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Effects of some local plants on conventional and natural production of tomato (*Solanum lycopersicum* L.)

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Abstract

The study of the valorization of the plants of our environment for agricultural purposes is likely to make it possible to spend less to produce and therefore better benefit from its agricultural activity, to make production more accessible to the greatest number, to preserve health people and nature in general against chemicals. The objective of this work is to compare conventional tomato production with the one obtained from natural plants to determine whether natural production cannot practically replace conventional production obtained from chemicals in a suitable manner. In this perspective, the tomato variety Nunhems was used, liquid manure from two leguminous plants *Acacia muricata* and *Gliricidia sepium*, *Tithonia diversifolia* and wood ash extract. Seven treatments were made up from the nursery, therefore the unfertilized and untreated control treatment T1, the fertilized treatments T2 and T3 based on *Acacia muricata* manure + *Tithonia diversifolia* manure and wood ash extract. Treatments T4 and T5 were fertilized with *Gliricidia sepium* manure + *Tithonia diversifolia* manure and wood ash extract and treatments T6 and T7 chemically fertilized with NPK (20-10-10) and ammonium sulphate. Treatments T2, T4 and T6 were treated naturally and treatments T3, T5 and T7 chemically against diseases and pests. After 25 days in the nursery, 5 best plants from each treatment were transplanted to a plot where they were planted in a completely randomised block. Growth, production, physical, phytopathological and entomological parameters were regularly recorded. Among others, the weight of 30 fruits (g) showed a significant difference between the different treatments. The control treatment T1 was characterised by the lowest average (73.20±66.86a) in this weight, while the highest averages were found in treatments T3 (173.00±3.16c) and T5 (174.00±3.16c). The control treatment T1 was characterised by the lowest average (16.8±15.38a) in total healthy leaves while the highest averages were found in treatments T3 (40±1.22d) and T4 (40.4±2.07d). At the end of the study it was found that organic fertilization and natural treatment against diseases and pests in tomato production were better from the tested plants.

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Introduction

Tomato (*Solanum lycopersicum* L.) is a popular, commercially and economically important horticultural product worldwide (Costa and Heuvelink, 2018; Sanja *et al.*, 2021). Although this culture is important, the quality and productivity of the majority of plants, notably tomatoes, depend on the one hand on growing conditions and chain conditions such as humidity and heat and on the other hand on the parasite pressure (Wang *et al.*, 2021; Yalaga *et al.*, 2021). Tomato is known as a plant that is very susceptible to pathogens and pests. In regions of humidity and heat, such as in Central Africa, growing tomatoes is a real challenge (Ukeh and Chiejina, 2012; Sanja *et al.*, 2021). In addition, diseases caused by pathogens and pests thrive in the same regions. Very often, the combination of these biotic and abiotic stresses (humidity, heat) is responsible for the weakening and damage of tomato tissues leading to a reduction in yield which can go as far as total loss (Ukeh and Chiejina, 2012; Sanja *et al.*, 2021). Therefore, it is necessary to improve crop tolerance to the combined effects of humidity, heat and diseases transmitted by pathogens and pests.

In Cameroon, these abiotic problems are divergent. In Southern Cameroon, tomato cultivation is faced with the problem linked to humidity and heat while in the Northern part of Cameroon, this abiotic stress is linked to the lack or insufficiency of water and minral elements. which are generally the cause of plant drought when appropriate measures are not taken in time (Yarou *et al.*, 2017; Kinsou *et al.*, 2021). As for biotic problems, they are caused by pests and competition with weeds for space, water, nutrients and light (Swart *et al.*, 2019). Unwanted plants also have the possibility of harboring within them, crop enemies in general and in particular of tomatoes such as nematodes, fungi, parasites and insects (Nilusmas, 2020).

To address these issues, producing safe food through sustainable and environmentally friendly practices involving reduced use of chemicals in fields to reduce potential environmental damage is a major challenge to address (Mohiddin *et al.*, 2010; Verónica *et al.*, 2019). This approach would make it possible to avoid the conventional practice which recommends the use of synthetic chemical pesticides which is the method most implemented in Cameroon. In this regard, green plants are an excellent alternative that can replace chemicals for pest control or for improving the growth of this plant.

Green plants are recognized for their biological degradation and lower toxicity properties which can be used to fertilize the soil, prevent and treat plant diseases and fight against attacks by pests during tomato cultivation (Vasquez, 2017). . This is the case for leguminous plants such as *Acacia aroma*, *Acacia muricata*, *Gliricidia sepium* which are likely to be very rich in nitrogen, necessary for soil fertilization (Doumbia *et al.*, 2020). Plants such as *Tithonia diversifolia* generally containing significant amounts of potassium and phosphorus which are high biodegradation plant species and which certainly have antiparasitic properties such as comfrey and neem which are also rich in potassium (*Azadirachta indica*) (Gnago *et al.*, 2010; Déla *et al.*, 2014; Yarou *et al.*, 2017). These plants are able to fight insect pests such as white flies and wasps, rodents, fungi and bacteria (Kulimushi, 2014; Yarou *et al.*, 2017). The evaluation of the effect of green plant extracts in the process of soil fertilization, prevention and treatment of diseases and as well as in the system of combating attacks by pests is part of the search for natural methods growth and improvement of tomato tolerance against parasitic pressure.

Materials and methods

Study site

The trial was carried out at the Station of the Institute of Agricultural Research for Development (IRAD) in Foumbot, one of the Sub-divisions of the Noun Division. The Sub-division of Foumbot with an area of 579 km², is a town in the West Cameroon region (5° 30′ 00″ N and 10° 37′ 59″ E) with an average altitude of 1071 m and an equatorial climate with two climatic seasons and four ecologically dry months. Throughout the year, the average annual temperature fluctuates around 21°C. The average relative humidity is above 80% with maxima during the months of August and September. The soils are mostly of black volcanic origin with a high agronomic value. (Mfouapon *et al.*, 2014; Nfor *et al.*, 2021). Foumbot is limited to the North by the Sub-division of Koutaba, to the North-West by the Sub-division of Kouptamo, to the South by the Division of Ndé with the main city Banganté, to the South-East by the Division of Djebem, to the West by the Divisions of Bafoussam I and Bafoussam II and to the East, by the Division of Massangam (Fig. 1) (Mfouapon *et al.*, 2014; Nfor *et al.*, 2021).

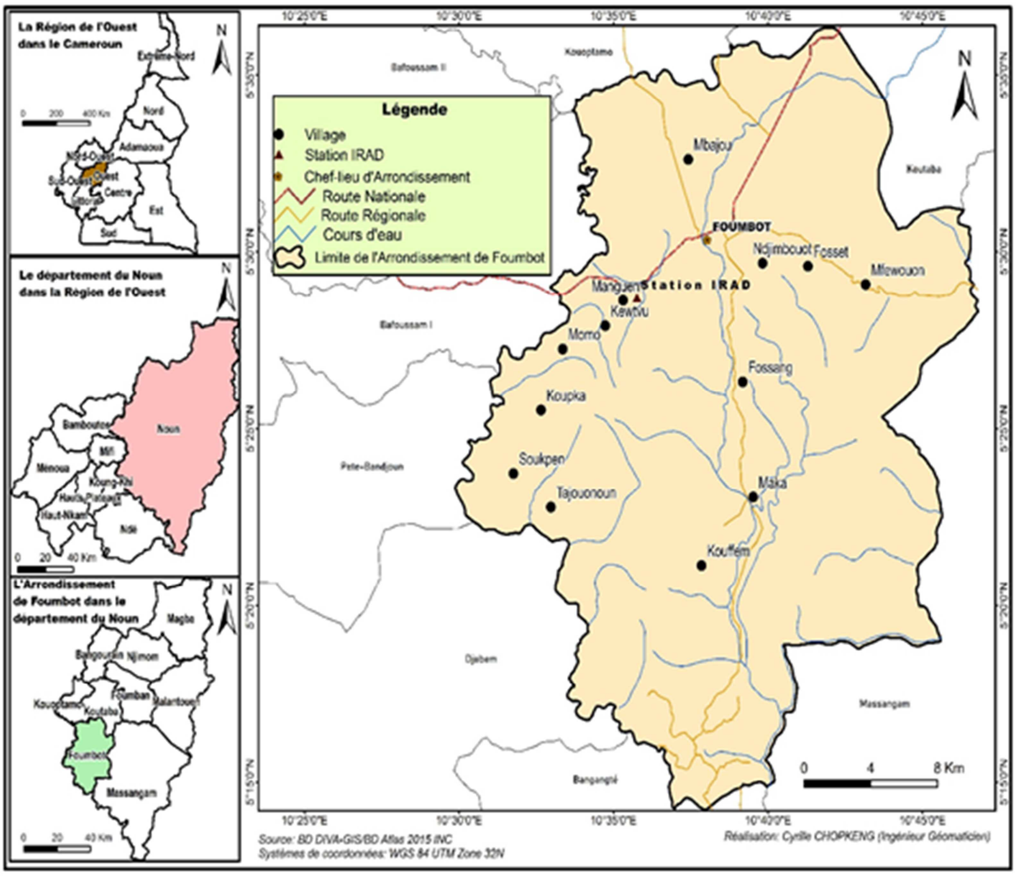

Fig. 1. Geographic location map of the IRAD Foumbot Station, study location

Materials

Different species consisting of Nunhems tomato, fresh cloves of garlic (*Allium sativum*), fresh fruits of chili pepper (*Capsicum annuum*) and fresh leaves of Comfrey (*Symphytum officinale*) used were purchased on the markets and at the CIPRE of Bafoussam. Fresh legume plants of *Acacia muricata* and *Gliricidia sepium* and fresh plants of *Tithonia diversifolia* and *Carica papaya* were all collected in the locality of Foumbot. Neem (*Azadirachta indica*) and palm (*Elaeis guineensis*) oil were purchased at market «A» in Bafoussam, *Acroceras zizanoides* plants and Chinese bamboo (*Bambusa vulgaris*) were harvested in the plantation of the IRAD Station by Foumbot. Fertilizers (NPK and ammonia sulfate), pesticides (Coragen, Plantine B 80 WP, Caiment B, Cigogne) and soap used were purchased in stores selling phytosanitary products.

Methods

The aqueous extracts of manure, plants and ash were obtained following the recommendations of PAMTAC-B (2018) and AVSF (2020).

Preparation of aqueous extracts

Aqueous extracts of legume manure

The leaves of *Acacia muricata* and *Gliricidia sepium* were each time cut using pruning shears. Each species was used to fill the 10 L container three-quarters full. The container was then topped up with water. Ten days later, the aqueous extract of each manure was obtained. One kilogram of branches made of *Tithonia diversifolia* leaves was cut using pruning shears and introduced together with water into a 10 L container. Ten days later, fermentation was achieved and the mixture was filtered to collect the extract. As for the Comfrey manure (*Symphytum officinale*), one kilogram of fresh comfrey leaves was roughly cut and introduced into 10 L of water and contained in a container of the same volume. The whole thing was macerated for 15 days until the bubbles on the surface of the mixture disappeared. This mixture was then filtered using a 1 mm diameter sieve and the extract obtained was kept in plastic bottles and stored away from heat and light (PAMTAC-B, 2018).

Aqueous extracts of ash and garlic cloves (Allium sativum)

The sifted ash was obtained from a firewood hearth in a locality not far from the outskirts of the IRAD Foumbot Station. Five hundred grams of this ash were each time measured and placed in a 10 L bucket. The aqueous ash solution was then obtained by filling the bucket with water. Twenty-four hours after filtering the mixture, the Biopesticide was obtained. As for the preparation of the garlic extract, 200 g of unpeeled garlic clove were crushed using a Moulinex and the ground material obtained was introduced into a bottle containing 1 L of water. A tablespoon of palm oil was added to the mixture and the whole mixture was macerated for 24 hours followed by filtration to obtain this aqueous extract.

Aqueous extracts of chili pepper (Capsicum annuum) and papaya leaves (Carica papaya)

The aqueous extract of chili pepper was regularly obtained by keeping two hundred grams of fresh chili pepper in 2 L of water for 3 days. As for the aqueous extract of papaya leaves, 1 kg of papaya leaves was regularly cut using the knife and then crushed using a Moulinex before being introduced into a 10 L drum and topped up with 2 L of water. The mixture was macerated for 24 hours to obtain this extract.

Experimental design, fertilizations and treatments

Nursery

The nursery was set up in a rectangular shape (5.6 m × 0.4 m) made up of 7 ridge-shaped treatments having received tomato seeds and mulched using *Acroceras zizanoides* plants (Table 1). The control treatment (T1) consisted only of tomato seeds without any fertilization or any treatment against diseases and pests. Treatments T2, T3, T4, and T5 were naturally fertilized although this natural fertilization was different depending on the treatments. Thus, treatments T2 and T3 were each fertilized with one liter of *Acacia muricata* purine extract diluted in 10 L of water and applied every 7 days while treatments T4 and T5 were each fertilized with medium of one liter of *Gliricidia sepium* manure extract diluted in 10 L of water and applied every 7 days. As for *Tithonia diversifolia*, 1 L of manure extract diluted to 50% as recommended by PAMTAC-B (2018) was applied every 7 days to the plants of treatments T2, T3, T4 and T5. Treatments T4 and T5 were each additionally fertilized using one liter of *Gliricidia sepium* manure extract diluted in 10 L of water. Treatments T2 and T4 were treated naturally against diseases and pests while treatments T3 and T5 were treated chemically against these diseases and pests. The natural treatment against diseases and pests of treatments T2 and T4 was carried out using garlic extract diluted in 2 L of water to which water was added to fill the 16 L sprayer at a frequency of application corresponding to every ten days. These treatments T2 and T4 also each received 0.5 L of pepper extract introduced into 15 L of water before being transferred to the sprayer for an application frequency corresponding to one application every four days. Treatments T2 and T4 also each received papaya leaf extract every 15 days before being transferred to the sprayer and supplemented with water. Treatments T3 and T5 were chemically treated against diseases and pests respectively using the fungicide PLANTINE B 80 WP at a quantity of 20 mL (approximately one teaspoon) and the systemic insecticide K-OPTIMAL. This insecticide was applied as a preventative measure in a quantity of 10 mL in the sprayer. Treatments T6 and T7 were also chemically fertilized with NPK (20-10-

10). Five grams of urea were introduced every two weeks into the sprayer and applied to the plants of treatments T6 and T7. While the plants of treatment T6 were treated naturally against diseases and pests with the same natural products and following the same protocol as the plants of treatments T2 and T4, those of treatment T7 were treated chemically such as the plants of treatments T3 and T5. The plants of treatment T6 were therefore treated against diseases and pests using garlic extract, chili pepper and papaya leaves while those in the treatment T7 were treated against diseases and pests using the fungicide PLANTINE B 80. WP and K-OPTIMAL systemic insecticide. At the end of the work carried out in the nursery, the 25-day-old plants were transplanted into the field.

Table 1. Nursery layout

Treatment numbers	T1	T2	T3	T4	T5	T6	T7
Constitution of Treatments	Control without fertilization and without treatment against diseases and pests	A + T+ W + Biological treatment against diseases and pests	A + T+ W + Chemical treatment against diseases and pests	G + T+ W + Biological treatment against diseases and pests	G + T+ W + Chemical treatment against diseases and pests	20-10-10+ Biological treatment against diseases and pests	20-10-10+ Chemical treatment against diseases and pests

Legend: A: *Acacia muricata*; T: *Tithonia diversifolia*; W: Wood ash; G: *Gliricidia sepium*

Production

Following a Completely Randomized Block (CRB) design, the experimental plot was made up of 7 treatments and 5 repetitions. The plants were transplanted and placed in a plot of 5.6 m × 2.10 m divided into 5 ridges of 5.6 m × 0.30 m each and regularly spaced 0.1 m apart. A distance of 0.1 m was left at the start of each ridge before sowing the first plan and the plants were spaced apart on the same ridge by 0.90 m, and finally the last plant of each ridge was planted at 0.1 m from the end of the log. Water was brought to the plot each time the lack of rain was felt. The ridges were made in such a way as to allow excess water to flow and drain freely following intense rains and on the other hand, arrangements were also made to conserve water as much as possible watering on site during periods of absence of rain. The plants of the different treatments were fertilized in the same way both in the nursery and in the field. However, the chemical fertilization consisted of 75 g of NPK (20-10-10) and ammonium sulfate, applied at start-up just after transplanting at a frequency every 2 weeks.

In the field, the plants of the treatments T6 and T7 were also chemically fertilized with NPK (20-10-10) and ammonia sulfate and the plants of treatment T6 treated naturally against diseases and pests based on aqueous extracts of garlic, chili pepper, papaya leaves, comfrey manure and 2 mL of neem oil under the same conditions and frequencies as the plants of treatments T2 and T4. While the quantities and frequencies of application of comfrey manure followed the logic of PAMTAC-B (2018) for other prevention and treatment products against insects and pests, those of neem oil followed the method of Abdourahamane *et al.* (2020) in soybean production in Benin. Instead, the plants of treatment T7 were chemically treated against diseases and pests using the same chemicals as the T3 and T5 treatment plants, and under the same conditions and at the same frequencies. As soon as the first fruits appeared, the plants of treatments T3, T5 and T7 were chemically treated with a spoonful of coragen insecticide (at a frequency of twice a week) which was applied per plant to fight against the tomato leaf miner (*Tuta absoluta*). Forty mL of the mixture consisting of half a volume of K-OPTIMAL and half a volume of CIGOGNE were introduced into a sprayer for an application frequency corresponding to one application every 4 days to repel insects and whitefly on plants in treatments T3, T5 and T7. The plants in these three treatments also received 60 mL of PLANTINE B 80 WP at a frequency of twice a week. An application of 20 mL of CAIMENT B insecticide per plant every 4 days was then carried out.

At the end of the work carried out, certain parameters were studied such as the number of plants having resumed one week after transplanting (NPROWAT), the number of weeks for the start of fruit production (NWSFP), the diameter of the plants at the start of fruit production (DPSFP), the number of leaves at the start of fruit production (NLSFP), the surface area of the plants at the start of fruit production (SPSFP), the total number of fruits per plant (TNFP), the vigor of the plants at the start of fruit production (VPSFP), the color of the plants at the start of fruit production (CPSFP), the weight of 30 fruits produced per plant (WFPP), the total number of flower buds (TNFB), the total number of aborted fruits (TNAF) and the total number of matured fruits (TNMF), the total number of leaves produced (TNLP), the total number of healthy leaves (TNHL) and the total number of diseased leaves (TNDL).

Statistical analyzes

Analysis of variance (ANOVA) was carried out using the statistical software "Statistical Package for the Social Sciences (SPSS)", version 25.0. The means of the different treatments were compared at the 5% probability threshold, using the Student-Newman-Keuls (SNK) test. A Principal Component Analysis (PCA) was carried out for the different parameters based on the R software, version 4.0.4, the packages used being Factomine R and Factoextra.

Results

Effects of treatments on growth, yield and physical quality parameters of tomato

Growth parameters (number of plants taken, number of leaves, diameters at the collar, surface areas of the plants), yield (number of weeks for the start of production, total number of fruits, weight of 30 fruits, fruit yield) and the physical quality of the tomato (plant vigor, color of plants and fruits) were evaluated according to the different treatments (Table 2).

Table 2. Variation in growth, yield, physical quality of the tomato, entomological and phytopathological parameters depending on the different treatments

ariables	Treatments							Sig
	T1	T2	T3	T4	T5	T6	T7	
PROWAT	1,00±0,00	1,00±0,00	1,00±0,00	1,00±0,00	1,00±0,00	1,00±0,00	1,00±0,00	1,00
umber of Leaves	27,40±2,50^{a}	42,00±2,12^{a}	42,20±0,84^{a}	39,00±2,12^{a}	37,00±1,00^{a}	32,00±0,71^{a}	33,00±1,00^{a}	0,16
iameter (Cm)	0,37±0,03^{a}	0,76±0,02^{b}	0,76±0,02^{b}	0,77±0,03^{b}	0,75±0,03^{b}	0,72±0,03^{b}	0,73±0,01^{b}	0,00
urface des plants m^{2})	4578,00±8,18^{ab}	5290,00±2,00^{b}	5537,00±5,15^{b}	5928,00±7,62^{b}	6094,80±9,42^{b}	2480,00±14,14^{a}	2646,00±5,10^{a}	0,00
umber of weeks at e start of production	7,00±0,70^{a}	8,00±0,00^{a}	8,00±0,00^{a}	8,00±0,00^{a}	8,00±0,00^{a}	6,00±0,00^{a}	6,00±0,00^{a}	0,02
otal number of fruits	25,80±2,37^{a}	90,00±4,12^{b}	84,00±3,16^{b}	86,00±3,81^{b}	83,00±3,81^{b}	95,40±1,67^{b}	98,00±2,55^{b}	0,00
eight of 30 Fruits)	73,20±6,69^{a}	168,00±3,54^{c}	173,00±3,16^{c}	171,00±3,16^{c}	174,00±3,16^{c}	119,00±9,51^{b}	114,00±3,16^{b}	0,00
ruit yields (t/ha)	4,00±0,37^{a}	13,80±1,26^{b}	13,30±2,29^{b}	13,4±1,63^{b}	13,2±3,36^{b}	11,22±2,54^{b}	11,3±1,01^{b}	0,00
lant Vigor	2,00±0,00^{a}	6,00±0,00^{b}	6,00±0,00^{b}	6,00±0,00^{b}	6,00±0,00^{b}	6,00±0,00^{b}	6,00±0,00^{b}	0,00
lant Color	2,00±0,00^{a}	6,00±0,00^{b}	6,00±0,00^{b}	6,00±0,00^{b}	6,00±0,00^{b}	6,00±0,00^{b}	6,00±0,00^{b}	0,00
NFB	34,6±3,16^{a}	95±4,50^{b}	89,2±2,78^{b}	90,6±3,78^{b}	88±4,18^{b}	101,6±2,30^{c}	103,4±2,78^{c}	0,16
NAF	8,8±0,81^{a}	5,2±0,83^{a}	5,2±0,83^{a}	4,6±0,89^{a}	5±1,58^{a}	6,2±0,83^{a}	5,2±1,64^{a}	0,00
NMF	25,8±2,36^{a}	89,8±4,12^{b}	84±3,16^{b}	86±3,80^{b}	83±3,80^{b}	95,4±1,67^{c}	98±2,54^{c}	0,00

It emerges from this work that the number of plants which resumed one week after transplanting was identical for all the 7 treatments carried out. As for the number of leaves per plant and the number of weeks from the start of tomato fruit production, no significant difference is observed at the 5% probability threshold depending on the different treatments. However, the results show that the rest of the parameters differ depending on the treatments. To this end, the study of the diameter of the stem at the collar, the total number of fruits per plant, the yield of fruits per hectare, the vigor of the plants and the color of the plants shows a significant difference between the control treatment (T1) and other treatments (T2 to T7).

This control treatment is characterized by the lowest averages (0.37±0.34a cm; 25.80±23.65a; 4.00±3.65a t/ha; 2.00±0.00a and 2.00±0.00a 00±0.00a) respectively for the parameters diameter of the stem at the collar, total number of fruits per plant, yield of fruits per hectare, vigor of the plants and color of the plants compared to the averages of the parameters of the other treatments (T2 to T7). The study of the surface area of the plants (cm^2) shows a significant difference between the different treatments. The lowest averages are observed respectively in treatments T7 (2646.00±5.10a) and T6 (2480.00±14.14a) while the highest averages are observed in treatments T4 (5928.00±7. 62b) and T5 (6094.80±9.42b). The weight of 30 fruits (g) also showed a significant difference based on different treatments. The control treatment (T1) is characterized by the lowest average (73.20±66.86a) while the highest averages are found in treatments T3 (173.00±3.16c) and T5 (174.00 ±3.16c). The effects of fertilizers and pesticides on other production and plant pathology factors (production of total number of flower buds (TNFB), total number of aborted fruits (TNAF) and total number of mature fruits (TNMF)) have was highlighted following the different treatments. The TNFB and TNMF respectively each showed a significant difference according to the different treatments. The control treatment (T1) is characterized by the lowest average (34.6±31.62a and 25.8±23.64a) for this TNFB and TNMF, while the highest averages are found respectively in the T6 treatments. (101.6±2.30c and 95.4±1.67c) and T7 (103.4±2.78c and 98±2.54c) for this TNFB and TNMF.

Principal component analysis (PCA) of the effects of fertilizers on growth, yield and physical quality parameters of tomatoes

The eigenvalues and proportions of information which are concentrated on the axes of the PCA can be found in table 3 below. The results show that 80.70% of initial information is clarified exclusively by the first component at axis 1, while 17.86% of information is provided at axis 2 by the second component. This reflects the possibility that we have to be able to explain 98.56% of information found in the initial variables, by means of axis 1 and axis 2 constituting the initial variables (Table 3).

Table 3. Eigenvalues and proportion of inertia of the PCA axes

	Axe 1	Axe 2	Axe 3	Axe 4	Axe 5	Axe 6
Own value	8,88	1,96	0,10	0,04	0,008	0,0005
Percentage of variance	80,70	17,86	0,95	0,41	0,07	0,01
Cumulative percentage	80,70	98,56	99,51	99,92	99,99	100

The existing relationships between all the variables and the two initial components of axis 1 and axis 2 are represented in the correlation circle in figure 2 with the correlations varying from 0.94 to 0.98. On axis 1 we find a good representation of the variables: number of weeks for the start of production, surface area of the plants, number of leaves and weight of 30 fruits which show a positive correlation across the two axes. During this time we have a negative and positive correlation respectively on axis 1 and on axis 2 of the variables: diameter, fruit yield, plant vigor, color of plants and fruits, number of fruits. On the other hand, the variable TNAF presents a negative correlation between the two axes (Fig. 2).

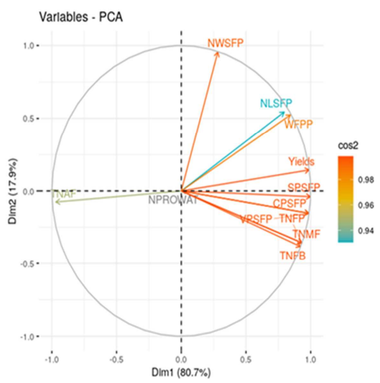

Fig. 2. Correlation circle of the variables studied for the effects of fertilizers on the parameters of growth, yield and physical quality of the tomato

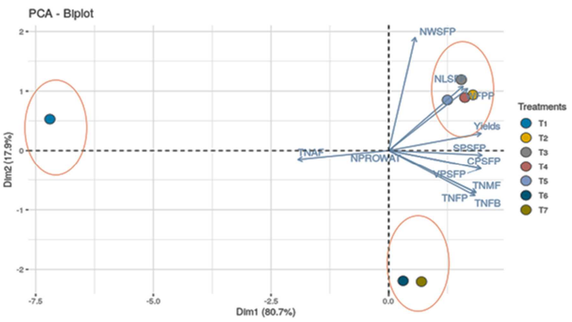

Fig. 3. Principal component analysis (PCA) of individuals and variables of the effects of fertilizers on growth, yield and physical quality parameters of tomato

Principal Component Analysis reveals three main groups, characteristic of the different treatments carried out. The first group consists of control plants (T1) which did not receive any phytosanitary treatment. The second group is made up of plants from treatments T6 and T7 which are those having been fertilized with NPK and ammonium sulfate. However, the plants in the treatment T6 were treated naturally against pests while those in the treatment T7 were chemically treated against these pests. As for the third group, it consists of plants from treatments T2 and T3 which have been naturally fertilized with aqueous extract of *Acacia muricata* manure and plants from treatments T4 and T5 having been fertilized naturally with aqueous extract of *Gliricidia sepium* manure (Fig. 3). However, the plants of treatments T2 and T4 were treated naturally against diseases and pests while those of treatments T3 and T5 were treated chemically.

Depending on the parameters according to axis 1 grouping in terms of total inertia, 71.6% have an antagonism between the mixed group which have been organically fertilized and the control one which was not fertilized. The mixed group with organic fertilization represents, in relation to all the parameters that were measured, notable measurements at the level of the positive abscissa in contrast to the low parameters observed at the level of the control group. We find measurements that are either low or high on average at the level of the group fertilized with NPK and ammonium sulfate or intermediate group. There is reason to conclude that the gradient of tomato growth and yield parameters is thus explained by axis 1.

Table 4. Variation of phytopathological parameters

Variables	Treatments							Sig
	T1	T2	T3	T4	T5	T6	T7	
TNLP	27,4±25,02^a	42±2,12^d	42,2±0,83^d	39±2,12^c	37±1,00^c	32±0,70^b	33±1,00^b	0,000
TNDL	10,6±9,73^b	1,6±1,14^a	2,2±0,83^a	1,6±1,14^a	2,8±0,83^a	1,6±1,34^a	2,4±1,14^a	0,460
TNHL	16,8±15,38^a	40,4±2,07^d	40±1,22^d	37,4±2,07^d	34,2±0,44^c	30,4±1,81^b	30,6±1,51^b	0,000

TNLP=Total Number of Leaves Produced, TNHL=Total Number of Healthy Leaves, TNDL=Total Number of Diseased Leaves ; The results were presented in the form of average ± standard deviations of these averages. At the probability threshold 0.05, the values with different assigned numbers are significantly different.

Effects of pesticides on some phytopathological factors

Total number of leaves produced (TNLP), total number of healthy leaves (TNHL) and total number of diseased leaves (TNDL)

The effects of pesticides on some phytopathological factors (total number of leaves produced (TNLP), total number of healthy leaves (TNHL) and total number of diseased leaves (TNDL)) were evaluated according to the different treatments. Each of these factors shows significant differences depending on the different treatments. The TNLP factor is characterized by the high values in treatments T2 (42±2.12d) and T3 (42.2±0.83d) while the control treatment T1 (27.4±25.02a) is characterized by the value the weakest. Regarding the TNDL factor, the results show a significant difference between the control treatment (T1) and the other treatments (T2 to T7). This control treatment is characterized by the highest value (10.6±9.73b) compared to the values observed in the other treatments (T2 to T7). In terms of the TNHL factor, all the other treatments differ from the control treatment T1 which is characterized by the lowest value (16.8±15.38a) while the highest values are found in the treatments T3 (40±1. 22d) and T2 (40.4±2.07d) (Table 4).

Principal component analysis of total number of leaves produced, total number of healthy leaves and total number of diseased leaves

Based on the data in Table 4, a PCA was carried out. The eigenvalues and proportions of information which are concentrated on the axes of the PCA can be found in Table 5 below.

Table 5. Eigenvalues and proportion of inertia of the PCA axes of the TNLP, TNHL and TNDL

	Dim 1	Dim2	Dim3
Own value	1,93	1,06	1.6^{e}-30
Percentage of variance	64,54	35,46	0
Cumulative percentage	64,54	100	100

We note that 64.54% of information is initially and exclusively explained by axis 1, while 35.46% of information is provided at the level of axis 2 by the second component. These observations make it possible to explain 100% of the information that exists in the initial variables, according to components 1 and 2 and therefore axes 1 and 2.

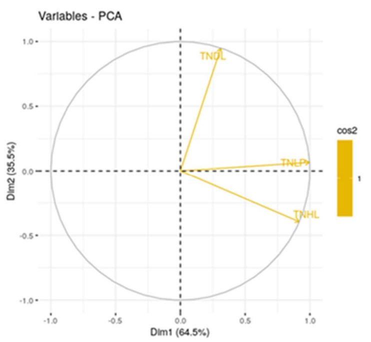

Fig. 4. Correlation circle of TNLP, TNHL and TNDL

The correlation circle presents the relationships between all the variables and the first two components of axes 1 and 2 in Fig. 4. Axis 1 shows all the parameters with a correlation which is of order 1. On axis 1, the variables TNDL and TNLP are represented with a positive correlation on both axes while TNHL is positively correlated on axis 1 and negatively correlated on axis 2.

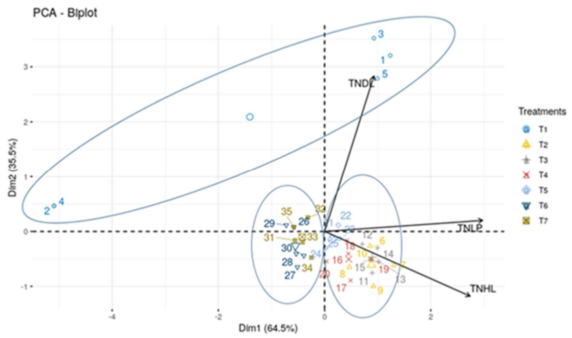

Fig. 5. PCA of individuals and variables TNLP, TNHL and TNDL

The Principal Component Analysis according to Fig. 5 of the phytopathological parameters also highlights 3 main groups. The first group consists of plants from the control treatment (T1), the second group consists of plants from treatments T6 treated naturally and T7 treated chemically against diseases and pests while the third group consists of plants from treatments T2, T3, T4 and T5 which have been fertilized naturally and treated naturally for treatments T2 and T4 and chemically for treatments T3 and T5 against diseases and pests.

Treatments T6 and T7 were opposed according to the parameters compared to axis 1 which brings together 64.5% of the total inertia. At the level of the positive abscissa, the third group consisting of the plants of treatments T2, T3, T4 and T5 was characterized by significant values in relation to all the parameters which were measured unlike the second group therefore the values were weak. The first group consisting of plants from treatment T1 presented totally positive values in relation to axis 2. Thus, axis 1 describes the gradient of the growth and yield parameters of the tomato while axis 2 describes the phytopathological and entomological parameters of this plant.

Discussion

Growth parameters

The effects of local plant extracts on tomato growth parameters were evaluated during this study. According to the results of this work, the recovery rate of the plants one week after transplanting (WAT) was the same, around 100% for all treatments. The abiotic factors of the site such as temperature, soil water and wind generally impact the recovery of plants after transplantation, which would have been favorable for all these plants which remained alive at that date. These results are similar to those obtained by Ngoy *et al.* (2020) who showed during work on the evaluation of tomato productivity under organic (Guano and ash) and mineral amendments that the recovery rate was the same regardless of the treatment used.

However, a variance was recorded for the average number of leaves parameter between 27 and 42.2. Plants amended with *Acacia muricata* (T3 and T2) have the highest values for the trait high number of leaves, followed by those amended with *Gliricidia sepium* (T4 and T5), then plants fertilized with NPK and ammonium sulfate (T7 and T6) and finally the control plants which have received no amendment. Organically fertilized plants would have had greater amounts of nutrients coming not only from the leguminous plant (*Acacia muricata* or *Gliricidia sepium*), but also from *Tithonia diversifolia* and ash. Legume plants are generally very rich in nitrogen because apart from the nitrogen absorbed from the soil like all other plants, these legumes have the capacity to fix atmospheric nitrogen from the air. Woody legumes generally make soil life better through greater spore density, boosted microbe biomass and better soil respiration quality (Kaboré *et al.*, 2020). Regarding plant surfaces, the largest sizes were obtained from plants that had been fertilized naturally (T2, T3, T4 and T5) leading to a significant differentiation compared to those obtained from conventional fertilization treatments (NPK and ammonium sulphate: T6 and T7) which followed them and those obtained from the control treatments (T1) which did not receive any fertilization. These results show the importance of organic matter in positively modifying the process of releasing nutrients from the soil, which would promote the rapid assimilation of nutrients from the soil by the plant through its roots. These results are similar to those found by Ngoy *et al.* (2020) during the respective evaluation of the effect of bat guano, wood ash and NPK on tomato production. During their work, they observed that the size of the plants fertilized with Guano and then with wood ash were respectively the largest, followed by the unfertilized control plants and finally the plants fertilized with NPK and ammonium sulfate came in last position with low values.

Production parameters

The results obtained regarding the number of weeks for the start of production did not present any significant difference between the different treatments. However, plants fertilized with NPK and ammonium sulfate began to produce at 6 weeks after transplanting, those naturally amended at 7 weeks after transplanting and the unfertilized control plants at 8 weeks after transplanting. The PCA also shows three groups following this logic. These results corroborate those obtained by Siene *et al.* (2020) when evaluating the productivity of corn based on organic fertilizer (chicken droppings, cow dung) and NPK and ammonium sulfate.

During their work, they found that the date of panicle initiation was the same for both organically and chemically fertilized plants and even for unfertilized control plants.

Regarding the number of fruits produced, we note that the average of the total number of fruits produced is significantly higher for all plants compared to control plants. Organically amended plants nevertheless present a slight inferiority compared to the latter. The chemical characteristics of the arable soil are made even better in the presence of chemical fertilizers, which impacts on good development and greater yield of plants. These results can then be explained by the presence and availability of phosphorus in the NPK. These results corroborate with the work of Ngoy *et al.* (2020) who led, among other things, to the conclusion that NPK allowed a greater production in number of tomato fruits than bat guano and wood ash respectively. Compared to the weight of 30 fruits, the organically amended plants presented a result significantly above those of the plants fertilized with NPK and ammonium sulphate which in turn were significantly above the weight of 30 fruits harvested from the plants unfertilized controls. Organic amendments presented an almost identical result. These results were once again similar to those reported by Ngoy *et al.* (2020) discovered in relation to bat guano that it favored obtaining a weight of 10 tomato fruits significantly greater than those of plants fertilized respectively with NPK and then those not fertilized.

Entomological and phytopathological parameters

In the present study, the results demonstrated that plant extracts can control tomato diseases and pests. The total number of diseased leaves shows a significant difference between the control treatment (T1) and the other treatments (T2 to T7). This control treatment is characterized by the highest value (10.6±9.73b) compared to the average parameters of the other treatments (T2 to T7). The treatments (T2 to T7) during the study of obtaining healthy fruits made it possible to reduce losses of around 5% unlike the control treatment (T1) which recorded a loss of 25.43% of the harvest. This significant reduction in loss in treatments T2 to T7 would be due to plants treated naturally or chemically against these diseases and pests. These results are similar to those obtained by Tounou *et al.* (2012) who showed that plant extracts would act negatively on the population dynamics of insect pests of cowpea (*Vigna unguiculata*). Extracts from local plants have biologically active substances that act negatively on these pests. These observations corroborate those observed by Isman *et al.*, 1990 and Verkerk *et al.*, 1993 who demonstrated that neem contains a complex of biologically active substances called tetranortriterpenoids or more specifically limonoids responsible for the majority of biological effects observed in organisms who are exposed to various neem extracts. These plant extracts used have repellent properties against tomato pests, hence this significant reduction in harvest loss. These observations are similar to those observed by Meadow *et al.*, 2001; Metspalu *et al.*, 2001; Bruce *et al.*, 2004; Agboka *et al.*, 2009 and Cherry and Nuessly, 2010 who demonstrated that several plants possess insecticidal or repellent properties for the control of insect pests belonging to different families.

Conclusion

Tomato cultivation for market gardening, more practiced in developing countries and in Cameroon, remains mainly produced using synthetic chemicals. These chemicals, although effective, are expensive, toxic, polluting and therefore do not constitute a sustainable process for the management of the cultivation of this plant. The study carried out as part of this work aimed to test the valorization of some local plant to be able to fertilize the soil in a tomato production situation, and to manage to fight against diseases and pests during field production. From this study, it was revealed that the growth and production parameters of tomato behave generally better in a situation of soil fertilization based on *Acacia muricata* or *Gliricidia sepium* manure extracts. The phytopathological and entomological parameters behaved better in the presence of extracts of garlic, chili pepper, papaya leaves, neem oil, wood ash and extracts of comfrey manure and *Tithonia diversifolia*.

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