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Effect of Organic Fertilizers on the Susceptibility of Tomato *Lycopersicon esculentum*: Solanaceae to *Helicoverpa armigera* Lepidoptera: Noctuidae in the Niayes Area Senegal.

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Abstract: The aim of this study is to compare the effects of organic manures on tomato (*Lycopersicon esculentum* var. *Mongal*) by analyzing their impact on the yield, dry-matter, and the susceptibility of tomato to *Helicoverpa armigera* Hübner (Lepidoptera, Noctuidae) in Niayes area (Senegal) Under pesticide free condition. The experimental design was set in complete random block with 7 treatments. The overall yield varied between 30.4t/ha with the horse dung treatment and 24.5t/ha with the untreated. The Poultry and Groundnut manures recorded the highest losses due to damages by *H. armigera* respectively 13.3 and 13.2t/ha. The Horse and Fish manures were the least affected by the pest (9.7 and 10.1t/ha) and therefore recorded the highest net yields respectively 20.7 and 17.7 t/ha. However the Cow and Sheep manures showed more dry-matter to tomato fruit conferring them a longer shelf-life. The horse dung based-fertilizer is highly recommended in tomato farming in the sahelian agroecosystems. The chemistry of the manures in relation to the plant performance is discussed in this paper. A combination of the organic manure is suggested to improve the sustainability of soil fertility and crop productivity.

Key words: *Helicoverpa armigera*, manures, vegetables, Organic farming, urban agriculture.

INTRODUCTION

In Senegal horticulture is an important source of income. Tomato *Lycopersicon esculentum* L. Solanaceae is one of the most important cultivated crop and there is a high demand of this vegetable which is almost used in all local dishes. The world average productivity of tomato is around 14t/Ha[3]. In Senegal, during 2008-2009, the industrial scale of tomato production was about 87,988 tons for a surface of 2510 ha[12]. However, tomato farming encounters some constraints such as soil degradation and salinity, excessive drought aggravated by the scarcity of rainfall. The level of salinity in the Niayes is very high because of the incursion of marine water into the continental water. On the other hand, the reductions of farming fields due to land grabbing and pest pressure are likely the common current situation in all horticultural areas. Regarding the pest, *H. armigera* (Lepidoptera, Noctuidae) is the most important on tomato. In Senegal, this noctuid became since the 80's one of the main pest in the vegetable agro ecosystems. *H. armigera* is a polyphagous pest with a wide host-plant range including: Cotton, corn, sorghum, millet, beans tomato, potato, eggplant, etc.[5]. Chemical control is the major management tool for *H. armigera*, with harmful drawbacks on the environment and human health. Therefore considering all these constraints afore mentioned, farmers rely on the use of organic fertilizers to avoid high salinity but also to increase crop yield. Studies showed that the use of organic fertilizers can boost plant growth and improve soil fertility[7,10] and its productivity[8].The Senegalese farmers early realized the importance of plant sanitation by using various organic manure because it is cost effective and environmentally friendly. However the impact of these organic manures on pest management is poorly studied. Therefore the rationale of this study is to compare the effect of several manures on tomato especially the impacts on the yield, quality of fruits and susceptibility to pest attack under synthetic chemical free condition.

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MATERIALS AND METHODS

Study Site: The experiment was conducted at Pikine area, in Dakar (Senegal) on the fallowing plots located in plate, during the dry season between February and March 2007. The site is located in the isohyets 200-300 mm. The climate is a sahelian type with two distinct seasons: a long dry season from November to June with monthly average temperatures ranging between 15 °C and 20 °C and a short rainy season from July to October with monthly average temperatures varying between 25 °C and 35 °C. The study site is a part of the "Niayes". The soil type is a sandy tropical ferruginous, low in organic matter and often affected by wind and water erosion but particularly suitable for vegetable farming. The borehole water is almost superficial in that area.

Soil and Manures Analysis: Chemical analysis of soils and manures were conducted prior to planting. Three samples of soils were analyzed as well as the samples of manures at the chemistry laboratory of the Food Institute of Technology (ITA) in Senegal. Samples were collected from elementary plots and analyzed for their nitrogen, phosphorous and potassium content. The PH, the humidity, the conductivity and the rate of dry-matters were also assessed. Analysis was conducted according to the protocol[1] AOAC (1990).

Experimental Design: The experimental was set in complete random block design. The total number of elementary plots was 21. Plot dimension was 2m x 1.5 m = $3m^2$. Seven (7) treatments and three (3) repetitions were applied: Untreated (Without amendment), Sheep (sheep-dung manure of), Horse (Horse-dung manure), Fish (fish manure), Poultry (poultry dung), Cow (cow-dung), Groundnut (Groundnut hull).

The number of seedlings per plot was 12, spacing: 0.5 m. The experimental crop plant was tomato var. *Mongal*. The basic mineral fertilization was 200kg/ha for all the treatments. An amendment of 30 tons/ha of manure was applied. There was no synthetic chemical application and plants were irrigated with filtered and treated waste water.

Effects of Organic Manures on the Yield Estimation and Net Yield: The evaluation of the yield and the damage were carried out during the harvesting of the tomato fruits. In each plot, the overall yield was weighed and a sample of 2kg was analyzed and the perforated fruit were scored the proportion of loss was then evaluated. The net yield which the proportion of fruits to be sold has been assesses to have a figure of the economical impact.

Statistical Analysis: Data were analyzed using Statview 4.55[13] for ANOVA and mean separation (Fisher test) and the level of significance was 5%. A general linear model (GLM) was used performed and a correlation procedure was used to evaluate the relationship between tomato productivity and organic manures chemistry.

Results:

Chemical Analysis of the Soil and Organic Manures: The chemical analysis for the soil and the manure showed various patterns. The PH varied between 9.4 and 5.6 for respectively Sheep and Groundnut. The soil sample had almost the same PH than the Cow, Sheep and Horse treatment. Groundnut and Fish treatment were acid. The humidity was higher in Cow dung while the total Nitrogen was higher on Fish. The content in Phosphorus was more important on Fish and Sheep treatment and the lowest value was recorded on the control. The Fish treatment recorded the highest content in Potassium and the highest conductivity (Table I).

Effects of Organic Manures on the Yield Estimation and Net Yield: The overall tomato yield was more important in Horse and Cow manures 30.4 and 28.5 t/ha; the lowest yield of tomato was recorded on the untreated and Poultry respectively 24.5 and 25.9 T/Ha.

Damages of *H. Armigera* on Tomato: The Horse treatment recorded the lowest damages (9.7t/ha). More damages were observed on the fruits harvested from the Poultry and Groundnut treatments respectively 13.3 and 13.2t/ha. There was no significant difference between the various treatments regarding to damages. However the differences were economically significant. These results show that the level of losses could be reduced by applying the following amendments horse, fish and sheep (Table 2)

Effect of the Organic Manures on the Net Yield: From the total production the net yield (yield ready for sale) was more important in the Horse and Fish manure (Figure 5). The Horse treatment recorded the highest net yield 20.7 t/ha. The untreated and Poultry recorded the lowest net yield 12.7 and 12.6 t/ha. There was a significant difference in net yield between Horse and untreated and Horse Poultry treatments ($p = 0.05$, Fisher).

Effects of the Organic Manures on Dry-matter: The sheep and cow based manures recorded the highest rates of dry matter 32 and 33% meaning that these two manures confer a better shelf-life to tomato than the others. The lowest dry-matter content was observed on

Table 1: Chemical analysis of soil and tested organic manures

Treatments	PH (10%)	Humidity (g/100g)	Total nitrogen (mg/100g (*))	Phosphorus (mg/100g)	Potassium (mg/100g)	Conductivity (Mhos /cm ^{3})
Untreated	9.0	0.3	170	8.9	9.9	0.8
Sheep	9.4	15.4	1910	109.7	544.1	9.3
Cow	9.3	22.7	1810	77.6	1248.1	10.6
Groundnut	5.6	3.8	1600	23.0	653.0	4.6
Horse	9.2	18.9	700	39.5	1258.4	4.3
Poultry	8.9	17.0	1350	182.1	1088.4	10.6
Fish	6.8	14.2	6460	511.0	1410.7	10.9

(*): Total nitrogen stated from dry matter

Table 2: Effects of the organic manures on the overall yield, losses and net yield in t/ha.

	Overall yield	Losses	Net yield
Untreated	24.5±1.8	11.8±2.0	12.7±1.0
Groundnut	27.6±4.5	13.2±3.2	14.4±2.9
Horse	30.4±3.6	9.7±2.0	20.7±1.9
Sheep	25.8±3.6	12.4±3.1	13.4±2.2
Fish	27.8±2.6	10.1±1.5	17.7±1.5
Cow	28.5±2.4	12.5±2.7	16.0±1.0
Poultry	25.9±2.8	13.3±3.0	12.6±2.3

Table 3: Pearson correlation (r; p) between:tomato productivity and the chemical analysis of the organic manures.

	PH	Humidity	Phosphorus	Potassium	Conductivity	Nitrogen	Dry-matter
Overall yield	0.85	0.02	0.38	0.11	0.93	0.01	0.59
	0.06	0.83	0.02	0.6	0.07	0.97	0.0004
Net Yield	0.87	0.02	0.1	0.2	0.44	0.09	0.01
	0.3	0.96	0.005	0.44	0.09	0.92	0.01
Losses	0.92	0.01	0.38	0.11	0.59	0.06	0.59
	0.06	0.83	0.02	0.59	0.06	093	0.01

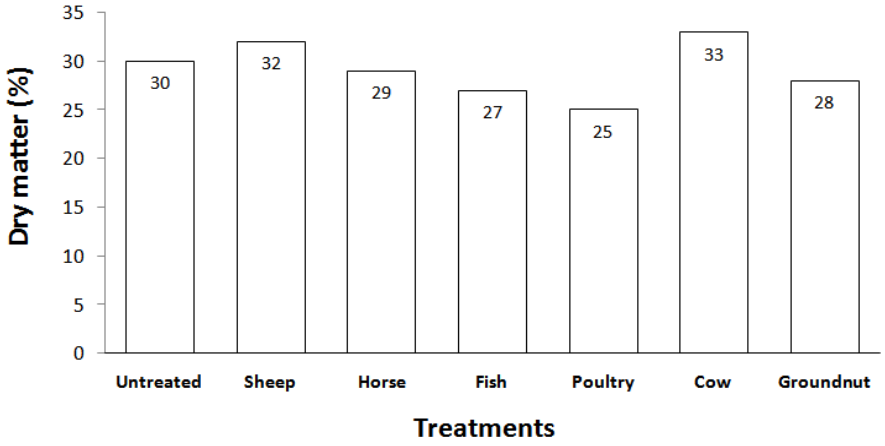

Fig. 1: Effect of treatments on the dry matter content. There was a significant difference between sheep-poultry, fish-cow (respectively p = 0.02 and p = 0.04; PLSD Fisher Test)

Poultry treatment 25%. There was a significant difference between Sheep and Poultry, ($p = 0.02$); Fish and Cow ($p = 0.04$); Poultry and Cow treatments ($p = 0.01$). Hence the treatments which confer a better shelf-life to tomato fruits are Cow, Sheep, Horse and Groundnut (Figure 6).

Discussions:

Effect on Soil Chemistry: Compared to untreated soil, the organic manures confer several patterns to the soil and provide various nutrients to the plant. The chemistry of the soil is affected in term of PH, conductivity and soluble salts. This variability in terms of nutrient definitely affected the physiology and productivity of the plant. Tomato plant requires some basic nutrients such as N, P K and other minor Mg and Ca. Organic manure like Fish, Poultry and Groundnut provide high level of nitrogen which can be very stressful to tomato[9]. The Fish manure had the highest content in N P K and the highest conductivity. The PH level with the Fish treatment was also acid which favorable to tomato plant. However, the cultivar *Mongal* has been shown to be salt sensitive[14]. Regarding the conductivity, the untreated soil and the horse manure had the lowest values respectively 0.76 and 4.33 Mhos/cm^3. The Horse manure showed High content of Potassium.

Effect of the Organic Manures on Plant Productivity: The mineralization process in the soil is also a very important step in soil fertility. The cattle manures are known to have a low process of mineralization especially Cow dung and Sheep dung. Horse manure is adapted to the process of tomato production in sandy soil. Horse and Fish manure confer to plants better conditions as attested by the yield and the net yield.

Tomato treated with Poultry manure showed a good overall yield. However the level of damages was very severe and the dry-matter was very low. Poultry manure can therefore be a suitable replacement for inorganic fertilizer in tomato production as it is natural and very accessible in the Niayes[2,3,11]. There was a correlation between the conductivity and the overall yield, net yield and losses (table 3).

Effect on the Plant Susceptibility: The experimental variety of tomato *Mongal* is known to be resistant to pest attacks. In the case of the Horse treatment, the plant can tolerate a certain threshold of damage without compromising the overall yield. Tomato fruits can regenerate and recover from perforations after insect attack and end up being marketable. As a result there were low levels of damages observed in Horse treatment. Comparatively to other treatments, the amendment containing horse dung offers higher net yields. These results confirm farmer's observations. It has been reported that Horse dung reduces eggplant parasites populations in the soil[6]. On the other hand Sheep and Cow treatment didn't contribute in reducing pest attacks.

Effects of the Organic Manures on Dry-matter: There was a difference in terms of dry-matter content. The treatments which give a better shelf-life to tomato fruits are by order of importance the amendments cattle manures (Cow, Sheep and Horse) and Groundnut and Fish (figure 1). It has been showed that manures with high Nitrogen content increase the level of water in the fruit. Potassium plays an important role in the taste and dry-matter. The Horse manure had the highest content of Potassium. The balance N/K is a paramount key in the quality of fruits as far as tomato is concerned[4]. Fish and Poultry recorded the lowest dry-matter. At the same time those manures had high content of Nitrogen and low PH. They also had the highest content in Phosphorus (table 1). This variability of nutrient affected the dry matter, therefore the quality of the fruit as shown on table 3: there was a very strong correlation between the dry-matter and the productivity ($r > 0.9$).

Conclusion: Tomato (*Lycopersicum esculentum*) responded strongly to organic fertilization, giving the following increase in yield. This study highlighted the importance of pest control; with no pesticide application, *H. armigera* affects drastically vegetable production. However the use of organic manure like horse and Fish dung manure can reduce the level of loss up to 24%, compared to Sheep dung manure whereby half of the yield is lost. Even if difference were not significant, at a larger scale (t/ha) it can be significantly lucrative to the farmer. The suggestion that comes out of this study is possibly to advise farmers to use also combination of those manures with the Horse, Cow and Sheep to enhance the productivity. It is also recommendable to use those manures (Fish, Poultry and Groundnut) in a second line when the effects of the cattle manures are fading.

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