Soil Fitness for the Production of the Black Nightshade "Solanum Scabrum" on a Ferralsol in the Highlands of West Cameroon and Improvement of Yields in Connection with Fertilization and Water Intakes

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ABSTRACT

Following a survey, irrigation was shown to be a limiting factor in black nightshade production (Boukong, 2017). In order to evaluate the land's capacity for producing black nightshade, the impact of water intakes on yield, the efficiency of water use, and the profitability of fertilizer and water use, a study was conducted on two oxisol campaigns at the University of Dschang Research Application Farm. Three-repetition split-plot design was employed. The variables were water volumes with tree modalities (V1, V2, V3) and frequencies with three modalities (F1, F2, F3). According to the results, the pedoclimatic conditions that prevailed in the first and second campaigns matched the S1-1C class, which is still a moderate climatic limitation, and the S2/S3CF class, which is marginally suitable due to the limits imposed by fertility and climate, respectively. When the two campaigns were combined, the combination that produced the best marketable fresh output was irrigation daily with 1282 mm or 8.5 mm of water per day (V2 F1) for a yield of 53T/ha. Applying 858 mm or 5.7 mm/day every two days is the combination (V1F2) that offers the best water and fertilizer use efficiency (373, 29). Applying 858 mm daily (V1F1) or 5.7 mm daily yields the most profitability; this treatment also has the best RVC of 7 and a profitability of 638. For market gardeners growing in the same edapho-climatic and socioeconomic environment from January to April, these two combinations allowed for the most efficient use of water, fertilizers, and profitability.

Keywords: Land assessment, effective use of fertilizers, effective use of water, yield, solanum scabrum.

INTRODUCTION

The number of undernourished persons in sub-Saharan Africa rose from 44 million to 128 million, according to the OECD/FAO (2016), as the continent's population grew more quickly than its agricultural output. As the leading producer (52.3%) in the CEMAC zone, Cameroon is primarily an agricultural nation and has been named "Grenier de la Zone Cemac" by the FAO (2011). However, 2.7 million people, or 10% of the Cameroonian population, experience acute food insecurity, according to the PNVRSA (2021) national and nutritional security survey report. It would mostly be caused by insufficient food intake (malnutrition or dietary insufficiency), while local veggies can help reduce malnutrition (Labadarios and Nel, 2000).

According to Schippers (2000), the "African nightshade" is one of the most common leafy vegetables in the warm, humid parts of Africa and is without a doubt the second most significant category of traditional vegetables on the continent, behind the Amarants.

In Cameroon's market gardening industry, leafy vegetables rank third in terms of agricultural production value, after tomatoes and onions. Temple, 1998. According to food consumption studies, they consume 6.5 kg annually each resident, which allows for the extrapolation of Cameroon's national production to be 100,000 t (Temple et al., 2005). in vitamins, minerals, and nutritious components, without exhibiting debilitating

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antinutritional aspects According to Bailey (2003), these have excellent nutritional value and quick growth. Bailey (2003) Westphal and associates (1985). Because this vegetable would supply 50% and 100% of protein and iron, respectively, based on the composition provided by Edmonds and Chweya (1997) (Abukutsa et al., 2010).

According to Boukong (2017), 12.5% of producers grow black nightshade (Solanum scabrum) solely for consumption, whereas 87.5% grow it for both the market and consumption. Furthermore, this area is experiencing a shortage of land due to demographic pressure. The availability of pesticides (28.7%), fertilization (24.7%), irrigation (20.3%), and priority illnesses seem to be the biggest issues facing growers in this area, according to the same poll. For this reason, the availability of water for production during the growing season is one of the challenges facing market gardening in west Cameroon. Furthermore, future projections show that fewer rainy seasons, higher temperatures, and more erratic weather patterns will have a devastating impact on the agricultural output and performance of many African nations.

MATERIALS AND METHODS

Site Description

The investigation was carried out in the Application and Research Farm at the University of Dschang, Cameroon. The first campaign ran from December 17, 2017 to April 09, 2018, and the second campaign ran from early January 2018 to early April 2019. The land was situated near a water source on an oxisol. At an elevation of 1407 meters, the site is situated in the Menoua department of West Cameroon, specifically at 5 ° 20' north latitude and 10 ° 03' east longitude. Table 2 displays the climate data that was gathered for the study.

Materials

The SS09 black nightshade cultivar, often known as "Foumbot" and distinguished by its huge leaves, was utilized. In Cameroon's West Highlands, this is the most often used cultivar. The water used for irrigation came from a reservoir not far from the experimental plot and its chemical composition is presented in Table 3.

Experimental Setup

Poultry manure was used for fertilization, applied at a rate of 5 tons per hectare two days prior to transplantation and at a rate of 600 kg per hectare four days following transplanting. As an additional treatment, the average ETP (4 mm/day) as established by Penman was used to determine the water application level per unit area. The water volume had three modalities (V1 = 1 ETP = 4 mm/day/m²; V2 = 2 ETP = 8 mm/day/m²; V3 = 3 ETP = 12 mm/day/m) while the frequency of water application had three modalities (F1 = daily, F2 = every two days, and F3 = every three days). Watering regulations were rigorously followed from transplantation until the regular recurrence of rain. From transplanting to the frequent return of rain, watering standards were strictly adhered to. Following then, watering was more dependent on rainfall as measured by a rain gauge.

Table 1: Combinations of the modalities of the different factors used

Factor		**Frequency of irrigation**		
		F1	F2	F3
Volume of water	V1	V_1F_1	V_1F_2	V_1F_3
	V2	V2F1	V2F2	V2F3
	V3	V3 F1	V3 F2	V3 F3

The irrigation volume changes as a result of the precipitation returning earlier than expected. Instead, in the first and second campaigns, we had 408.1 mm (5.4 mm/day) and 449.6 mm (5.9 mm/day) for V1, 555.9 mm (7.4 mm/day) and 745.9 mm (9.9 mm/day) for V2, and 836 mm (11.1 mm/day) and 840.5 mm (11.2 mm/day) for V3.

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Table 2: Weather conditions during the testing period

Characteristics at 75 after transplanting						
	First campaign			**Second campaign**		
	V1	**V2**	**V3**	**V1**	**V2**	**V3**
Number of rainy days	**31**			**21**		
Rainfall depth (mm)	**335,7**			**254,5**		
Effective volume applied (mm)	**72,4**	**220,2**	**500,3**	**195,1**	**491,4**	**586**
Average temperature (°C)	**23,07**			**24,9**		
n/N	**0,44**			**0,18**		
Relative humidity (RH %)	**78,19**			**78,58**		

n/N = Insolation

Experimental Design

Three blocks, each with six experimental units, made up the split-plot experimental design, which included 24 units in total. To avoid water transfer, the 1.25 m x 2 m experimental units were spaced 1 m apart. The blocks were one and a half meters apart. To break up clods of earth, the experimental units were leveled with a rake after being physically built with hoes and shovels.

Parameters Mesured

The cumulative commercial output was calculated by adding the results of four harvests that were conducted at 30, 45, 60, and 75 days after transplanting (DAP) during the black nightshade growth cycle. Harvestable branches (length > 5 cm) were cut 1 cm from the main stem for the second, third, and fourth harvests after the main stem was cut 15 cm above the ground for the first harvest. With the exception of border plants, 18 plants were harvested. Following their weighing, the masses of these plants were converted to yield (kg/ha) and then to t/ha using the formula below:

PF (kg/ha) = PM (kg) x 10,000 / VS

Where VS = Vital Area (m2). This represents the surface area occupied by the 18 sampled plants. The spacing was 25 cm x 25 cm, hence VS = 0.25 m x 0.25 m x 18 = 1.125 m2.

Laboratory Analyses

Physical and chemical characteristics of samples of soil and laying hen droppings were examined (Table 4). The process described by Bouyoucos (1962) was used to obtain the particle size distribution. A pH meter was used to measure the pH of the soil. Bray II solution was used to extract phosphorus, which was then measured with a spectrophotometer. A flame photometer was used to measure K and Na, while complexometric titrations were used to measure Mg and Ca. Pauwels et al. (1992) were used to determine apparent CEC (CEC7). According to Pauwels et al. (1992), a part of the fine soil was utilized for the study of total Kjeldahl nitrogen and organic carbon (OC).

Statistics Analysis

The study's findings were input into an Excel spreadsheet. ANOVA was conducted using R program. Duncan's test was used to separate the means of the factors' effects and their interactions.

Land Assessment

This will be done using the FAO method, modified by Kidhir.

Water Use Efficiency and Fertilizer Use Efficiency

Since the season did not have a significant effect on yields, we combined the water quantities, the fertilizer quantities applied (organic and mineral), and the yields obtained during the two seasons.

Economic Analysis

We were able to evaluate the profitability of the various treatments we employed during our trial by using the value-to-cost ratio (VCR) and the rate of return. The price of the various fertilizers on the Dschang market, transportation expenses, spreading expenses, irrigation expenses, and additional labor costs are all taken into consideration in this study. These factors are connected to the rise in yield that fertilizers have on crops as well as the interest on investment. Cost of fertilizer (FC): 55 FCFA/kg (€0.08/kg) for layer manure and 400 FCFA/kg (€0.61/kg) for NPK-20.10.10 (600 kg/ha); Fertilizer application cost (FAC): 35,000 FCFA/ha (€53.36/ha) for layer manure and 25,000 FCFA/ha (€38.11/ha) for NPK-20.10.10; Fertilizer transport (FT): 5 FCFA/kg (€0.01/kg);

Boukong et al. (2018) state that the additional harvest labor cost (AHLC) is equal to the fresh harvested material's additional yield (YR)* 7.5 FCFA/kg (€0.11/kg). Water application cost (WAC): Experience has shown that irrigating one hectare with 8 mm takes 6.67 man-days, or 10,979 FCFA per day per hectare (€16.74 per day per hectare); water pumping cost (WPC): This was calculated using fuel consumption and the motor pump's depreciation plus maintenance costs (20% of the purchase price).

The total cost (TC1) is obtained from the sum of the various costs mentioned above.

The investment interest (II) for production was obtained from the formula II = [TC1 x 5.5% x (n / N)]; where n = production duration in days from the application of poultry manure (77 days); N = number of days in the year (365 days); 5.5% is the recognized interest rate in the Cameroonian economy;

The total cost of production (TC2) through the use of fertilizer and water CP = CT + II;

The additional yield cost price (PRRS) is the product of an additional yield and the unit price of the farm gate sale, which is 130 FCFA/kg, or €0.20/kg in the off-season (€0.20/kg); Additional yield (IR) = average yield of the combination of factor modalities minus the average yield of the control combination without fertilizer for the corresponding unit:

Returns with irrigation and

$$IR (\%) = [(PRIR – CT2) / CT2] \times 100$$

$$= [(PRIR / CT2) - 1] \times 100$$

$$= (RVC - 1) \times 100$$

According to FAO (1987) and reiterated by the African Soil Health Consortium (ASHC) (2015), following fertilizer application in an environment where water is not a constraint, an RVC ≥ 2 is acceptable and scalable.

This study examined the influence of the factors studied on optimizing fertilizer use. Coefficient of Concordance W was employed.

RESULTS AND DISCUSSIONS

Pédoclimatic Characterization

Soil, Poultry Manure and Water Characteristics

The soil had a PH_{H2O} that ranged from moderately acidic (5.3-6) to slightly acidic (6-7), had a high organic matter content (4.2-6.0) but the quality of this matter was poor (14-20) as for available phosphorus, it varied from very low (< 7) to low (7-16).

The ratio C/N of the poultry manure range from good in first campaign to bad in the second campaign.

The water used has a slightly acidic pH (6-7). It's very low electrical conductivity (< 0.7 dS/m) and the RAS of 2.15 meq / l (0 < 2.5 < 4) do not constitute a restriction on the use of this water for agricultural production.

Table 3: Physicochemical characteristics of soil, poultry manure and water

Parameters	**Soil 2018**	**Soil 2019**	**poultry manure 2018**	**poultry manure 2019**	**water**
pH-eau	5,67	6,2	7,7	7	6,59
OC (%)	2,18	2,82	28	33,04	/
OM (%)	4,75	4,86	48,27	56,97	/
C/N	12,17	14,34	10,37	15,08	/
∑ of bases (meq/100g, mg/l)	6,12	5,80	/	/	/
CEC (meq/100g)	17,12	11,39	/	/	/
P available (ppm)	6,43	7,5	/	97,70	61,16
SAR $(meq/L)^{1/2}$	/	/	/	/	2,15
EC (µS/cm)	/	/	/	/	0,48

OC (%) : organic carbon ; **OM (%)** : organic matter ; **C/N** : carbon on nitrogen ; ∑ **of bases** : sum of bases ; P available : available phosphorus ; P Total : total phosphorus ; SAR : sodium absorption ratio ; EC : electrical conductivity.

Land Evaluation

Table 4: parametrics values of the climat

characteristics	**Value**		**Parametric value**		**classe**	
	campaign 1	**Campaign 2**	**campaign 1**	**campaign 2**	**campaign 1**	**campaign 2**
irrigation (mm)	600	678,67	95	91,06	S1-1	S1-1
Average temperature (°C)	23,07	24,96	89,65	97,6	S1-1	S1-0
Relative Humidity (%)	78,19	78,58	79,68	79,03	S2	S2
n/N	0,44	0,18	85	60	S2	S2

Calculation of the Climatic Index in the First Campaign

$IC = 79{,}68(0{,}95 \times 0{,}90 \times 0{,}85)^{1/2} = 67{,}92$

Adjusted IC =16,67 + (0,9x IC) =16,67+ (0,9 x 67,92)

IC Adjusted =77,80

Calculation of the Climate Index in the Second Campaign

$IC = 60(0{,}91 \times 0{,}98 \times 0{,}79)^{1/2} = 50{,}36$

Adjusted CI = 16.67 + (0.9 x CI) = 16.67 + (0.9 x 50.36)

Adjusted CI = 61.99

The calculated Adjusted CI value corresponds to a climate of average suitability for black nightshade cultivation in the first and second seasons.

Table 5: Parametric values and classes of soil elements

Charatéristics	**Value**		**Parametric Value**		**classe**	
	Campaign 1	**Campaign 2**	**Campaign 1**	**Campaign 2**	**Campaign 1**	**Campaign 2**
Climat (c)			77,80	61,99	S2	S2
Topography (t) slope (%)	2,5	2,5	98	98	S1-0	S1-0
Caratéristics	**Values**		**Parameters Values**		**classes**	
	Campaign 1	**Campaign 2**	**Campaign 1**	**Campaign 2**	**Campaign 1**	**Campaign 2**
Humidity (w) inondation	/	/	100	100	S1-0	S1-0
Drainage	bien	bien	100	100	S1-0	S1-0
Texture	SL	SL	100	100	S1-0	S1-0
depth (cm)	> 150	> 150	100	100	S1-0	S1-0
CEC (meq/100g)	17,12	11,39	93,6	78	S1-1	S2
Base saturation (%)	36,57	51,39	93,95	100	S1-1	S1-0
Organic carbon (%)	2,18	2,82	100	100	S1-0	S1-0
pH topsoil	5,67	6,2	86,5	85	S1-1	S1-1
ESP (%)	0,70	1,40	99,3	99	S1-0	S1-0

Calculation of the Soil Index in the First Season

IT = 77.80 x (98/100 x 99/100 x 87/100 x 94/100 x 94/100 x 100/100 x 100/100 x 100/100 x 100/100 x 100/100 x 100/100 x 100/100 x 100/100) 1/2 = 67.19

For 50 < IT < 75

Adjusted IT = 50 + [(IT-5) x 0.410]

Adjusted IT = 50 + [(67.19 – 5) x 0.410]

Adjusted IT = 75.49

Calculation of the Soil Index in the Second Season

IT = 61.99 x (98/100 x 78/100 x 85/100 x 99/100 x 100/100 x 100/100 x 100/100 x 100/100 x 100/100 x 100/100 x 100/100 x 100/100 x 100/100) 1/2 = 49.72

For 25 < IT < 50

Adjusted IT = 25 + [(IT – 5) x 0.455]

Adjusted IT = 25 + [(49.72– 5) x 0.455]

Adjusted IT = 45.34

As can be seen from the above, campaign 1's soil index, with an average of 600 mm of water, fell into the S1-1c class, which is appropriate given the moderate climate constraints (relative humidity). With a water volume of 679 mm for the second campaign, the soil index class matched S2/S3cf, which is only slightly appropriate given the constraints imposed by fertility (base saturation) and climate (relative humidity and insolation).

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Performance Parameters

Table 6: Summary of Annova's table of cumulative harvestable branching number

Source of variation	df	Probability NRR	Probability Cumulative yield Sheets	Probability Cumulative marketable yield
block	2	0,91262	0,65879	0,912
campaign	1	0,28539	0,43126	0.478
Volume	2	0,06842.	0,08718.	0.049*
campaign : volume	2	0,32914	0,16830	0.037*
Frequency	2	0,05911	0,54420	0.426
Frequency : campaign	2	0,23940	0,92400	0.935
Frequency : Volume	4	0,86606	0,25793	0.204
Frequency : campaign : volume	4	0,33432	0,47987	0.439
Coefficient of variation		10,1%	12,8 %	11,9%

Signif. codes: '*' 0.05 df : degree of freedom

None of the parameters considered had a significant effect on the number of harvestable branches and leaf yield. The interaction of the season and the water volume had a significant effect on the marketable fresh yield.

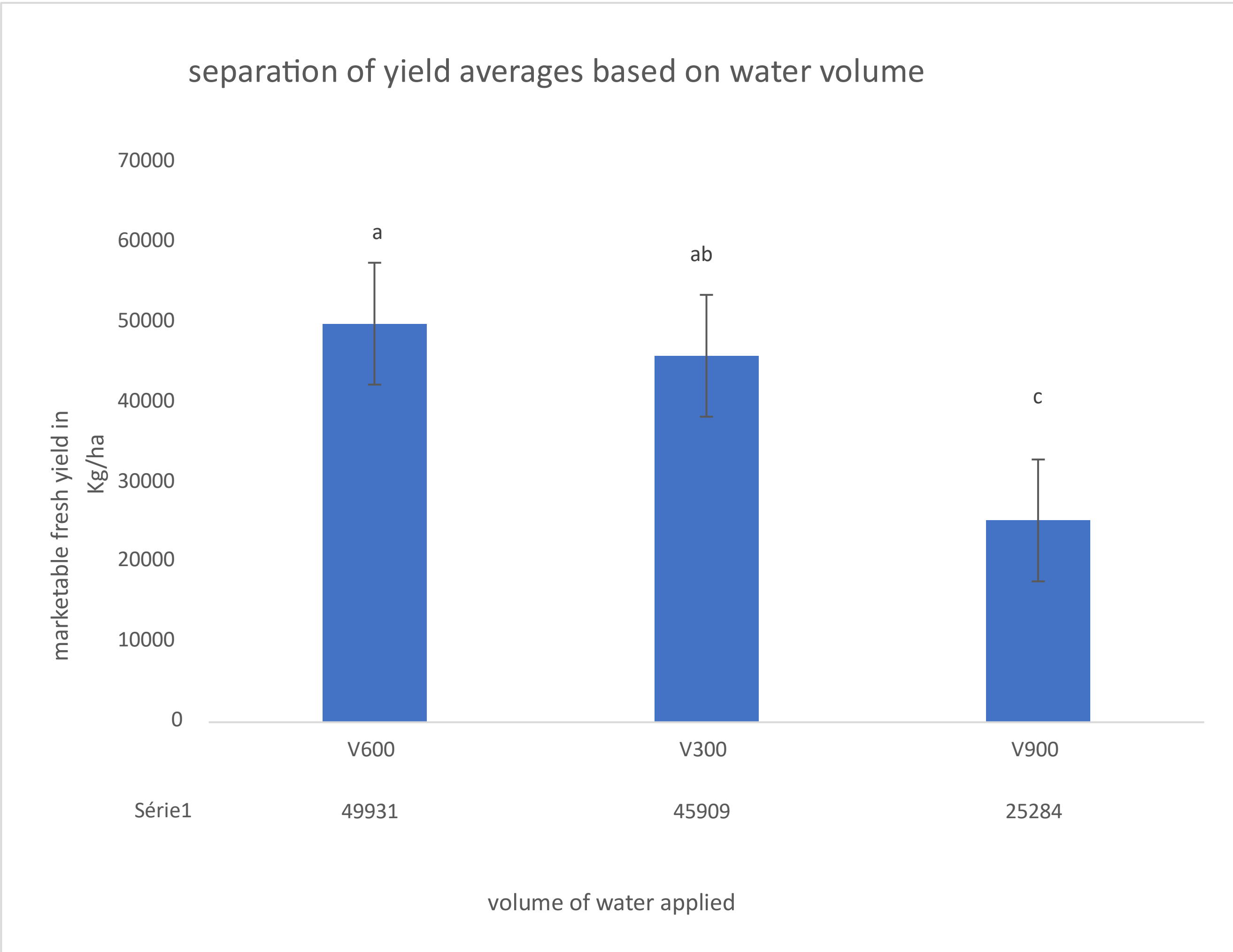

Figure 1: separation of yield averages based on water volume

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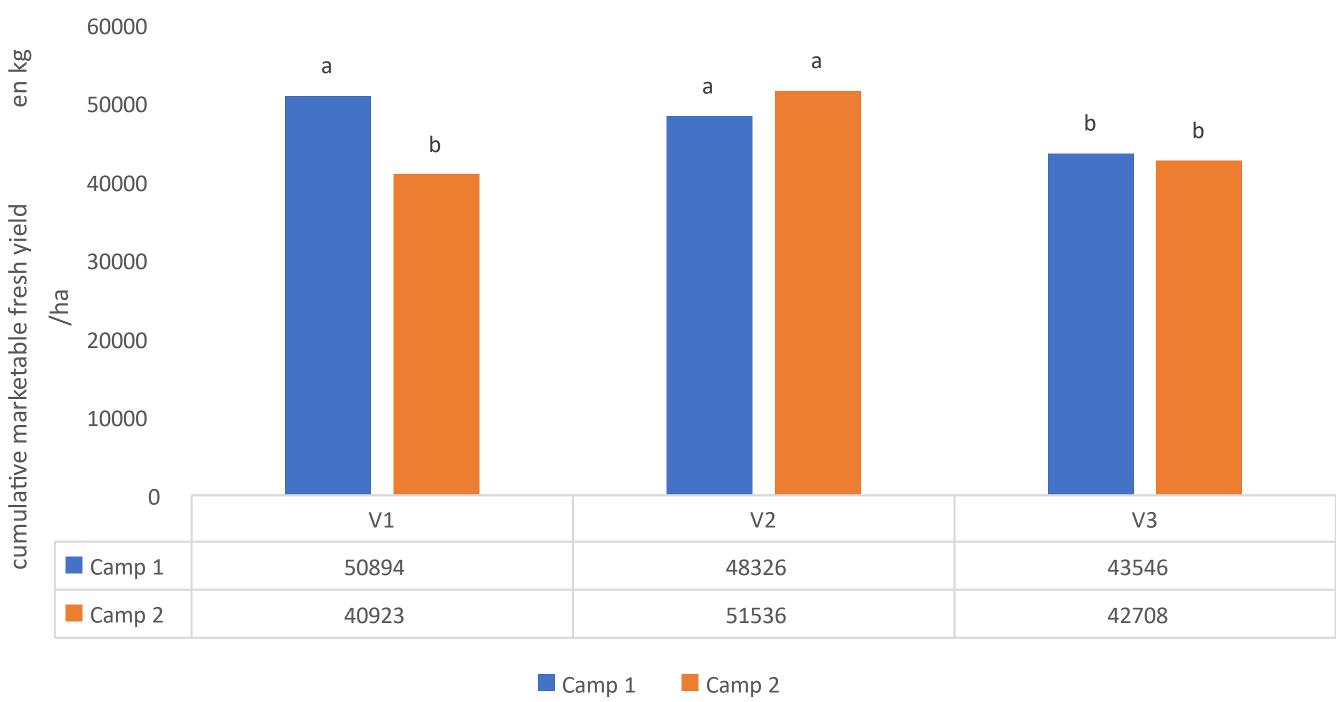

Figure 2: separation of yield averages based on campaign: volume interaction

Table 7: Effective use of water and fertilizer in agronomy

	Frequency (days)	Volume (mm)	Fertilizers in kg	Cumulative yield	fertilizer use efficiency	water useefficiency
T1	1	858	11200	259 422	23	302
T2	1	1282	11200	274 311	24	214
T3	1	1672	11200	292 621	26	175
T4	2	858	11200	319 823	29	373
T5	2	1282	11200	285 779	26	223
T6	2	1672	11200	293 156	26	175
T7	3	858	11200	211 644	19	247
T8	3	1282	11200	216 534	19	169
T9	3	1672	11200	229 197	20	137

Economic Profitability

Effective Use of Water and Fertilizer in Agronomy

Table 8: Estimated profitability of high-performance combinations

Treat	RCMM (t/ha)	RS (t/ha)	CT1 (Fcfa)	II (Fcfa)	CT2 (Fcfa)	PRRS (Fcfa)	RVC	RT (%)
T2	274311	112692	3409335	39558	3448893	16903800	**5**	**390**
T3	292621	136952	4359335	50580	4409915	20542800	**5**	**366**
T4	319823	129688	2734335	31726	2766061	19453200	**7**	**603**
T5	285779	129606	3409335	39558	3448893	19440900	**6**	**464**
T6	293156	135732	4359335	50580	4409915	20359800	**5**	**362**
T7	211644	60136	2734335	31726	2766061	9020400	**3**	**226**
T8	216534	119560	3409335	39558	3448893	17934000	**5**	**420**
T9	229197	102613	4359335	50580	4409915	15391950	**3**	**249**

DISCUSSION

Pédoclimatic Environment

Since Edmonds and Chweya (1997) state that for the plant to produce at its best, it requires annual rainfall ranging from 500 to 1200 mm and temperatures between 20 and 30 °C, the average amount of water received in the first and second campaigns was 600 and 678.67 mm, respectively. After this time, the average relative humidity was recorded. The crop benefits moderately when the n/N ratio is less than 0.5. In the first season, the soil index seems to have belonged to the S1-1c class, which is appropriate but has significant climate restrictions due to relative humidity, in accordance with Sys et al.'s land evaluation based on tobacco demands (1993). The soil index class for the second season with a water volume of 679 mm was S2/S3cf, which is only slightly appropriate given the constraints imposed by the climate (relative humidity and insolation) and fertility (base saturation). Greater soil suitability for solanum scabrum production is demonstrated in the first season, which is supported by a higher yield.

Effect of Factors on Performance Parameters

At the 44th, 69th, and 74th DARs, data on the quantity of harvestable branches was gathered. No parameter or interaction examined had a significant impact on the total number of harvestable branches, according to the analysis of the cumulative number of branches. However, the analysis of the three harvests' cumulative fresh yield (45th, 60th, and 75th DAR) revealed that both the volume and the interaction campaign had an impact on the yield. This means that the weight, length, and width of the leaves—rather than the number of branches—were the factors that affected the yield. In fact, research by Muthomi and Musyimi (2009) on how water deficiency affects solanum scabrum growth in nurseries demonstrates that stress causes a drop in leaf number and surface area, which in turn lowers photosynthesis and production. Similarly, Said Saleh et al. (2017) found no discernible variation in the impact of various water treatments on the quantity of green beans' leaves and branches per plant. According to Masinde P.W. et al. (2006), nightshades reduce leaf surface area, which helps them fight water scarcity. Season: volume interaction and volume had a substantial impact on cumulative fresh marketable yield. The best yield (50 t/ha) was obtained in the first season with a 408 mm application (1 ETP), and in the second season with a 2 ETP treatment (745.9 mm; 51 t/ha). The predominant meteorological conditions were the primary cause of the variation in the dose that produced the highest yield between the two seasons. Nevertheless, the application of 2 ETP, or 600 mm, produced the highest yield over the course of the two campaigns combined. Furthermore, the treatment with the lowest yield during the two campaigns was the application of 3 ETP, or 900 mm. In line with the findings of (Lontsi, 2014) on irrigation of cabbage, where he acquired a larger yield than the typical production of this crop, these two yields are higher than the average yield of black nightshade produced during the rainy season (47t/ha). For this reason, we can claim that irrigated land has the potential to be more productive than non-irrigated land. Furthermore, we observe that yield increases as water supply increases up to a certain point before starting to decline. This is explained by the fact that an overabundance of water causes the roots to suffocate since there is insufficient oxygen present. Saleh and colleagues (2017). Both overwatering and underwatering, however, decreased yields, though not as much as underwatering, according to Cripps et al. (1982). The yield was not significantly impacted by the frequency of water application, most likely because the early return of rainfall made it difficult to stick to the original schedule.

Economic Rentability

The primary goal of irrigation in agriculture is to maximize productivity in conjunction with an ideal water supply. It is frequently advised to keep soil moisture levels around field capacity during the growing season in order to accomplish these goals (Fereres et al., 2003, McKeown et al., 2010). To prevent detrimental side effects like nitrogen leaching and a rise in pest infestations, excessive watering should be avoided as it can be expensive. J. Seidel and associates (2017). According to the law of diminishing returns (WUE), more water should therefore result in an increase in yield at the same rate as the additional costs (Said Saleh et al., 2017). The application of 858 mm cumulatively throughout the two seasons, or 1 FTE every other day, was the treatment that, in our testing, produced the best water use efficiency and the best fertilizer use efficiency.

Economically speaking, all treatments are profitable because, according to the FAO, in tropical regions, a treatment must have an RVC greater than two. However, the treatment with the highest profitability is the daily application of 858 mm, which yields a profitability of 639, meaning that for every 100 francs (0.15 €) invested, 639 francs (0.97 €) are generated.

CONCLUSION

The land evaluation indicates that the soil index during the first growing season was in the S1-1c class, which is appropriate but has considerable climate limits because of relative humidity. With greenhouse horticulture, this climate limitation can be controlled. With a water volume of 679 mm for the second growing season, the soil index class matched S2/S3cf, which is only slightly appropriate because of fertility (base saturation) and environmental constraints (relative humidity and insolation). Although adding organic matter can improve base saturation, these climate limits cannot be addressed in the field.

No factor or interaction had a substantial impact on growth metrics. Marketable fresh yield was affected by both the volume factor and the season-volume interaction; the greatest output was 49 t/ha for a volume of 600 mm, or 2 FTEs. In these edapho-climatic circumstances, nightshade producers would benefit most from this volume.

From an agronomic standpoint, the optimal input dose is reflected in fertilizer and water use efficiency. Every two days, 856 mm (1 FTE) of water is used. With this dosage, the yield to input ratio can be as high as possible. The daily application of 856 mm (1 FTE) of water yields the maximum economic profitability. If you want to grow nightshade in the highlands of western Cameroon during the dry season, this is the one we suggest.

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