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Influence of Fertilizers on Incidence and Severity of Viral and Bacterial Potato (*Solanum tuberosum* L) Diseases under Field Condition

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***Abstract*— *The potato production in the Far North Region, Cameroon is confronted with rarities or unevenness of rainfall, diseases and pests. In order to improve the production of this plant, a study was conducted in two villages (Mouvou and Gouria) with the general objective of evaluating the impact of fertilizers on the development of viral, bacterial and pest diseases of this plant. The experimental design used was a completely randomized block S with 4 treatments repeated 3 times each. The fertilizer treatments were: Mycorrhizae (MYC), NPK (20-10-10) chemical fertilizers, chicken droppings (CD) and a control (T) that received no application. The plant material used was a local variety of potato (Dosa). Diseases were identified, incidence, severity and rainfall were evaluated. The viral diseases identified were: Virosis M, Rust Stain and PLRV. Bacterial diseases were Bacterial Wilt and Common Scab. The highest incidences of 18.91 % and 10.44 % were obtained with Virosis M and Rust Stain in MYC treatment at Mouvou and Gouria respectively. But, in CD treatment incidence was 2.22 % and 0 % at Gouria for Virosis M and Rust stain respectively. the average rainfall was 697.75 mm. Severity was low in CD treatment in all the sites (< 20 %). All diseases were present in Gouria. The average rainfall was higher in the Gouria site 716.5mm than in Mouvou site which received 679 mm of water. The CD treatment can be recommended to the farmers of Mogodé for the phytosanitary protection of potatoes.*

Keywords*— *Solanum tuberosum, fertilizers, diseases, incidence and severity.

I. INTRODUCTION

Among agricultural commodities, the potato (*Solanum tuberosum* L.) occupies a predominant place in the food supply of many countries because of the areas it occupies, the jobs it provides and the production volumes it generates. World production has been estimated at more than 368 million tons from 19.4 million hectares in 2013 (Issa et al., 2017), making it the fourth largest producer after wheat, rice and maize, making it the main non-cereal food in the world (FAO, 2013).

Originally from the highlands of Peru (Spooner et al., 2005), it was introduced to Cameroon in 1940. It is cultivated in high altitude zones (1000 to 3000 m) (IRAD, 2012) and extensively in six of Cameroon's ten regions (North-West, South-West, West, Adamaoua, Littoral and Extreme-North), mainly by rural people and mainly women (Fontem et al., 2005). It constitutes a staple food for the populations of these regions (annual consumption of 4 to 10 kg per inhabitant per year) an important source of income because production surpluses are either sold on the local market or exported to neighboring countries. National production was estimated at 229,000 tons on 23,500 hectares in 2009 (IRAD, 2012). Thus, despite the importance of potatoes in the national economy, total production remains below real potential, yields are generally low (Burton, 1989; Diop et al., 2019) and range between 3 and 11t/ha, while those of European countries average 25 t/ha (Sayed et al. 2015) and reach 60 t/ha.

In the Far North Cameroon Region, particularly in the Mogodé subdivision (Mayo-Tsanaga), the only and main production area, the low yields observed are associated with poor peasant farming practices (Ngoyi et al., 2020), the scarcity or inequality of the rains and especially to diseases and pests. Many diseases have been reported on potatoes in several countries (Masum et al., 2011; Habtamu et al., 2012 ; Alkher et al., 2015 ; Son et al., 2018) and in Cameroon (Fontem et al., 2003; Fontem et al., 2005 ; Lontsi et al., 2019).

Potato crop losses due to bacterial diseases could be direct or indirect. Brown rot and Bacterial wilt (*Ralstonia solanacearum*) of potato are the major bacterial diseases in potato production area (Prior et al. 2016 ; Kong et al. 2016 ; Charkowski, 2020). Whereas more than 50 different viruses and one viroid have been reported infecting potatoes worldwide only a handful of them cause major losses globally (Chiunga and Valkonen, 2013). PVY and PLRV (potoato leafroll virus) are now the most damaging viruses of potato world-wide, with PVY having overtaken PLRV as the most important. Tuber yield losses are caused by either of them in single infections and can reach more than 80% in combination with other viruses. PVX or PVM occurs commonly worldwide and causes losses of 10–40% in single infections and is particularly damaging in combination with PVY or PVA (Baldo et al., 2010).

Several solutions have been proposed to overcome these diseases production constraints: These include the use of varieties with high production potential, resistant to diseases and adapted to the agro-ecological zone (IRAD, 2012) and the use of chemical fertilizers by farmers. However, these fertilizers when there are within the reach of farmers, there is lack of control over their tis can leads to risks that can disrupt the environmental balance. In the other hand, diseases encountered in the fields are caused by some cultural practices that maintain the development, proliferation or reduction of the pathogens responsible for these diseases, as well as on the parameters that govern the development of epidemics (Thurston, 1992; Tompkins et al., 1992; Reid et al., 2004). Organic amendments and composting can affect the inoculum which is the primary source of disease infestation in the field (Thurston, 1992; Compaore et al., 2010).

On the other hand, the addition of certain mineral and organic fertilizers can lead to the rapid development of plants, making them more or less susceptible to attack by pathogens (Thresh, 1982; Nawal et al., 2014; Abiodum et al., 2015). Despite the knowledge about the relationship between fertilizer application and diseases expression, fertilizer application is adopted by farmers in Cameroon just to increase their crop yield. But, little information is available on the effect of this applied fertilizer on the incidence and severity of diseases of potato. Nevertheless, knowledge of host nutrition in relation to disease development provides a basis for modifying current agricultural practices to reduce disease incidence and severity.

It is necessary to implement strategies aimed at improving agricultural production that are based on the respect of ecological, economic and toxicological functionalities in the context of food security and environmental protection. Hence bio fertilization by the use of mycorrhizae, is more resistant to pathogenic bacterial and fungi attacks and exposure to soil toxins (Moser and Haselwandter, 1983; Ngonkeu, 2003; Gnamkoulamba et al., 2018) and organic fertilization by the use of chicken droppings that provide more mineral elements (potassium) improves plant resistance to pathogens and environmental balance. Therefore, a study was undertaken with the general objective of evaluating the impact of fertilizers (mycorrhizae and chicken droppings) on the development of potato viral, bacterial diseases in the district of Mogodé (Mayo-Tsanaga) Far-North, Cameroon.

II. MATERIALS AND METHODS

Plant material and Fertilizers

The plant material used for this trial was a local variety of potato (Dosa). Its development cycle is three (3) months. It has a round shape, white skin and flowers.

The mycorrhizal inoculum used for this work consisted of a mixture of spores from fungi of the genera *Glomus* and *Gigaspora*. It was provided by the Nkolbisson Biotechnology Centre of the University of Yaoundé I.

The organic manure used was chicken droppings from the Teufack Poultry Farm in Mokolo.

The chemical fertilizer used was NPK (20-10-10) as a maintenance and background fertilizer.

Experimental design

The experimental design was in completely randomized blocks. Each block consisted of 4 treatments constituting plot units repeated three times each. The fertilizer treatments consisted of: Mycorrhizae (MYC), chemical fertilizer (NPK); Chicken droppings (CD) and control (T) that received no application. Each site had a total of 60 plants per plot unit. That is 160 plants per block and 480 plants per site. A total of approximately 960 potato plants were used to set up the trial at the two sites. Each plot was 5m long and 5m wide. The plots were 1m long and 2m wide. Each site had an area of 525 m^2, 25 m long and 21m wide.

Seeding and fertilizer application

The sowing was direct seeding with 80 cm between rows and 25 cm between bunches at a rate of one pre-germinated tuber per bunch. The depth of sowing was about 2-3 cm.

For mycorrhizae (MYC), the method used was coating. Ten (10g) of inoculum was applied with the tubers and per pot at the time of sowing. For the treatment of chicken droppings (CD), 200 g of were taken and applied per bunch at sowing. Twenty (20 g) of NPK was applied per bunch 30 days after sowing. The control treatment (T) did not received any application during the entire study.

Evaluation of the effect of treatments on the development of diseases

Incidence and severity were measured to assess the development of the diseases identified in the treatments. Environmental parameters were quantified by monitoring rainfall at both sites.

Assessment of incidence

Incidence of diseases were evaluated using the following formula: $\boldsymbol{I}(\%) = \frac{\boldsymbol{np}}{\boldsymbol{N}} \times \mathbf{100}$ where, I is incidence; np number of plants showing symptoms per plot ; and N total number of plant in plot

Assessment of severity

The severity of the disease was assessed by estimating the leaf area occupied by the symptoms of the disease using the formula: $\textbf{Sé}\boldsymbol{v}\textbf{é}\boldsymbol{rit}\text{é} = \frac{\sum \boldsymbol{n} \textbf{ X } \boldsymbol{I}}{\boldsymbol{N}} \times \mathbf{100}$

Where Σ is the sum of the products between the number of diseased plants (a) and the number of plants with the index given in% (b). N is the total number of plants in the plot The severity index was used as an estimation scale: 0=no symptoms; 1/4 of the diseased leaf corresponds to 25%; 2/4=50% of the attacked leaf; 3/4=75% and 4/4=100% of the diseased leaves. The number of diseased leaves per plant was associated with this index.

Quantification of the environment

The evaluation of rainfall provides information on the degree of precipitation that can influence the state of crop planting and the evolution of the disease. The data were collected using two rain gauges installed in the middle of the fields in Mouvou and Gouria. Each rain gauge consisted of a conical tube, hung on a wooden support. Rainfall was measured after each rainfall.

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) and means were separated using the Duncan's multiple range test (5%). SPSS 16.0 software was used to perform the statistical analyses.

III. RESULTS AND DISCUSSION

Diseases identified by site

Table 1: Diseases identified in the Mouvou and Gouria sites (Ngoh Dooh et al. 2020 in Press)

	MOUVOU	GOURIA
Viral diseases	Virose M Rust stain	PLRV Virose M Rust stain
Bacterial diseases		Bacterial wilt Common Scab

Impact of fertilizers on the incidence of diseases in the field

Incidence of Virosis M

The analysis carried out revealed a statistically significant difference (P=0.02) between treatments, with the highest incidences obtained with the MYC treatments, 18.91 % and 16.83% respectively in Mouvou and Gouria. But, in Gouria incidence was 18.91 %. In control, incidence was higher in Mouvou,15%, than in Gouria, 5 % (Figure 1).

Impact of treatments on the incidence of Rust Stain

The analysis performed showed that the treatments significantly (P=0.013) influenced the incidence of the disease in both sites. The highest incidence was obtained in Gouria with the MYC treatment, 10.44 % in contrast to the CD treatment. In contrast, in Mouvou, the highest incidence was obtained with the NPK treatment, 8.88 % while in CD treatment incidence was low 2.22 % (Figure 1).

Impact of treatments on the incidence of PLRV

The incidence was highest with the NPK treatment 5.55 % than in control 3 %. On the contrary, in MYC and NPK treatments the disease was absent in Gouria. (Figure 1). This disease was absent in Mouvou site.

Impact of treatments on the incidence of bacterial wilt

The treatments applied significantly influenced (P= 0.03) the average incidence of the disease in Gouria. The highest incidence was obtained with the NPK treatment, 5.55 %. In control, incidence was about 2.3 %. In MYC and CD treatment in Gourai as well as all treatments in Mouvou, disease was absent (Figure 1).

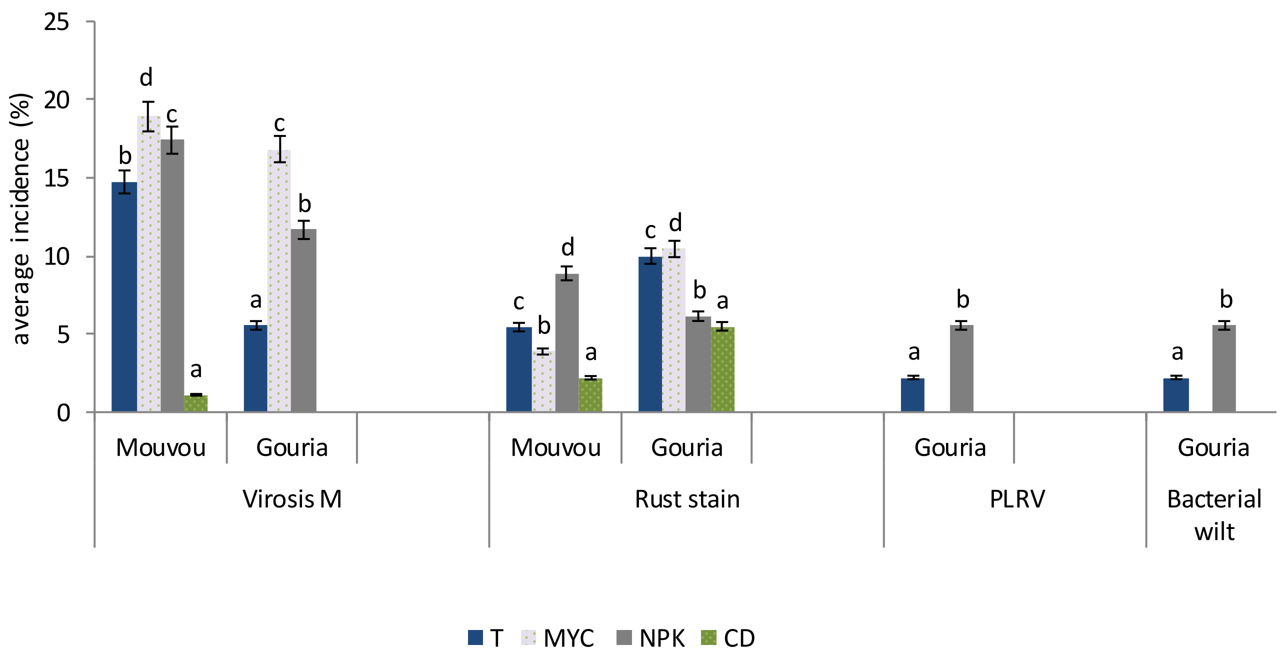

Fig.1: disease incidences at both sites.

T= control; MYC= mycorrhizae; NPK= chemical fertilizers; CD = chicken dropping
Values followed by the same letter in the same site are not significantly different at the 5% threshold according to Duncan's test.

Impact of treatments on severity of diseases in the field

Impact of treatments on the severity of Virosis M

The analysis performed showed a statistically significant difference (P=0.003) between the different treatments applied. This analysis showed that, in Mouvou, the highest severity was obtained with the control treatment and NPK, 27.94±5.08 and 27,45±5,01 % respectively, while in CD treatment it was 11.08±2.14%. In the Gouria site, the MYC treatment obtained the highest severity, 10.97±3.03 %. Disease was absent in CD treatment (Table 2).

Impact of treatments on the severity of Rust Stain

Statistical analyses show significant difference between treatments (P < 0.05 %) in the two sites. Highest severities, 21.11±10.58 % and 20.65±5.15 % were obtained with the control and MYC treatments respectively in Gouria and Mouvou. In CD treatment in Mouvou, severity was low, 9.67±1.1 % (Table 2).

Impact of treatments on the severity of PLRV

The analysis carried out showed that there is no statistically significant difference (P=0.70) between the different treatments applied to Gouria. It emerged from this analysis that the highest severity was obtained with the NPK treatment, 10.33% in contrast to the MYC and FP treatment where the disease was absent. The control treatment obtained the average severity of 8 % (Table 2).

Effect of treatments on the severity of bacterial wilt

The treatments applied had a significant influence (P=0.03) on the severity of the disease in Gouria. This analysis shows that the highest severities were obtained with the control and NPK treatments, 10.33% and 8.65% respectively. The disease was absent in the MYC and CD treatments (Table 2).

Table 2: severity of different diseases in the two sites.

Sites	Diseases	Treatments			
		T	MYC	NPK	CD
Mouvou	Virosis M	27.94±2.08c	24.89±1.9^b	27.45±2.01^c	11.08±2.14^a
	Rust stain	9.83±1.3^c	20.65±1.5^d	14.16±1.01^a	9.67±2.51^b
Gouria	Virosis M	8.33±1.15^a	10.97±3.73^b	10.71±2.22^b	*
	Rust stain	21.11±2.58^c	12.35±1.0^a	18.33±1,9^b	18±3.1^b
	PLRV	8.0^a	*	10,33^b	*
	Bacterial wilt	8.65^a	*	10,33^b	*

T= control; MYC = mycorrhizae; NPK= chemical fertilizers; CD = chicken droppings.
Values followed by the same letter in the same disease are not significantly different at the 5% threshold according to Duncan's test.
*Means that the disease was absent in the treatment.

Evolution of rainfall in the two study sites

Rainfall was ranged from 0 mm (week 1 of June) to 1620 mm (week 2 of September) at the Mouvou site with a peak of 1620 mm observed in the second week of September and from 0 mm (week 1 of June) to 1800 mm (week 1 of September) with a peak of 1800 mm observed in the first week of September at the Gouria site. Average rainfall was higher at the Gouria site (716.5mm) than in Mouvou site, which received (679 mm) (Figure 2).

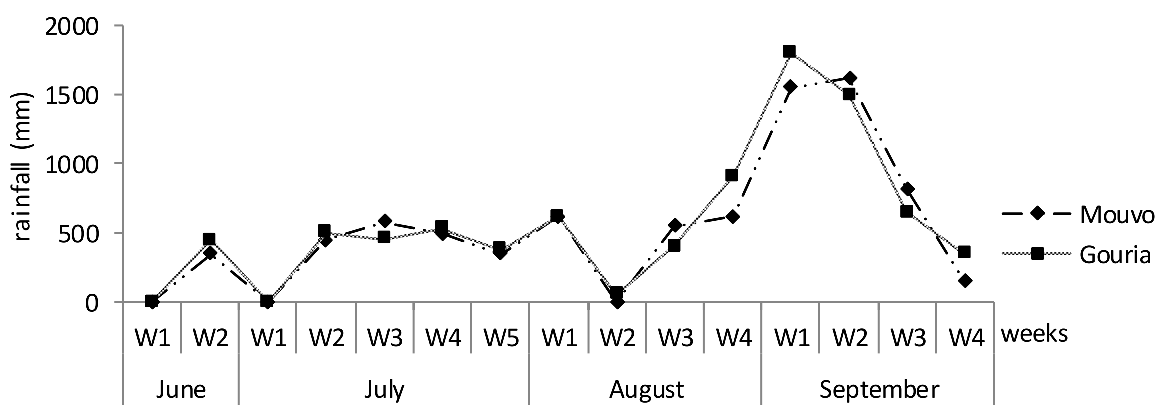

Fig.2: Evolution of rainfall in the two study sites.

IV. DISCUSSION

The present work was based on the evaluation of the impact of bio (mycorrhizae), organic (chicken droppings) and chemical (NPK) fertilizers on the development of viral, bacterial and pest diseases of potato crops in the district of Mogodé (Mayo-Tsanaga) Far North, Cameroon. Results obtained in the field showed that potato production is confronted with viral (Virosis M, Rust Stain and PLRV), bacterial (Bacterial Wilt and common scab), ringworm and pest (lepidopteran larvae) diseases. These attacks occurred after germination, and mainly during the phases of vegetative growth, flowering, fruiting-maturation and harvesting. These results corroborate those of Mulger and Turkensteen, (2005) and Chiunga and Valkonen (2013). According to these authors, the vegetative propagation mode per tuber favours a greater spread of pathogens than by seed multiplication and it is not rare for a tuber to harbour several pathogens.

Numerous viral diseases and pests such as Virosis M and rust stain were respectively observed during the vegetative growth and flowering phase. This can be explained by the fact that the presence of young leaves, fruiting organs and characteristic odours attract many insects that are vectors of viral diseases. N'gbesso et al, (2013), (Lepoivre (2003) and Chiunga and Valkonen (2013) have also showed that the flowers of many plants attract pollinating insects that are considered as vector agents of viral diseases.

The almost homogeneous distribution of viral diseases under all treatments in the two sites is explained by the fact that both sites are located in the same agro-ecological zone (Sudano-Sahelian zone), and therefore, there is the presence of similar vector agents (insects) responsible for the transmission of viral diseases disseminated in the zone. This result corroborates that of Traoré (1997) who has found that in the sahelian zone, insects are more abundant and therefore responsible for the transmission of many viral diseases. Ngoko, (1994) in his work, highlighted the presence of grey spot (viral disease) in all the agro-ecological zones of Cameroon.

The treatments applied influenced the development of the diseases identified in the two study sites. The incidence and severity of the viral diseases were low in the CD and MYC treatments in the control. In the CD treatment, the low rate of M virus and rust stain was explained by the effectiveness of the chicken droppings which provided more mineral elements (e.g. potassium) that improved plant resistance to pathogens and reduced both soil and leaf pathogens. These results are in agreement with those of Hachicha et al. (1992), Compaoré et al. (2010) who have shown that, many minerals like phosphorus and potassium can enhanced resistance of plant in field

On contrary, higher incidence obtained in NPK can be explain by solidity or well being of plant which attracked insects, vectors for pollinisation and viral diseases (Issa et al. 2017). In fact, a potash deficiency will have a direct impact on the maintenance of cell turgidity and thus the regulation of water in the plant. Potash will also be essential for the quality of tuberization. Finally, it will enable the plant to increase its natural resistance, particularly against frost, disease and drought (Reid et al., 2004). In the other hand, under- or over-fertilization of nitrogen is detrimental to crop productivity. In underdose, it does not allow the plant to have an optimal growth. In over-dose it will favour an over-abundant foliage which will be favourable to the development of diseases and will delay maturity and harvest. Nitrogen remains nevertheless essential to ensure good growth (Son et al., 2018).

V. CONCLUSION

The incidence and severity of diseases were almost 0 % in the CD treatment as compared to the control, NPK and MYC treatments. The CD treatment proved to be the most beneficial treatment in terms of potato phytosanitary protection.

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