NPK + MgO	54,89 [ab]

*Means followed by the same letter are not significantly different according to Duncan test (P = 0.05).

Effects of organic and mineral amendments on total and marketable yields (%) of potato tubers

Total yields

The application of the different types of fertilization significantly increased total yields and yields of marketable potato tubers compared to the control (Table 4). The highest yield increase of 175% was recorded in plots amended with poultry manure. Potato yield increases of 150% and 101% were obtained from plots fertilized with NPK + MgO (12.67 t/ha) and amended with compost made of garden waste, respectively. The lowest yield increase of 60% was recorded from plots amended with compost mixtures.

Table 4. Total yields and marketable tubers yields (t/ha).

Fertilization	Total yields (t/ha)		Marketable yields (t/ha)	
	Untreated	Treated	Untreated	Treated
Control	5,06 [e*]	5,56 [c]	4,20 [d]	5,51[c]
Compost with garden waste (CGW)	10,19 [c]	11,63 [b]	9,45 [b]	11,63 [a]
Compost with kitchen waste (CKW)	9,69 [c]	10,97 [b]	7,52 [c]	9,03 [b]
CM (CGW + CKW)	8,13 [d]	9,55 [b]	4,25 [d]	4,86 [c]
Poultry manure	13,75 [a]	22,61 [a]	10,14 [a]	12,98 [a]
NPK + MgO	12,67 [a]	14,93 [a]	10,61 [a]	11,53 [a]

*Means on the columns followed by the same letter are not significantly different according to Duncan test (P = 0.05).

Table 5. Effect of fungicide treatment on total yields (t/ha).

Fungicide application	Yields (t/ha)	Loss in yields (%)	Rate of increase (%)
Treated	11,04 [a*]	20	80
Untreated	8,79 [b]	-	

*Means on the columns followed by the same letter are not significantly different according to Duncan test (P = 0.05).

Yields in marketable tubers (t/ha)

The analysis of variance of the different fertilization and fungicide treatments did not show a significant fertilization x fungicide interaction. However, this analysis showed a highly significant effect ($P<0.05$) of fertilization and fungicide treatment. The application of the different types of fertilization significantly increased yields in marketable potato tubers. The highest yields were obtained from plots that were subjected to NPK+MgO treatment (10.61 t/ha), followed by plots that were fertilized with CGW (9.45 t/ha) and poultry manure (9.14 t/ha). The lowest marketable yields were obtained from plots that received compost mixtures (4.25 t/ha) (Table 4). Fungicide treatment significantly increased total yields by 80% (Table 5).

Discussion

Late blight has been reported as one of the most devastating diseases of Solanaceae and constitutes a limiting factor in potato production in Cameroon (Fontem and Aighewi, 1993; Fontem, 1995). Results showed that potato tuber yield was inversely proportional to late blight severity and bacterial wilt incidence. The SAUDPC values were low in treated sub plots. Sub plots that were fertilized with manure had the highest severity values. This could be due to the high Nitrogen content of the manure. Excess Nitrogen is known to favour rapid growth and development of new tissues but creates a favourable microenvironment for disease development (Tarla *et al.,* 2011). The SAUDPC values were higher than those reported by Djeugap *et al.* (2011) in late blight of huckleberry. Bacterial wilt also constitutes a limiting factor in potato production in the world. Generally, the first symptoms of bacterial wilt were observed 37 DAS in experimental units that received compost made of kitchen waste and poultry manure. The wilting rates is high (> 50%) in plots amended with poultry manure and CKW. This suggests that these two organic matters could have low bactericidal effects due to their low content in antagonistic microorganism. Organic matter used in making CKW was constituted of the peelings of various roots and tubers that could harbour pathogenic agents that cause wilting. *Rastonia solanacearum* is a polyphagous soil borne bacterium which infects a wide variety of root and tuber crops (Pradhanang *et al.,* 2000; Jan *et al.*, 2000). The CGW significantly reduced bacterial wilt. This compost could act as elicitors that induce the resistance of potato crop and could explain the reduction of wilt intensity (Walters *et al.,* 2013). Potato varieties like CIPIRA and TUBIRA that were formerly considered to be resistant are now susceptible to late blight. Yield losses of 24% obtained were lower than those obtained by Fontem (52%) in 1995. This difference could be attributed to the varietal difference between CIPIRA and "Tezelfeu", local variety used by Fontem, and the cultural methods. Henfling (1987) reported that total loss in production can be recorded from cultivation (specify the crop) with low control measures (Henfling, 1987). Hence, the severity could be higher than 0.9 when the disease attacks a susceptible variety at the early age of the growing period (Sengooba *et al.*, 2001).

Fig. 1. Wilted potato plant with visible lesions on tubers (A) and pegs to note position of wilted plants (B), 60 days after planting.

Fig. 2. Granulometric aspect of compost used in the trial; CGW: compost of garden waste, CKW: compost of kitchen waste and CM: compost mixture CGW + CKW (m/m: ½).

Conclusion

This study showed that the fungicide Ridomil Gold Plus reduced late blight severity and increase marketable tuber yields by 76% in plots amended with CGW and mineral fertilizer compared to the control. Compost made with garden waste reduced the intensity of bacterial wilt compared to the other types of amendments. Loss in marketable tuber yield due to late blight was 24% and loss in marketable tuber yield due to bacterial wilt was 18%. The highest yield increase of marketable tubers of 57% were recorded from plots with poultry manure, followed by plots amended with mineral fertilization and CGW, with 52 % and 50% yield increase, respectively. The use of Ridomil (metalaxyl + CuO) and CGW controlled late blight and could be integrated in a control strategy of this disease and to increase yields. Compost made of garden waste could be recommended for controlling bacterial wilt. The microbiological and chemical composition of the CGW shall be studied to identify the potential microorganism or compounds responsible for potato protection.

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References

Abbasi PA, AL-Dahmani J, Sahin F, Hoitink HAJ, Miller SA. 2002. Effects of compost amendments on disease severity and yield of tomato in conventional and organic production systems. Plant disease **86,** 156-161.

Adebayo OSI, Ekpo EJA. 2001. Effects of organic amendments on tomato diseases caused by *Ralstonia solanacearum* and *Fusarium oxysporum* fsp *lycopersicum*. In: Tanywa JS, Nampala P, Tusiime G Osiru M eds. African Crop Science Conference Proceeding Vol.5 Part 1 and 2, Kampala, Uganda, 305 – 307.

Berger RD. 1980. Measuring disease intensity. In: E.C. *Stakman, Commemorative Symposium on Crop Loss Assessmen*t. University of Minnesota Misc. Publ. 7, St Paul, 28-31.

Campbell CL, Madden LV. 1990. Introduction to plant disease epidemiology. John Wiley.

CEAEQ (centre d'expertise en analyse environnementale du Québec) et MINAPAQ (ministère de l'agriculture, des pêcheries et de l'alimentation du Québec). 2003. Détermination de la matière organique par dosage du carbone organique dans les sols agricoles : méthode Walkley-Black modifiée. Ministère de l'environnement du Québec, 10 p.

CIP (centre international de pomme de terre). 1987. La pomme de terre. Bulletin d'information technique, Lima Peru 37-44 p.

CIRAD. 2004. Analyse des sols. Préparation des échantillons de sols pour l'analyse physico chimique. Laboratoire d'analyse du Centre de coopération International en recherche agronomique pour le développement, 8p.

Djeugap FJ, Fontem DA, Tapondjou AL. 2011. Efficacité *in vitro* et *in vivo* des extraits de plantes contre le mildiou (*Phytophthora infestans)* de la morelle noire. International Journal of Biological and Chemical Sciences **(5)6,** 2205-2213.

FAO (Food and Agricultural Organization) 2010**.** Traditional Food plants. A resource book for promoting the exploitation and consumption of food plants in arid, semi-arid and sub-humid lands of Eastern Africa. FAO Food and Nutrition **42,** 458-466.

Fontem DA, Aighewi B. 1993. Effect of fungicides on late blight control and yield loss of potato in the western highlands of Cameroon. Tropicultura **10,** 15-19.

Fontem DA, Olanya MO,Njualem DK. 2004. Reaction of certain Solanaceous and Asteraceous plant species with *Phytophthora infestans* in Cameroon. Phytopathology **152 (6),** 331-336.

Fontem DA. 1995. Yields of potato as influenced by crop sanitation and reduced fungicidal treatments against late blight. Tropicultura **13,** 99-102.

Henfling JW. 1987. Late Blight of potato *Phytophthorainfestans.Technical Information Bulletin* 4.2nd Ed. Revised. International potato centre, Lima- Peru. 25p.

Jan DVE, Kastelein P, Bekkum PV, Wolf JMV. 2000. Survival of *Ralstonia solanacearum* Biovar 2, the causative agent of potato brown. Phytopathology **(90)12,** 1358-1366.

Maga JA. 1980. Potato glycoalkaloide. Critical Review Food Science Nutrition **12,** 371-405.

Njualem DK, Demo P, Mendoza HA, Koi JT, Nana SF. 2001. Reactions of some potato genotypes to late blight in Cameroon. African Crop Science Journal **(9)1,** 209-213.

Pradhanang PM, Elphinstone JG, Fox RTV. 2000. Identification of crop and weed hosts of *Ralstonia solanacearum* biovar 2 in the hills of Nepal. Plant Pathology **(49)4,** 403-413.

Remade 2006. Compost and disease suppression, Organics Factsheet, Scotland.

Sengooba J, Hakiza JJ, Olanya OM, El-Bedewy R, Berger L, Adipala E. 2001. An overview of opportunities and challenges to the management of late blight in tropical environment. African Crop Science Proceedings **5,** 395-398.

Talla DF, Fon DE, Fontem DA. 2011. Economic analysis of fungicide and fertilizer applications on huckleberry (*Solanum scabrum* Mill.) fresh shoot yield. Journal of Tropical Agriculture **49(1-2),** 58-63.

Walters DR, Ratsep J, Havis ND. 2013. Controlling crop diseases using induced resistance: challenges for the future. Journal of Experimental Botany **64(5),** 1263-1280.

Yadessa GB, Van Bruggen, Ocho FL. 2010. Effects of soil amendments on bacterial wilt caused by *Ralstonia solanacearum* and on the yield of tomato. Journal of Phytopathology **92(2),** 439-450.