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Dry matter accumulation by organs of the Chinese potato plant (Colocasia esculenta (L.) Schtt) according to planting distance in Ecuadorian Amazon conditions.

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R-I	**D3**	**D2**	**D1**
R-II	**D1**	**D3**	**D2**
R-III	**D2**	**D1**	**D3**

TREATMENTS (Planting distances)

D1-1,0 m x 0,40 m = 25000 plants ha^{-1}, 91 plantas por parcela
D2-1,0 m x 0,60 m = 16666 plants ha^{-1}, 63 plantas por parcela
D3-1,0 m x 0,80 m = 12500 plants ha^{-1}, 45 plants by plot

The accumulation of dry matter per organ of the Chinese potato plant (Colocasia esculenta (L.) Schtt) local white variety was determined in three moments of crop development, using three planting distances (1.0m x 0.40m, 1.0m x 0.60m and 1.0mx 0.80 m) in the conditions of the Ecuadorian Amazon, evidencing the physiological development of the crop. A factorial design in blocks was used completely at random, forming 9 plots of 30 m2, where the study factor was the planting distance representing the treatments. For data collection, five plants were randomly selected in perfect intraspecific competition. The variables were evaluated at 60, 120 and 180 days after planting. The analysis of double variance was carried out, using the Tukey test at a probability level of 95%. The highest values of dry matter accumulation by plant organs were obtained in the plantation distance of 1.0 m x 0.80m.

Key words: Dry matter; planting distance; Ecuadorian amazon.

INTRODUCTION

The Chinese potato crop (Colocasia esculenta (L.) Schott is widely planted in tropical and subtropical climates (Talwana et al., 2010) (Mabhaudhi et al., 2014). It does not have aerial stems and has large leaves that come from an underground corm that forms a small pseudostem. The world production of Chinese potato has a tendency to increase considerably every year. As of 2014 it had a growth of approximately 10 million tons, concentrating the highest volumes in the central and western zone of Tropical Africa, China, Oceania and countries in the region such as: Colombia, Ecuador and Honduras (FAOSTAT, 2017), occupying the fifth position among root and tuber crops worldwide (FAO, 2010). As fundamental characteristics it can be highlighted that it requires a soil pH between 5.5 to 7.8, a temperature between 25 ° and 35 ° C for its maximum photosynthetic rate and a high humidity in the soil so it has an optimal development with rainfall greater than 2500 mm per year and altitude between 600 to 1800 masl, although it could be cultivated at sea level (Manner & Taylor, 2011). This crop is part of the daily diet of millions of people around the world and in developing countries it is a crop that constitutes a source of income for small producers in rural areas, being one of the most highly valued crops by the Antillean population due to its energy richness and easy digestion, resulting in a cheap source of carbohydrates in relation to other species of tubers or cereals, due to its high starch content (Himeda et al., 2012).

In Ecuador it is cultivated mainly in the plains of the tropics, in the outer foothills of the mountain range and in the amazon region given the requirement of the plant to conditions of soil moisture (Puerres, 2010). It is a crop of economic importance for the inhabitants of the Ecuadorian Amazon Region (AER) Caicedo et al., (2013), being the Pastaza province with the highest levels of production and acceptable yields, which could be improved from scientific information on aspects of their agrotechnical and agroecological management, but that up to now they do not exist Alemán et al., (2014). To this has been added the scarcity of studies on planting density and others, which allow obtaining high agricultural yields. That is why the study of the different planting distances, as well as the use of organic fertilizers is reported as a practice that generates increased yields in this type of crop Adekiya, Aruna and Agbede, (2016).

In this context, the objective of this work was to study different planting distances based on the accumulation of dry matter by plant organs in the edaphoclimatic conditions of the Ecuadorian Amazon.

MATERIALS AND METHODS

A completely randomized block factorial design was used, where the study factor was: three planting distances, which represent the treatments. Plots of 5 meters wide by 6 meters long were formed, for an area per plot of 30 m2, 3 plots for replicas and 9 total plots, for an active area of 270 m2 and a passive area of 172 m2, with an area total experiment of 442 m2. The variables were evaluated at 60, 120 and 180 days after planting in the following way: a) Fresh and dry weight of plant organs: The fresh weight of each vegetative organ of the plant, as well as that of the cormels at harvest time, was determined on a precision balance. To determine the dry weight, each organ was placed in a heat oven at 60 ° temperature until constant weight was obtained, b) Biological yield (BY): Sum of the dry weights of the plant organs (root, stem, leaves and cormels), c) economic yield (EY): Total dry weight of cormels per plant and d) Harvest Index (HI): It is the relationship between Economic Yield and Biological Yield (EY /BY).

RESULTS AND DISCUSSION

The planting distance significantly influenced the dry weight of the plant organs at 60, 120 and 180 days after planting (table 1). At 60 DDP the highest values of dry matter accumulation per plant are obtained in the limbus with 26.17 g at the lowest population density, which corresponds to the distance of 1.0 mx 0.80 m with statistical difference for the distance of 1.0 mx 0.60 m and this in turn with the smallest distance used in the experiment. Surely influenced by the low population density and therefore greater vital area that facilitates better use of soil nutrients, incidence of light and water caused by the high rainfall in the area under study. Similar studies carried out by Yánez, (2009) show that when the population density is low, the dry matter increases by plant organs.

A los 120 DDP el peciolo es el órgano de la planta con mayor cantidad de materia seca producida. Esta fase de desarrollo del cultivo conocida como la llamarada del crecimiento, ocurre entre los 120 y 150 días en las condiciones de la amazonia ecuatoriana, donde el tamaño del peciolo crece de forma acelerada. Esto ocurre seguramente porque la planta es favorecida por las condiciones ambientales de la zona, específicamente a la alta pluviosidad. Estos resultados coinciden con el estudio realizado por Byrd *et al*. (2014), que informaron que el crecimiento de la planta se afecta de manera significativa cuando existe limitada disponibilidad de agua, nutriente y luz.

Table 1. Dry weight of the vegetative organs of the plant according to planting distance

DATE	VARIABLES	D1 1,0 m x 0,40 m	D2 1,0 m x 0,60m	D3 1,0 m x 0,80 m
60 DAP	DW ROOT (g)	3,01 **b** ± 0,30	4, 11 **a** ± 0,51	4, 19 **a** ± 0,51
	DW STEM (g)	13,01 **c** ± 0,75	14,87 **b** ± 1,28	16, 59 **a** ± 1.53
	DW FISH (g)	12,22 **c** ± 1,62	13,64 **b** ± 2,28	15, 57 **a** ± 1,67
	DW LIMBO (g)	15,69 **c** ± 3,24	24,12 **b** ± 2,00	26, 17 **a** ± 1,95
120 DAP	DW ROOT (g)	5,79 **b** ± 1,31	7, 68 **a** ± 1,51	7, 76 **a** ± 1,58
	DW STEM (g)	43,98 **c** ± 11,52	69,85 **b**± 10,78	84, 42 **a** ± 3,88
	DW FISH (g)	138,58 **c** ± 43,70	173,66 **b** ± 59,32	216,02 **a** ± 47,91
	DW LIMBO (g)	61,77 **c** ± 13,77	78,07 **b** ± 6,21	85,08 **a** ± 6,23
180 DAP	DW ROOT (g)	13,68 **b** ± 1,49	14, 91 **a** ± 2,20	15,08 **a** ± 2,29
	DW STEM (g)	155,86 **c** ± 17,95	213,17 **b** ± 33,59	279, 84 **a** ± 16,74
	DW FISH (g)	191,01 **c** ± 50,94	244,59 **b** ± 81,47	294, 71 **a** ± 67,43
	DW LIMBO (g)	197,28 **c** ± 57,98	336,83 **b** ± 26,28	365, 81 **a** ± 27,38

DAP: days after planting; DW: Dry weight; Tukey P<0.05 Different letters indicate that there are significant differences between treatments

At the end of the crop cycle (180 days) the limbus is the organ of the plant with the highest content of dry matter with values higher than 365 g, producing 28.98 g more with respect to the accumulated in the distance of 1.0 mx 0.60 m and 168.53 g with respect to the planting distance of 1.0 mx 0.40 m. This result is logical because this organ of the plant is the part in charge of photosynthesis and regulating perspiration. Plants in their competition for sunlight and vital area conditions activate their photosynthesis mechanism and metabolic activity that makes them produce a greater amount of dry matter per unit of leaf area. Making an analysis of the convenience of using these wastes from the Chinese potato harvest in swine feeding, we can affirm that a considerable amount of dry matter can be obtained by using low population density. Similar results were obtained by Caicedo, (2013), where he demonstrated that Chinese potato cultivation can contribute to a valuable energy source for the formulation of animal diets.

Figure 1 shows higher numerical values in the order of 18, 143 and 397 g of dry matter per plant for the 60, 120 and 180 days respectively between the lowest and the highest population density, which means that the plants at greater distances of plantations accumulate more total dry matter in their organs, which constitute a good source of lower-cost carbohydrates in relation to cereals and other types of roots and tubers (Krishnapriya & Suganthi, 2017).

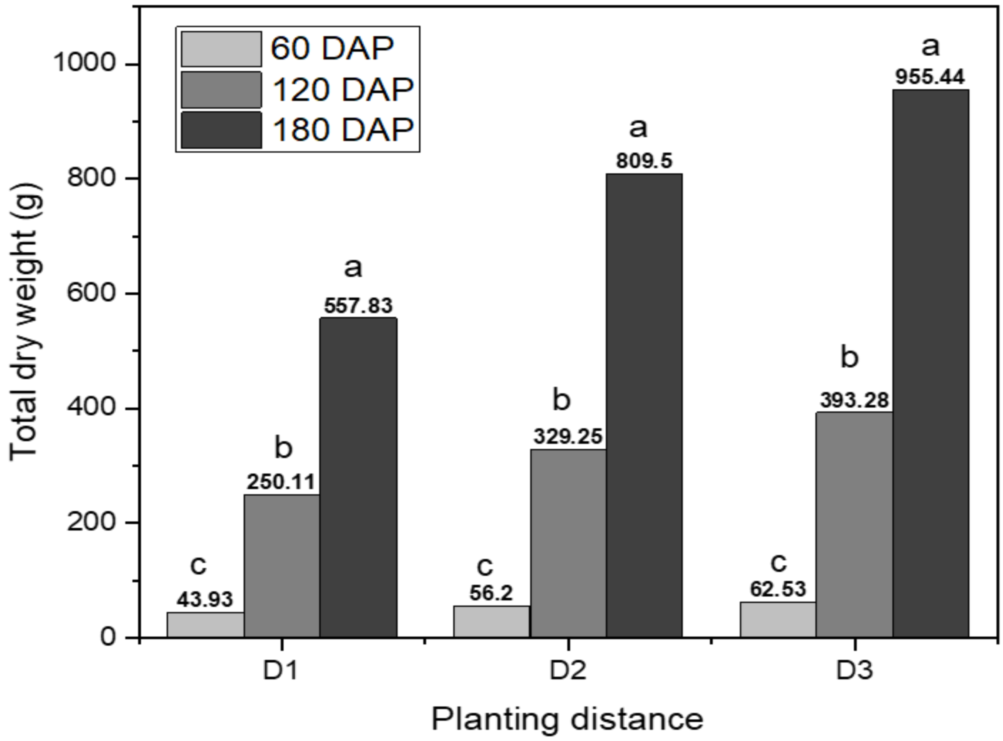

Figure 1. Variation of total dry matter according to planting distances (D1: 1x 0.40m; D2:1x0.60m,D3:1x0.80m) at different moments of crop development. Tukey p≥0.05. Equal letters indicate that there are no significant differences between treatments.

Between 60 and 120 days after planting, the increase in total dry matter is 12 times higher than that obtained in the same period of time for the final phase (120 to 180 DDP), which shows the high photosynthetic activity in that period of crop development. At 180 DDP each plant produces an average 398 grams more of dry matter when planted at 1.0 mx 0.80 m in relation to those planted at distances of 1.0 mx 0.40 m, surely favored by the vital area of the plant and the edaphoclimatic conditions of the area, mainly due to the high rainfall. Probably because plants in their competition for sunlight and living area conditions activate their photosynthesis mechanism and metabolic activity that makes them produce a greater amount of dry matter per unit of leaf area. Similar results are reported by Cabrera et al., (2010) when studying different genotypes and population densities.

Influence of planting distance on biological and economic yield and harvest index performance.

The planting distance significantly influenced the physiological variables of the crop such as biological yield (RB), economic yield (RE) and harvest index (IC). The biological yield (RB), presents a higher value (1621.25 g of DM / plant) with the plantation distance (1.0 m x 0.40 m), where 25,000 plants / ha are obtained. Statistical analysis shows significant differences between treatments for all cases. This means that the planting distances influenced the content of dry matter (DM) produced by the plants, surely influenced by the high population density and greater number of organs per plant. Similar results are reported by Caicedo (2015), who obtained up to 40% dry matter (DM) from by-products of tubers and plant organs when using high population densities.

Table 2. Variation of biological and economic yield of the crop according to planting distance.

TREATMENTS VARIABLES	Biological yield (g MS/plant)	Economic yiel (g DW cormels / plant
D1-1,0m x 0,40m	1621,25 **a** ± 22,98	228,47 **b** ± 89,73
D2-1,0m x 0,60m	1245,37 **b** ± 30,20	242,73 **b** ± 79,76
D3-1,0m x 0,80m	1105,95 **b** ± 91,16	262,88 **a** ± 152,96

Tukey p≥0.05. Equal letters indicate that there are no significant differences between treatments.

Regarding the economic yield (EY), a significant effect can be observed in the distance of 1.0 mx 0.80 m with respect to the other treatments with values of 262.88 grams of DM of cormels per plants, surely influenced by the low population density where the plant develops in a larger vital area and therefore has a greater amount of available nutrients, which brings with it a greater weight of cormels and plant organs. Similar results were found by Yánez, (2009), where he states that the dry matter (DM) is influenced by the low weight of cormels and their formation. The harvest index (HI) shows us the relationship between economic performance (RE) versus biological yield (BY) (figure 2). The most significant values are observed in the highest population density (1.0 mx 0.40 m), where a value of 0.37 is obtained, which means that 37% of the total dry matter accumulated by the plant corresponds to agricultural fruit, in this case cormels, which allows identifying the efficiency of the crop in photosynthetic conversion. Similar results were found by (Lasso and Cundumí, 2016), where they reach values close to 40% DM in different edaphoclimatic conditions. A low density of plants per area of12,500 plants per hectare could restrict the high harvest rate, resulting in values of 0.25.

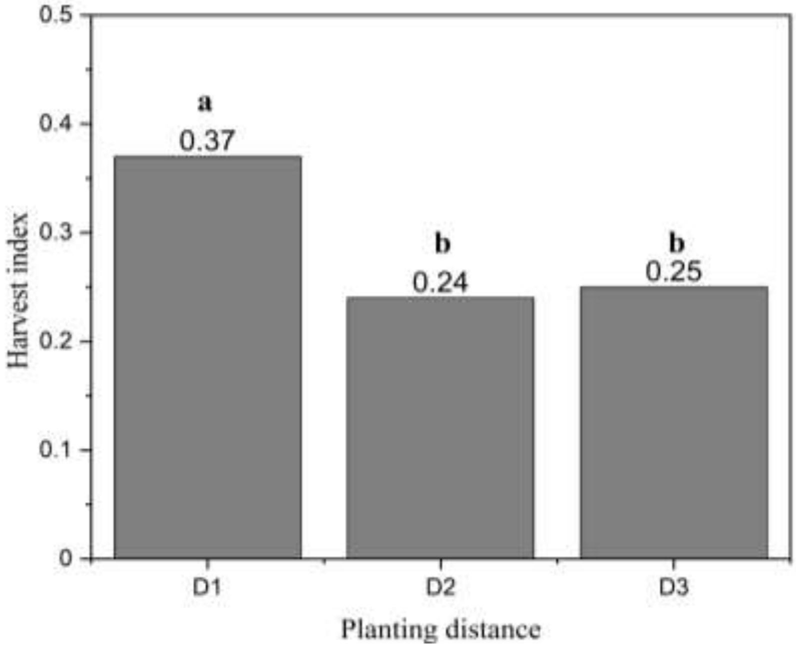

Figure 2. Harvest index according to planting distances (D1: 1x 0.40m; D2:1x0.60m, D3:1x0.80m). Tukey p≥0.05. Equal letters indicate that there are no significant differences between treatments.

CONCLUSIONS

1- The highest accumulation of dry matter (DM) per plant is obtained in the highest population density that corresponds to the planting distance of 1.0 m x 0.40 m where 25,000 plants per ha are achieved.

2- It is shown that there are significant differences between the factors for the biological yield variables (BY), being the planting distance of 1.0 mx 0.40 m the one with the highest value with 1621.25 g of dry matter of cormels per plants.

3- The highest economic yield (EY) values are obtained at low population density, which corresponds to a plantation distance of 1.0 mx 0.80 m, where 12,500 plants are achieved per ha with values of 262.88 g of dry matter by cormels.

4- The highest harvest index (HI) is obtained by plants in the high population density that corresponds to the planting distance of 1.0 m x 0.40 m, with values greater than 0.37.

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