GROWTH OF PIGEON PEA *(CAJANUS CAJAN)* USING AUXIN IRRIGATION IN A HOME GARDEN IN PANAMA

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Abstract: We evaluated the growth of 120 plants divided into two groups of 60 grown in an area of 1000 m^2. The control group was hydrated with water, while the experimental group received water fortified with auxins. The experiment was carried out for twelve weeks during the dry season, and the amount of water per plant in each application was 250 mL. The planting area is located in the town of Burunga, district of Arraiján, which corresponds to the province of West Panama. A comparison of the control group with the experimental group was established using the Mann-Whitney U non-parametric inferential statistics test. Statistically significant differences were observed between the control and experimental groups in all measurements except that of 120 hours, demonstrating that water with auxins strengthens the growth of pigeon pea plants. Furthermore, there were statistically significant differences in the edophological properties between the control and experimental groups.

Keywords: pigeon peas, auxins, crops, food security, *Cajanus cajan.*

INTRODUCTION

Pigeon pea cultivation is among the economic impact items in the Republic of Panama, with a per capita consumption of 0.7 kg/inhabitant, an average yield of 19 quintals per hectare, some 370.39 hectares planted, and a total of 7,108.41 quintals. It does not reflect production under irrigation or innovative technologies in this crop (MIDA, 2019).

Pigeon pea has aroused an interest in nutritionists because it is rich in protein (26-28%), complementing the vegetarian diet. It also contains vitamins (A, C, B complex), minerals (Ca, Fe, Zn, Cu), carbohydrates, and dietary fiber (Fousiya, Jayamani, Uma, & Hemavathy, 2021). The study's objective by Fousiya et al. (2021) was to study genetic variability in dual-purpose pigeon pea. The genotypes showed a wide range of genetic variability for the nine plant traits studied among sixty-four genotypes, including three control varieties.

It also represents one of the significant cereal legume crops in tropical and subtropical regions (Borah, Sarma, Sarma, Bhattacharjee, & Bordoloi, 2020). Borah et al. (2020) developed the work to find character association and causal relationship of seed yield and its components in early maturing genotypes. The authors consider that the average harvest duration is complicated in mixed cropping systems, hence promoting early maturity by developing new cropping patterns.

Pigeonpea has become a scientific attraction, so Saxena, Molla, Yadav, and Varshney (2020) developed a high-resolution genetic mapping of fertility restoration (FR) by combining a large population and high-density genetic map in pigeon pea (Cajanus cajan). The results indicate that the genetic map has 4867 markers, and four quantitative trait loci (QTL) for fertility restoration were identified. The authors believe this finding will be valuable for genomics-assisted breeding and identifying causal genes/nucleotides for fertility restoration in the pigeon pea hybrid-breeding program. They found the importance of 2-oxoglutarate/Fe(II)-dependent dioxygenases (2-ODDs), a superfamily protein that plays a significant role in auxin concentration. This protein converts IAA to active oxIAA, which controls auxin concentration and homeostasis, essential for reproductive development.

García-Pacheco, Cabrera, and Fuenmayor (2020) published a study to obtain and characterize flours as alternative protein and vitamin A sources. For this, they processed pigeon pea grain and managed to identify 15 amino acids, among which 10 are essential with a total of 49.19 g/100 g of protein, highlighting the content of Lysine (8.48 g/100 g). The study is crucial since the authors looked for nutritional alternatives to prepare traditional foods rich in protein for the Colombian population.

In Nigeria, Adepoju, Dudulewa, and Bamigboye (2019) investigated nutrient retention of pigeon pea and its effects through cooking means and time. They acknowledge that protein malnutrition is widespread among the rural poor population in some developing countries. However, they state that dietary protein alternatives exist. They mention that its properties include potassium, calcium, phosphorus, iron, zinc, manganese, and copper, making it a viable and low-cost food; however, its consumption is limited due to its hardness and slow cooking process. Adepoju et al. (2019) found that boiling and decanting led to a significant loss of nutrients in cooked samples compared to raw samples. However, cooking without decanting the cooking water retained more nutrients for both boiling and pressure cooker cooked samples; in the latter case, the time is reduced.

In this line of work, Adeleye, Awodiran, Ajayi, and Ogunmoyela (2020) demonstrated the influence of extrusion cooking on the physicochemical properties and digestion kinetics of starch from grains, including Cajanus cajan. Moisture was adjusted to a sample of 25 g / 100 g, then manually mixed before being subjected to short-term extrusion cooking at high temperature. Some of their results are shown in Table 1.

Table 1: Approximate composition of raw and cooked treated Pigeon pea (Cajanus cajan)

	Crude protein (%)	Crude fiber (%)	Ether extract (%)	Nitrogen free extract (%)	Ash (%)
Unextruded	21.20 ± 0.02	7.72 ± 0.25	8.50 ± 3.10	48.59 ± 2.74	4.88 ± 0.03
Extruded at 100 ˚C	20.07 ± 0.00	8.02 ± 0.02	3.37 ± 0.16	55.58 ± 0.61	4.50 ± 0.20
Extruded at 140 ˚C	18.66 ± 0.01	9.35 ± 0.13	2.03 ± 0.81	55.60 ± 0.69	5.02 ± 0.12

The findings indicate that extrusion cooking at 100°C or 140°C modified the water holding capacity and swelling power, but not the water solubility index of the extrudates. Adeleye et al. (2020) propose encouraging research with lesser-known grain legumes to enable their cultivation and consumption.

There have been other studies interested in this type of legume crop; for example, Hussain, Sharma, Joel, Rajasekaran, Senthil, and Senthil (2021), designed a study with a total of 20 extra early introgression lines of pigeon pea, along with randomized complete block design (RCBD) checks to identify variability and other genetic parameters for 10 agronomic traits. The results obtained through principal component analysis are associated with additive genetics, which allows it to broaden its genetic base and introduce beneficial traits in future crops.

According to Vega-Celedon, Canchignia, Gonzalez, and Seeger (2016), new plant hormones have been identified with the scientific advancement of the last decades, such as auxins (indole-3-acetic acid). Indole-3-acetic acid (IAA) is the primary native auxin of higher plants. Therefore, it is present in growth, development, and physiological processes, including cell elongation, division, and tissue differentiation (Vega-Celedon et al., 2016, page 34). Its contribution is so vital that the agrochemical industry has developed synthetic auxins that mimic the structure of AIA.

Pencík, Simonovik, Petersson, Henyková, Simon, et al. (2013) reports that native auxin (AIA) is a crucial regulator of plant growth and development. Its transfer between cells and tissues depends on different stimuli, including environmental, so its distribution is not uniform.

In Venezuela, Marquina, Ramírez, and Castro (2018) presented alternatives to increase germination, growth, and improve the production of horticultural crops. The authors reported that auxins inhibit main root growth at high concentrations but stimulate the formation of lateral and adventitious roots, which improve water and mineral uptake.

The present study evaluates the effect of water fortified with auxins during the dry seasonon pigeon pea growth.

MATERIAL AND METHODS

Plants

The growth in centimeters of 120 pigeon pea plants, divided into two groups of 60, was compared during the experiment. The control group was hydrated only with water, while the experimental group received water fortified with auxins. The study was conducted for twelve weeks during the dry season, corresponding to the months with minimum rainfall (between December and April). Planting was carried out on January 27, 2020, for all crops. Height growth measurements began on February 3, every eight days for twelve weeks. The last measurement was made on April 20 of that year. After this date, no measures were made because the first rain began five days after the previous data collection, which marked the data collection limit, which consisted of only measuring plant heights during the dry season, both for the control and experimental groups. The amount of water used per plant was 250 ml in each application, and the auxin content in the water was 500 parts per million. Each plant in each of the two groups was watered at 12, 24, 48, 72, and 120 hours.

Out of the sixty plants of the control group, ten served as controls, which did not receive water applications during the twelve weeks of the study, and all ten died before the fifth week. Similar behavior occurred with the ten control plants of the experimental group, to which auxin fortified water was not applied. They died before the sixth week, so the records do not appear since they died very early.

Edaphology

Most of Panama's territory comprises lowlands (89%), the remaining part of which corresponds to the Barú Volcano and the Cordillera Central. Concerning land use, 44% is forested, 21% corresponds to pastures, and 9% serves as arable land. The dominant soils can be seen in Table 1:

Table 1

Panamanian soil resources

Acrisol	AC	Low activity clays, low base saturation.
Cambisol	CM	Moderately developed.
Leptosol	LP	They comprise very thin soils on continuous rocks and soils that are extremely rich in coarse fragments. They have resource potential for wet season grazing and as forest land.
Nitisol	NT	Deep, well-drained red tropical soils with diffuse horizon boundaries and a subsurface horizon with at least 30% low activity clay, P fixation, many Fe oxides, strong structure.
Ferralsol	FR	They represent the classic, deeply weathered, red or yellow soils of tropical humid zones. They have good physical properties, such as soil depth, good permeability, and stable microstructure makes them less susceptible to erosion. The soil is easy to work because they are drained, but sometimes they can be dry due to their low water storage capacity.

Own elaboration based on Rodríguez, 2019; and IUSS, 2015.

The highlands of the province of Chiriqui are characterized by having a high altitude humid temperate climate, with deep and fertile soils derived from volcanic ashes (Rodriguez, 2019; IUSS, 2015).

Preparation of Auxin Extract

The auxin extract was prepared using 500 g of lentils placed in 1 liter of water for 12 hours, then removed from the water and set at room temperature for 12 hours to germinate. This procedure was carried out three times using the same initial water. The extract obtained was homogenized with the help of a blender, adding the necessary freshwater, filtered through a cotton cloth, and finally gauged to nine liters of water.

Sowing

The planting area is located in the town of Burunga, district of Arraiján, province of West Panama. The geographical coordinates are 79º41'30.9" West Longitude and 9º02'08.50" North Longitude (MICI, 2008).

It is a plain 100 meters above sea level, not traditionally farmland, but grazing land, with a humid and tropical climate. The dry season is partly cloudy, with frequent winds coming from the south and east with an average temperature between 29°C and 31 °C (IGNTG, 2017).

Design

The design of the study is experimental since there is a random selection. The condition was the same for all the samples. Table 2 summarizes the experimental design, we can observe the schematic comparison of five replicates (rows) of the control group with the treated group, for twelve weeks (columns), where each column corresponds to one week; the XiOi represents the treated group and the Oi the control group, which corresponds to the quasi-experimental design of multiple time series (Dorantes, 2018).

Table 2

Experimental Design

R	X_1O_1	X_1O_2	X_1O_3	X_1O_4	X_1O_5	X_1O_6	X_1O_7	X_1O_8	X_1O_9	X_1O_{10}	X_1O_{11}	X_1O_{12}
	O_1	O_2	O_3	O_4	O_5	O_6	O_7	O_8	O_9	O_{10}	O_{11}	O_{12}
	X_2O_1	X_2O_2	X_2O_3	X_2O_4	X_2O_5	X_2O_6	X_2O_7	X_2O_8	X_2O_9	X_2O_{10}	X_2O_{11}	X_2O_{12}
	O_{13}	O_{14}	O_{15}	O_{16}	O_{17}	O_{18}	O_{19}	O_{20}	O_{21}	O_{22}	O_{23}	O_{24}
	X_3O_1	X_3O_2	X_3O_3	X_3O_4	X_3O_5	X_3O_6	X_3O_7	X_3O_8	X_3O_9	X_3O_{10}	X_3O_{11}	X_3O_{12}
	O_{25}	O_{26}	O_{27}	O_{28}	O_{29}	O_{30}	O_{31}	O_{32}	O_{33}	O_{34}	O_{35}	O_{36}
	X_4O_1	X_4O_2	X_4O_3	X_4O_4	X_4O_5	X_4O_6	X_4O_7	X_4O_8	X_4O_9	X_4O_{10}	X_4O_{11}	X_4O_{12}
	O_{37}	O_{38}	O_{39}	O_{40}	O_{41}	O_{42}	O_{43}	O_{44}	O_{45}	O_{46}	O_{47}	O_{48}
	X_5O_1	X_5O_2	X_5O_3	X_5O_4	X_5O_5	X_5O_6	X_5O_7	X_5O_8	X_5O_9	X_5O_{10}	X_5O_{11}	X_5O_{12}
	O_{49}	O_{50}	O_{51}	O_{52}	O_{53}	O_{54}	O_{55}	O_{56}	O_{57}	O_{58}	O_{59}	O_{60}

Where:
R = randomization
X1 = Experimental treatment (auxins every 12)
X2 = Experimental treatment (auxins every 24)
X3 = Experimental treatment (auxins every 48)
X4 = Experimental treatment (auxins every 72)
X5 = Experimental treatment (auxins every 120)
O = Observations (measurement)

RESULTS AND DISCUSSION

Plants growth

Growth was recorded methodically at the same time for all plants in the two groups so that there were no variations that could affect the measurement. Likewise, the edaphological analysis made it possible to verify that the composition and nature of the soil were the same before planting for each plant, regardless of the group (control or experimental). Table 3 shows the evolution of the data collection of the control group, and Table 4 shows the information corresponding to the experimental group.

Table 3

Growth in height (cm) of ten pigeon pea plants hydrated: A. every 12 hours with 250 ml of water per plant. B. every 24 hours with 250 ml of water per plant. C. every 48 hours with 250 ml of water per plant. D. every 72 hours with 250 ml of water per plant. E. every 120 hours with 250 ml of water per plant.

A (12 hours)	**Weekly growth in centimeters of the control group (water)**											
#Week	1	2	3	4	5	6	7	8	9	10	11	12
No. of cases	10	10	10	10	10	10	10	10	10	10	10	10
Average	3.6	6.9	11	16.1	21.6	27.4	34.1	41.7	48.1	54.5	61.9	70.1
SD	0.5	1.2	2.0	2.9	4.2	4.9	5.3	4.8	5.9	7.0	7.7	8.8
Minimum	3	5	9	13	17	22	28	36	40	45	53	60
Maximum	4	9	15	23	30	38	45	50	58	67	75	85

B (24 hours)												
#Week	1	2	3	4	5	6	7	8	9	10	11	12
No. of cases	10	10	10	10	10	10	10	10	10	10	10	10
Average	3.1	6.3	9.5	13.2	17.7	22.3	27.1	32.5	37.2	42.5	47.3	52.7
SD	0.9	1.7	2.2	2.4	2.4	3.2	3.1	3.5	3.6	3.4	3.0	3.2
Minimum	2	3	6	9	13	17	22	27	32	37	43	48
Maximum	4	8	12	16	20	27	33	39	44	48	53	58
C (48 hours)												
#Week	1	2	3	4	5	6	7	8	9	10	11	12
No. of cases	10	10	10	10	10	10	10	10	10	10	10	10
Average	2.5	4.5	8.4	12.3	15.8	19.6	23.4	27.9	32.4	37.1	41.0	45.3
SD	1.1	2.0	3.3	4.6	5.8	7.2	8.5	10.2	11.9	13.4	14.8	16.3
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	4	7	11	16	20	26	30	34	42	46	50	54
D (72 hours)												
#Week	1	2	3	4	5	6	7	8	9	10	11	12
No. of cases	10	10	10	10	10	10	10	10	10	10	10	10
Average	1.6	2.4	3.1	3.7	4.6	5.9	6.9	8.0	9.0	10.1	11.4	13.0
SD	1.2	1.8	2.4	3.4	4.2	5.3	6.2	7.1	8.0	8.9	10.0	11.3
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	3	5	7	9	11	14	16	18	20	22	24	26
E (120 hours)												
#Week	1	2	3	4	5	6	7	8	9	10	11	12
No. of cases	10	10	10	10	10	10	10	10	10	10	10	10
Average	1.6	2.4	3.1	3.7	4.6	5.9	6.9	8.0	9.0	10.1	11.4	13.0
SD	1.2	1.8	2.4	3.4	4.2	5.3	6.2	7.1	8.0	8.9	10.0	11.3
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	3	5	7	9	11	14	16	18	20	22	24	26

Table 4

Growth in height (cm) of ten pigeon pea plants hydrated: **A**. every 12 hours with 250 mL of auxin water per plant. **B**. every 24 hours with 250 mL of auxin water per plant. **C**. every 48 hours with 250 mL of auxin water per plant. **D**. every 72 hours with 250 mL of auxin water per plant. **E**. every 120 hours with 250 mL of auxin water per plant.

A (12 hours)	Weekly growth in centimeters of the experimental group (water with auxins)											
#Week	1	2	3	4	5	6	7	8	9	10	11	12
No. of cases	10	10	10	10	10	10	10	10	10	10	10	10
Average	3.7	7.7	12.3	18.3	25.1	31.5	39.2	45.9	53.8	61.7	69.1	78.4
SD	0.9	1.6	2.9	3.8	4.8	5.8	5.1	6.2	6.9	7.8	9.1	10.5
Minimum	2	6	9	14	18	23	33	36	43	50	56	63
Maximum	5	10	17	25	33	40	47	55	65	75	85	95
B (24 hours)												
#Week	1	2	3	4	5	6	7	8	9	10	11	12
No. of cases	10	10	10	10	10	10	10	10	10	10	10	10
Average	3.9	7.2	10.4	14.8	19.9	24.5	29.5	35.9	41.5	48.3	55.0	61.9
SD	1.0	1.7	2.1	2.9	3.2	3.6	3.0	3.0	2.9	2.8	2.3	3.1
Minimum	2	4	7	10	14	19	25	31	37	46	52	57
Maximum	5	9	14	20	26	32	36	43	48	55	60	66
C (48 hours)												

#Week	1	2	3	4	5	6	7	8	9	10	11	12
No. of cases	10	10	10	10	10	10	10	10	10	10	10	10
Average	3.3	6.0	11.0	15.8	20.1	25.5	27.9	33.3	39.5	46.4	50.9	56.8
SD	1.2	1.5	1.2	1.0	1.5	2.3	2.4	2.8	3.9	3.5	3.6	3.6
Minimum	2	4	9	14	18	23	24	28	33	40	45	50
Maximum	5	8	13	17	23	29	32	37	45	52	57	63
D (72 hours)												
#Week	1	2	3	4	5	6	7	8	9	10	11	12
No. of cases	10	10	10	10	10	10	10	10	10	10	10	10
Average	2.9	4.9	7.3	11.8	15.1	18.9	18.2	20.3	22.8	25.7	28.3	32.1
SD	0.7	0.7	0.8	1.6	1.8	2.3	9.8	10.8	12.2	13.7	15.2	17.5
Minimum	2	4	6	10	13	16	0	0	0	0	0	0
Maximum	4	6	8	14	18	22	25	28	33	37	42	48
E (120 hours)												
#Week	1	2	3	4	5	6	7	8	9	10	11	12
No. of cases	10	10	10	10	10	10	10	10	10	10	10	10
Average	1.9	3.0	4.2	5.6	5.4	6.6	7.6	8.6	9.6	10.8	12.5	15.2
SD	1.1	1.7	2.4	3.1	4.8	5.9	6.8	7.7	8.6	9.6	11.0	13.3
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	3	5	7	9	12	15	17	19	21	22	25	30

Inferential results

When the data between the experimental group and the control group were compared using the Mann-Whitney U non-parametric inferential statistics test, it was observed that there are statistically significant differences between the control group and the experimental group in all measurements except the one where the irrigation frequency is 120 hours. In this case, although there are differences, they are not significant. The results are shown in Figure 1.

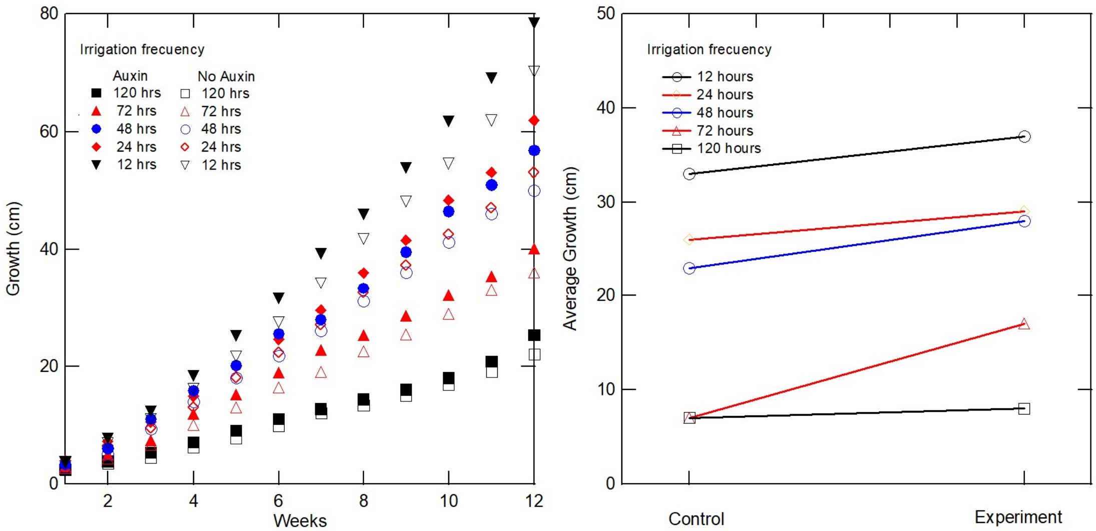

Figure 1: ***Left.*** Weekly total growth averages of pigeon pea plants of the experimental group (auxin fortified water) and control (no auxins). Irrigation frequency was every 12, 24, 24, 48, 72, and 120 hours for 12 weeks. ***Right.*** Comparison of the average growth (in centimeters) of pigeon pea plants between control (water without auxins) and experimental (water with auxins) groups.

The trend is that the increase in height is more accentuated in the experimental group, which indicates that water with auxins positively affects plant growth. According to figures provided by the IMA (2020), the pigeon pea requires between 530 *mm* and 2,000 *mm* of rainfall during each season to reach a height of between one and three meters in adulthood. In our study, 250 *ml* of water were distributed with a frequency of 12, 24, 48, 72, and 120 hours for 12 weeks, achieving growth of almost forty centimeters. The results are remarkable since they imply that plants can be grown any time of the year, in any plot, so that families can plant them for family consumption. Pigeon pea is an excellent nutritional source. In addition to that, it could represent significant savings to the families.

Edaphological analysis after the study

The results indicate minor differences between the control group (water) and the experimental group (water with auxin) regarding the contents of sand, silt, and clay, which implies that the soil was similar after the study was carried out.

Higher values were found in the samples of potassium (K), manganese (Mn), iron (Fe), and zinc (Zn) in the control group; however, it is pertinent to mention that manganese and iron allow the evaluation of soil toxicity. It should also be noted that, at high concentrations, some elements can intervene in the uptake of other elements, such as in the antagonistic relationships between Ca, Mg, and K. In our study, this is not the case.

The high values correspond to calcium (Ca) and phosphorus (P) in the experimental group. The latter is a fundamental element in plant growth. These particularities are surprising since higher values were expected in the experimental group. These findings differ from Adepoju et al. reported on potassium, phosphorus, iron, zinc, and manganese as crucial nutritional components in growth. The effect of auxin fortified water compared to water without auxin is shown in Table 5.

Table 5

Soil composition after 12 weeks

RESULTS OF SOIL ANALYSIS: HYDRATION ONLY WATER												
	are-lim-arc	M.O	PH	P	K	Ca	Mg	Al	Mn	Fe	Zn	Cu
Samples	**%Are-Lim-Arc**	%	PH	mg L^{-1}	mg L^{-1}	cmol kg^{-1}	cmol kg^{-1}	cmol kg^{-1}	mg L^{-1}	mg L^{-1}	Mg L^{-1}	mg L^{-1}
1	36-32-32	2.16	6.90	44.00	230.80	7.80	2.30	0.10	41.30	4.90	53.10	7.20
2	32-32-36	1.97	7.10	53.00	229.30	7.80	2.50	0.10	56.20	7.70	138.20	10.5
3	36-36-28	2.3	6.90	87.00	234.50	9.30	2.40	0.10	50.20	6.20	80.80	8.60
4	40-32-28	2.06	7.00	47.00	211.40	1.20	0.50	0.10	64.00	15.9	68.20	1.60
5	36-36-28	2.41	7.20	54.00	259.90	9.70	2.60	0.10	53.40	11.1	82.00	9.30
6	36-40-24	1.86	6.90	64.00	196.80	11.20	2.90	0.20	37.40	5.70	73.90	8.30
RESULTS OF SOIL ANALYSIS: HYDRATION WATER PLUS AUXINS												
	are-lim-arc	M.O	PH	P	K	Ca	Mg	Al	Mn	Fe	Zn	Cu
Samples	**%Are-Lim-Arc**	%	PH	mg L^{-1}	mg L^{-1}	cmol kg^{-1}	cmol kg^{-1}	cmol kg^{-1}	mg L^{-1}	mg L^{-1}	Mg L^{-1}	mg L^{-1}
1	36-36-28	2.08	7.20	85.00	218.30	9.90	2.60	0.10	45.10	4.80	53.90	7.90
2	40-36-24	1.86	7.10	78.00	180.70	9.00	2.30	0.10	30.60	4.00	49.70	6.30
3	40-36-24	2.41	7.10	78.00	221.70	9.10	2.40	0.10	62.00	17.2	67.40	8.70
4	40-36-24	2.41	7.10	68.00	178.20	7.20	1.90	0.10	30.90	3.50	41.10	9.10

5	36-36-28	1.86	7.20	76.00	185.90	7.70	2.40	0.10	35.60	4.10	43.50	7.80
6	48-36-16	2.08	6.10	74.00	137.50	7.70	2.20	0.10	36.00	3.30	32.10	6.40

CATIONIC RELATIONSHIP BETWEEN SOIL COMPONENTS: HYDRATION WITH WATER

Samples Identification	Ca/Mg	(Ca+Mg)/K	K/Mg	Mg/K	Ca/K	CICE	Saturation Al	K/CICE	Ca/CICE	Mg/CICE	Base Saturation
1	3.4	17.1	0.3	3.9	13.2	10.8	0.9	5.5	72.3	21.3	99.1
2	3.1	17.6	0.2	4.3	13.3	11.0	0.9	5.3	71.0	22.8	99.1
3	3.9	19.5	0.3	4.0	15.5	12.4	0.8	4.8	75.0	19.4	99.2
4	2.4	3.1	1.1	0.9	2.2	2.3	4.3	23.1	51.3	21.4	95.7
5	3.7	18.5	0.3	3.9	14.6	13.1	0.8	5.1	74.2	19.9	99.2
6	3.9	28.0	0.2	5.8	22.3	14.8	1.4	3.4	75.7	19.6	98.7

CATIONIC RELATIONSHIP BETWEEN SOIL COMPONENTS: HYDRATION OF WATER WITH AUXINS

Samples Identification	Ca/Mg	(Ca+Mg)/K	K/Mg	Mg/K	Ca/K	CICE	Saturation Al	K/CICE	Ca/CICE	Mg/CICE	Base Saturation
1	3.8	22.4	0.2	4.7	17.7	13.2	0.8	4.2	75.2	19.8	99.2
2	3.9	24.5	0.2	5.0	19.5	11.9	0.8	3.9	75.9	19.4	99.2
3	3.8	20.3	0.2	4.2	16.1	12.2	0.8	4.7	74.8	19.7	99.2
4	3.8	20.0	0.2	4.2	15.8	9.7	1.0	4.7	74.6	19.7	99.0
5	3.2	21.3	0.2	5.1	16.2	10.7	0.9	4.5	72.1	22.5	99.1
6	3.5	28.1	0.2	6.3	21.9	10.4	1.0	3.4	74.4	21.3	99.0

As expected in the comparison, the hydration of water fortified with auxins shows an improvement in soil fertility (Ca+Mg). Although its values are relative, it is possible to speak of a tendency.

Regarding the cationic ratios of (Ca+Mg)/K, the optimum values are between 10 and 40, which means that although the auxin-fortified water showed higher values, it does not reduce the importance of hydration with water.

CONFLICT OF INTERESTS. The authors declare that they have no conflict of interest. The sponsors had no role in the design of the study; in the collection, analysis or interpretation of data; in the writing of the manuscript or in the decision to publish the results.

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Authors´ Contributions. Francisco Corella: Conceptualization, Methodology, investigation, formal analysis, resources, project administration, writing of original draft, review and editing. Albano Díaz: formal análisis, review and editing. Ana Luisa García: formal Análisis, review and editing. Néstor Valles: Formal analysis, review and editing. Milagros Vaña: review and editing. Lurys Martínez: review and editing. Eliecer Tuñón: review and editing. Ericka Matus: Validation, formal analysis, data curation, writing of original draft, review and editing. Lorena Matus: Validation, formal analysis, data curation, writing of original draft, review and editing. Jay Molino: Methodology, investigation, formal analysis, validation, data curation, resources, supervision, project administration, funding adquisition, writing of original draft, review, editing.

CONCLUSIONS

The application of water with auxins for agricultural plants, especially in pigeon pea, is vital when rainfall is scarce in western Panama, as demonstrated in this study. The plants achieved more significant growth with an irrigation period of 12 hours. The results allow us to assess the relevance of this plant and its viability to be integrated into the essential family diet since it is a crop that could be produced throughout the year.

It is recognized that the balance of nutrients through the calculation of cation ratios was complex due to the difficulty of accessing specialized laboratories abroad; however, the results will allow other colleagues to work to improve the quality of pigeon pea in general and of the soil where it is planted, specifically.

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