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Evaluation of productivity of tomatoes under the effect of fertilization in tropical zone : Case study of Lubumbashi

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Abstract: Tomato is one of the market gardening cultures still present in the daily dishes of populations of the planet. Varietal improvement and soil infertility forced market gardeners to develop new cultivation techniques. It is with the aim of proposing a new combination of tomato-fertilizer that this study was conducted. A factorial test (3 * 4) was installed to evaluate and determine the best treatment. During the experiment, phenological and yield parameters were observed. The result is no statistical difference between the different combinations, however, the average yield was higher than the global average of more than 25 tonnes for this study. While soil tests indicate that it is deficient in major chemical elements, hence the recommendation to always fertilize before placing crops. This study demonstrates that with strict monitoring, the crop is profitable for market gardeners and also proves that it is possible to substitute mineral fertilization with organic fertilizer.

Keywords: Tomato, fertilizers, factorial, yield and varieties

Introduction

Tomato's an excellent fruit vegetable source of nutrients involved in maintaining the best health form in humans (Bresy et *al*., 2013). This culture's more appreciated by its content a vitamins, carotenoids, phenolic compounds and organic acids (Giovanelli & Paradiso, 2002). Its nutritional importance and its addiction to many dishes makes it one of the most widely practiced cultures around the world (Al-Harbi et *al*., 2016). According to FAO estimates, tomatoes rank third after potatoes and sweet potatoes, according to FAO estimates (FAO, 2002). Farmers in tropical regions are stuck with the lack of modern conservation techniques for fresh tomatoes. Knowing that the tomato continues after harvest and that chlorophyll degrades and is replaced by carotenoid (Liu et *al*., 2009). For consumers, in fact, the two quality attributes sought are the texture and the color of the skin (Muzingu, 2010). This deterioration of quality during the period of conservation, distribution and sale becomes a major constraint causing enormous losses (Batu, 2004). Due to rapid population growth, crop production has to increase significantly (Nyembo et *al*., 2012) and at any time. Knowledge of high susceptibility to pest and disease attacks in tomato growing (Fontem, 2003). Maintaining a production of fresh tomatoes at all times of the year, requires market gardeners the right choice of varieties (Kitabala et *al*., 2016). On the other hand, the soils of sub-Saharan African countries with low intrinsic fertility (Nyembo et *al*., 2013), the choice of the type of fertilizer and the optimal dose becomes paramount (Borguini et *al*., 2013 ; Roose et *al*., 2008 ;). Knowing that the nutrients exported by crops are not adequately replaced by farmers. Market gardeners are called to develop farming practices (Chuimika et *al*., 2015). It is in this order of idearsthat this study was inscribed in order to find a durable solution to farmers' needs and aims to evaluate the performance of two tomatoes varieties under fertilization. The hypotheses used in this study are such that the choice of varieties has an influence on the behavior of the tomato crop and that the fertilization effectively contributes to the improvement of crop yield.

Materials and method

Biological materials

Three varieties of tomatoes obtained on the local market have been selected as biological materials for this study, the characteristics of each of which are given in the table below.

Table 1. Caracteristique of three varieties of tomatoes

Varieties	Germinability	Moisture	Purity	Sensitivity	Fruit	Productivity
Roma	85%	8%	90%	Average	Full	High
Tengeru	90%	8%	95%	Average	Full	High
Rodade	90%	8%	95%	Average	Full	High

Fertilization consisted of the application of mineral fertilizer doses commonly used by farmers, the input of chicken manure and the use of a liquid fertilizer (D. i.grow).

Methodology

The applicability of this test required the installation of a factorial experiment (3 * 4) as an experimental device in three repetitions. The main factors, numbering three, consisted of varieties of tomatoes, while the secondary ones included the different doses of fertilizer. The experimental unit was a rectangular plot of $1.2m^2$ surface area where tomatoes were transplanted at 50 * 40 cm spacings. The sowing of tomato varieties was carried out on a plot of $1m^2$ for each variety, and considered as a nursery. Maintenance work such as watering and weeding was carried out as and when needed, after a month in the nursery vigorous seedlings were put in permanent parcels. The tomato varieties and fertilizer doses used during this study and according to the treatments are: V1: Roma, V2: Tengeru and V3: Rodade; and D1: 20 $t.ha^{-1}$ of chicken manure, D2: 450 $kg.ha^{-1}$of NPK (10-20-10), D3: 20 t of chicken manure + 375 l of solution of D. i. $grow.ha^{-1}$and D4: 450 kg of NPK (10-20-10) + 375 l of solution of D. i. $grow.ha^{-1}$in combination with the three varieties of tomatoes. The dilution of D. i. grow was made because of 3 l concentrate in $1m^3$ of water, while in the nursery the tomato seedlings were successful 150 kg of $NPK.ha^{-1}$ as fertilizers.

In final plot, maintenance on tomato seedlings consisted of regular watering according to the needs of the crop and growth phases, weeding at the onset of weeds and hoeing-ridging. Depending on the pest and pest attacks and on a preventive basis, the application of pesticides was carried out on all plots with regard to the varieties and fertilizers. Before development and installation of plots for experimentation, a composite soil sample was taken and submitted to the laboratory for chemical analysis. During the experiment, observations and sampling focused on phenological and yield parameters, and the data from this sample were subjected to two-way variance analysis.

Result

Analysis of the composite soil sample before experimentation

The laboratory analyzes on the chemical composition of the soil sample, reveals the result below presented in the table.

Table 2: Mineral composition of the experimental soil

pH KCl	**Content available**		**Total content**							
	%		%		µg					
4,71	N	P	K	Fe	Mn	Zn	Cu	Ba	Zr	Cr
	0,14	9,46	1,73	4,78	426	53	173	603	468	53

Resumption and survival of tomato seedlings according to the choice of varieties and fertilizer supply

No significant differences were observed in the analysis of the variance on post-transplant tomato uptake rate and number of plants surviving 90 days.

Table 3: Rate of recovery and survival of tomatoes under fertilization and varietal choice

Variety	Amendment	Rate recovery 15j	Survival rate 90j
V1	D1	70.0±1.3	48.3±2.2
	D2	70.0±1.0	58.3±1.5
	D3	80.0±1.2	31.6±1.5
	D4	73.3±1.5	53.3±2.2
	Mean	73.3±3.0	47.9±1.6
V2	D1	93.3±1.5	76.6±2.2
	D2	66.6±1.2	56.6±1.5
	D3	86.6±0.7	40.0±0.6
	D4	93.3±1.5	75.0±2.9
	Mean	85.0±1.0	62.0±2.0
V3	D1	93.3±0.7	66.6±1.5
	D2	80.0±1.3	66.6±2.2
	D3	76.6±1.5	53.3±2.1
	D4	70.0±0.0	56.6±0.7
	Mean	80.0±1.7	60.8±1.2
Moyenne fumure	D1	85.5±1.9	63.8±1.9
	D2	72.2±1.9	60.5 ±1.2
	D3	81.1±1.6	41.6±1.5
	D4	78.8± 1.6	61.6±1.6a
Variety effect		0.0882	0.1224
Manure effect		0.1708	0.0526
Interaction		0.1379	0.6075

Evolution of the number of leaves according to the choice of varieties and application of fertilizers.

After analysis of the variance in the number of leaves at different sampling dates, it appears that fertilizer intake significantly influenced, whereas the choice of varieties and their interaction had no effect on the 60th day. .

Table 4: Influence of the choice of varieties and fertilizer supply on the evolution of the number of leaves.

Varieties	**Amendment**	**Nb15 th day**	**Nbl30 th day**	**Nbl45 th day**	**Nbl60th day**
V1	D1	5.6±1.3	10.1±1.3	19.2±0.3	15.5±0.2b
	D2	4.6±0.2	9.6±1.1	25.8±0.7	41.0±0.5a
	D3	5.0±1.0	7.1±0.2	12.1±1.4	9.9±0.2b
	D4	4.1±0.2	7.5±0.4	16.0 ±0.1	29.9±0.3a
	Mean	4.8±1.0	8.5±1.0	18.3±0.3	24.1±1.5b
V2	D1	5.5±0.7	8.8 ±1.2	20.2±0.3	21.8±0.3b
	D2	4.8±0.3	8.9±1.2	14.6±0.4	48.1±1.1a
	D3	3.4±0.4	5.7±0.3	24.6±1.2	28.3±0.1b
	D4	4.0±0.0	7.3±0.1	21.8±1.1	41.3±0.1a
	Mean	4.4±0.2	7.7±0.7	20.3±1.4	34.8±1.7a
V3	D1	5.5±1.0	9.5±1.1	16.6±1.0	22.1±0.1b
	D2	4.5±0.4	8.9±1.4	22.4±0.0	28.7±1.74b
	D3	4.2±0.3	8.4±0.2	17.1±1.0	29.7±1.6b
	D4	3.6±0.1	7.9±1.2	26.1±0.1	50.0±1.5a

	Mean	4.5±1.0	7.9±1.2	20.6±1.3	32.6±1.6a
Manure effect	D1	5.5±1.2a	9.4±1.2a	18.7±0.3	19.82±0.5b
	D2	4.6±0.4ab	9.1±1.3a	20.9±1.3	39.3±1.4a
	D3	4.2 ±1.0b	7.1±1.2b	17.9±0.4	22.6±0.8b
	D4	3.9 ±0.2ab	7.6 ±0.4ab	21.3 ±0.3	40.4±1.1a
Variety effect		0.46372	0.25693	0.6150	0.00859
Manure effect		0.00262	0.00707	0.5822	6.97e-06
Interaction		0.62627	0.77861	0.0485	0.02291

Evolution of height of tomato plants due to the choice of varieties and fertilizer input

The growth of tomatoes was more influenced by the choice of varieties and the application of fertilizers. Thus, significant differences were obtained at different dates under the influence of varieties, while the interaction had no influence on plant growth.

Table 5: Influence of varietal choice and fertilizer supply on the evolution of the height of tomato plants.
Legend : Hp : height ot plant

Varieties	Amendement	Hp5 th day	Hp30 th day	Hp45 th day	Hp60 th day
V1	D1	15.6±2.5	32.70±0.5	47.8±1.5	54.4±1.6
	D2	15.5±1.5	39.9±3.0	50.6±1.2	58.4±1.3
	D3	14.9±2.6	37.2±1.2	46.9±1.4	57.5±1.2
	D4	14.4±0.9	32.6±0.2	39.4±0.3	52.9±0.3
	Mean	15.1±0.1ab	35.6±1.0b	46.2±1.0	55.8±1.3ab
V2	D1	14.5±1.3	32.6±1.1	36.3±1.4	45.5±1.2
	D2	18.1±3.2	48.3±0.6	55.3±0.3	61.6±1.1
	D3	11.7±1.1	28.7±1.1	32.6±1.2	40.8±1.1
	D4	11.9±1.1	40.0±0.3	43.8±1.1	59.5±0.2
	Mean	14.1±1.2b	37.4±1.1ab	42.0±1.0	51.9±1.4b
V3	D1	19.0±1.4	39.4±0.8	41.8±1.2	52.9±0.6
	D2	16.7±1.4	45.6±0.4	53.1±0.2	64.8±1.1
	D3	17.4±1.3	39.5±1.2	47.5±1.4	54.9±1.4
	D4	15.2±1.7	42.4±1.0	49.0±1.3	61.3±1.3
	Mean	17.1±1.2a	41.7±0.4a	47.9±1.2	58.5±1.1a
Manure effect	D1	16.4±0.7	34.9±1.2b	41.9±0.5b	50.9±1.2b
	D2	16.8±0.2	44.6±1.1a	53.0 ±0.2a	61.6 ±1.2a
	D3	14.7±1.1	35.1±1.2b	42.3±1.4b	51.1±1.3b
	D4	13.8±1.2	38.3±1.3ab	44.1 ±1.3ab	57.9 ±1.1ab
Variety effect		0.0315	0.012724	0.11512	0.03972
Manure effect		0.0808	0.000626	0.00642	0.00156
Interaction		0.3076	0.065984	0.09403	0.05397

Observation of yield parameters according to variety selection and fertilization

After calculation of yield and statistical analysis, this result shows that the averages are statistically similar in terms of variety selection, fertilizer application and interaction. Below is the table showing the influence of each of the treatment components and the behavior of observed parameters. The letters accompanying the averages, if different, reveal the significant difference.

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Table 6: Influence of variety selection and fertilizer input on yield parameters. Legend: Nfp : Number of flowers per plant, Nfr: Number of fruits produced per plant, W: Meantomato weight in grams and Y: Yield in tonnes / hectare.

Varieties	Amendement	Nfp50thday	Nfp 80 th day	Nfr60 th day	Nfr90 th day	W (g)	Y (t/ha)
V1	D1	8.3±1.1	1.3±0.3	5.2±1.1	17.2±1.2	26.8±1.4	34.3±1.1
	D2	5.9±0.1	10.3 ±1.2	12.5±1.2	20.5±1.2	42.9±1.3	20.7±1.2
	D3	1.7±1.2	1.0±0.3	2.3±0.5	15.1±1.5	37.7±1.4	22.4±1.3
	D4	2.8±0.4	7.8 ±1.6	8.4±1.1	20.2±1.3	43.5±1.1	23.2±1.2
	Mean	4.7±1.2	5.1±1.3b	7.2±1.7	18.3±1.3	37.7±1.6	25.2±1.5
V2	D1	5.1±0.2	5.9 ±0.4	3.8 ±1.2	16.2±1.2	44.8±1.2	31.4±1.4
	D2	3.3±0.3	18.7±1.9	9.7±1.3	20.3±1.1	44.12±1.1	22.2±1.3
	D3	3.3±0.3	8.4 ±1.2	4.3±1.1	17.0±1.7	38.8±1.3	25.7±1.2
	D4	5.4±1.2	21.3±1.3	4.8±1.0	13.7±1.5	45.6±1.5	32.3±1.5
	Mean	4.3±1.1	13.6±1.8a	5.64 ±3.51	16.8±1.4	43.4±1.5	27.9±1.3
V3	D1	4.6±1.3	8.2±1.6	4.7±0.2	15.7±1.7	43.9±1.3	29.7±1.2
	D2	5.1±0.1	12.1±1.4	11.1±1.3	20.0±1.4	48.7±1.6	28.0±1.3
	D3	3.9±0.5	4.9±0.1	3.7±1.2	14.9±1.3	48.7±1.7	28.0±1.5
	D4	4.9±1.0	18.301.3	7.7±0.2	21.0±1.3	49.7±1.2	25.3±1.3
	Mean	4.6±0.5	10.87 ±1.4a	6.8±1.3	17.9±1.5	47.8±1.6	27.8±1.2
Manure effect	D1	5.9±1.3	5.2±1.4b	4.5± 1.1	16.4±1.4	38.5±1.6	31.8±1.1
	D2	4.8 ±1.3	13.7±1.7a	11.1±1.3a	20.3±1.2	45.3±1.4	23.6±1.2
	D3	2.9 ±1.2	4.8 ±1.3b	3.5±0.1b	15.7±1.5	41.7±1.4	25.4±1.3
	D4	4.4±1.4	15.8±1.5a	6.9±1.2ab	18.3±1.5	46.3±1.3	26.9±1.3
Variety effect		0.930	0.001932	0.429	0.719	0.055	0.795
Manure effect		0.153	0.000108	3.04e-05	0.184	0.324	0.460
interaction		0.329	0.600632	0.725	0.639	0.705	0.912

Discussion

After analysis of the variance of data on the recovery of tomato plants, no significant difference was found between the treatments. However, a low rate of recovery was observed with regard to the selection of plants before transplantation. This good performance of seedlings during the transplantation phase could be due to favorable climatic conditions. Indeed, climatic conditions strongly influence crop behavior, particularly in their most critical phase (Nzila et *al*., 2007 ; Moreno et *al*., 2009). Knowing that newly transplanted seedlings do not yet have a developed root system, their survival is only influenced by climatic factors (Moreno & Moreno, 2008). At the end of ninety days after transplantation, a huge loss was observed, a loss that could come from pathogen attacks. Tomato is one of the most pathogen-sensitive crops (Sbartai et *al*., 2011), so during the experiment a variety of pathogenic organisms in the crop were observed. As for vegetative parameters during cultivation, there was a large increase in the number of leaves for the Rodade variety than the other two varieties. While for fertilization, it is more plants that received the organic amendments that behaved well with a higher number of leaves. The explanation would be that for the varieties the vegetative growth would be more a function of the genetic heritage of the variety and extrinsic factors (Nyembo, 2010). However, organic fertilization provides more mineral elements than synthesis and this diversity, the synergy between elements promotes rapid growth (Useni et *al*., 2014 ; Mulaji, 2011). The result on the number of flowers reveals that the variety V3 carried more flowers, paradoxically a number of fruits similar to the other two varieties. The fact is that a large number of flowers eventually abort. Fertilization showed a significant difference with the addition of D. i. grow which allowed the strong flowering and a higher number of fruits to sixty days. It was then the fruit weight and the yield calculation were similar with respect to varieties, fertilizers and their combination, the convincing explanation would be that the treatments carried more fruits were also the most attacked by the pathogens.

Conclusion

The objective of this study was to evaluate the behavior of tomato varieties under fertilizer. For this purpose, three tomato varieties were selected and combined with four fertilizer doses. Thus, a factorial device (3 * 4) was installed in three repetitions and during the experiment, the vegetative and yield parameters were revealed. It appears from the results after statistical analysis that the fertilization input and the choice of varieties influenced the vegetative parameters. It was then that the yield of the tomato remained similar with regard to varieties and fertilizers. This yield-based study proves that tomato is a speculation that allows farmers to harvest profitably because of its selling price in the local market.

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