Original Research Paper

The Behavior of Valencia Orange Cultivation (*Citrus x sinensis* (L) Osbeck cv. Valencia) in "Type Farms" in a Province in Central Jungle of Peru

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Abstract: The objective of research was to evaluate behavior of Valencia orange crops in "type farms" in the province of Chanchamayo, Junín, Peru. This research was carried out with the aim of knowing the behavior of Valencia orange crops in "type farms" in the province of Chanchamayo, Junín, Peru. The study was carried out in Chanchamayo, Junin Region, between January and December 2016. There were selected four "types of farming" (FT1, FT2, FT3, FT4), with plants of ten years of age. A "type of farming" was selected at random. In each "type farm", soil samples were taken and 50 plants were selected. Variables evaluate were: The chemical characteristics of the soil, incidence of pests and diseases, fruit quality (weight, diameter, and brix), and yield. For statistical analysis, each "type farm" was considered as a treatment and each plant as a repetition (4 treatments with 50 repetitions) and worked as if it were a Completely Randomized Design (CRD). The results showed that the behavior of the Valencia orange was better in the FT2, this "type farm" had the lowest incidence of pests and diseases, the best fruit quality, and the highest yield; but it is also the one that receives the highest investment. A low incidence of pests and diseases was observed, which suggests good phytosanitary management of the crop. The weight and diameter of the fruit varied with time. Fruits with the greatest weight and diameter corresponded to FT2 farming.

Keywords: *Citrus*, Valencia Orange, Yield, Quality, Pests

Introduction

Citrus fruits are an important crop worldwide, for the 2018/19 campaign the production was estimated at 101.5 million tons, where 53.4% corresponds to oranges, 31.5% to mandarins, 8.3% to lemons and limes, and 6.7% to grapefruits. Consumption is mostly fresh (83.8%) distributed among oranges and mandarins, distributed practically equally (USDA, 2020). In Peru oranges, tangelo, and mandarins are produced, the production of orange (*Citrus sinensis*) cv Valencia has shown an upward trend, in 2000 the national production was 255.7 thousand tons and in 2016, it reached the maximum production of the last 17 years (492 thousand tons). This increase in production is explained by the increase in harvested areas (up by 4% per year) and improvements in yield (2% per year). The main producing regions are Junín with 55% of the national production, followed by San Martín (11%), Lima (7%), Ica (6%), Puno (5%), and Cusco (5%). The Junín region, in the central jungle of Peru, is the largest orange-producing area in the country and the main supplier of the market of Lima, the capital of the country. However, despite the importance of this crop in the Peruvian tropics, the research is practically nil, if we compare it with other crops in the area such as coffee and pineapple. For this reason, specialists and citrus growers in the area point out the need to carry out research work to address the main problems of the crop and thus help its technological improvement. This is because the yield and quality of citrus fruits are very variable between one locality and another and between the farms of the same locality. Hart (1990), cited by Malagón Manrique and Prager Mosquera (2001), defines a farm as one of the levels of the hierarchy of agricultural systems, so farm-level work is very important.

The orange-producing farm's cv. Valencia, in Chanchamayo, presents very variable characteristics, but in previous studies and using cluster analysis, they have been grouped into four groups. The first group brings together 21.48% of farms, the second group at 32.52%, the third at 37.04%, and the fourth group at 2.96% (Ruiz Camacho *et al*., 2019). There is no documented information on the behavior of this crop in each group of farms, one way to know is by selecting a farm in each group and that is called "type farm", which is representative of the group from which it was selected. Studies using "type farms" have been carried out by Collantes González (2016); Salazar-Díaz (2012); Santistevan Méndez *et al*. (2017); Tuesta Hidalgo *et al*. (2014). This research work was carried out with the aim of knowing the behavior of Valencia orange cultivation in "type farms" of the province of Chanchamayo, Junín, Peru.

Materials and Methods

The study was carried out in Chanchamayo, Junín Region, between January and December 2016. Four "types of farming" of Valencia orange were selected. Ten-year-old plants were selected. In Table 1 characteristics of "types of farming" are presented. In each "type farm", soil samples were taken, which were sent to the Soil and Water Laboratory of the INIA Experimental Station in Pichanaki, Chanchamayo (Junín), where the chemical characteristics of each soil were determined. In each "farm type", 50 plants were selected, and using the criterios of Santistevan Méndez *et al*. (2017), the following variables were evaluated.

Chemical characteristics of the soil at the beginning of the rehearsal.

Incidence of pests and diseases. The main pests and diseases were evaluated monthly during the time the investigation lasted:

1. Fruit quality. The following aspects were considered
2. Weight of the fruit. It was evaluated monthly (12 harvests). A random sample of 10 fruits was taken from which the weight of each fruit was measurement Fruit diameter. It was evaluated monthly (12 harvests). A random sample of 10 fruits was taken. The diameter of each fruit was measured
3. Brix of the fruit. It was evaluated monthly (12 harvests). A random sample of 10 fruits was taken from which brix was measured
4. Yield. It was evaluated monthly, making a total of 12 harvests ("past") and the total harvested fruits were weighed

For statistical analysis, each "type of farming" was considered as a treatment and each plant as a repetition. The standard error was estimated. That is, we had 4 treatments with 50 repetitions and worked as if it were a Completely Randomized Design (CRD). An Analysis of Variance (ANOVA) was done to determine if there was an effect of the treatments and then a Tukey test (0.95) to assess the differences between treatments. The statistical program R 4.0.4 was used.

Table 1: Characteristics of the "type farms" of Valencia orange in Chanchamayo, Junín, Peru (Ruiz Camacho *et al*., 2019)

Characteristics	Farm Type 1 (FT1)	Farm Type 2 (FT2)	Farm Type 3 (FT3)	Farm Type 4 (FT4)
Quantity represented (%)	21.48	32.52	37.04	2.96
Average. Total area (ha)	3	2	2	8
Average. Area with orange (ha)	2	2	2	1.5
Average. Nº plants/ha	400	278	400	400
Number of payments/year	1	3	2	1
Pest and disease management	no	si	si	no
Investment ha/year (S/.)	1049	4860	2000	1140
Monthly income (S/.)	850	2375	1750	920
Locality	Santa Rosa de Ubiriki	Kivinaki	Boca Huatziriki	C.P. Villa Ashaninka
Geographical location	18L 0514188 UTM 8791305	18L 0520211 UTM 8787335	18L 0499926 UTM 8781726	18L 0522296 UTM 8787736

Results and Discussion

According to Hart (1990), cited by Malagón Manrique and Prager Mosquera (2001), farms are systems with different resources, processes, and production components, which individual or collective farmers combine to form subsystems that convert resources into products. In this sense, the study at the farm level has been increasing over the years (Batista *et al*., 2017; Santistevan Méndez *et al*., 2017). In this study, there were four "type farms" whose soil chemical characteristics were very similar. The pH ranged from 5.2-5.8, i.e., slightly acidic. Nitrogen (N) was in a range of 14-16 ppm, while Phosphorus (P), Potassium (K), Calcium (Ca), and Magnesium (Mg) presented values of 3.3-3.5 ppm, 35-39 meq/100 mL, 6.04-6.90 meq/100 mL and 2.31-271 meq/100 mL respectively (Table 2). In the case of phosphorus, the values are lower than those found in other tropical soils with orange plantations (Pasache Campos, 2017).

Considering that, pH has a strong impact on the availability of nutrients for plants, it can be inferred that growing oranges adapt well to slightly acidic soils. In the Satipo area, in soils with a pH of 5.85, good growth of orange plants has been reported (Pasache Campos, 2017). The results also do not show large variations in the levels found for N, P, K, Ca, and Mg, this is important considering that macronutrients have a great influence on citrus production levels. For example, found that increasing doses of N and K increased the yield of citrus fruits by almost 100%.

Incidence of pests and diseases. Pests and diseases affect the yield of the Valencia orange, among these, we can point to the "roast mite" (*Phyllocoptruta oleivora*), "leaf miner" (*Phyllocnistis citrella* Station), "whitefly" (*Dialeurodes citri*), "aphids" (*Aphis spiraecola*, *A. gossypii*, and *A. citricola*), "fruit fly" (*Anastrepha fraterculus*) and "gomosis" (*Phytophthora parasitica*), which have been by various authors such as Sánchez and Vergara (2004). These pests represent a great risk to the productivity of citrus fruits, it is estimated that *P. oleivora* and *D. citri* can decrease the yield by 40% (Sarada *et al*., 2018) and 30% respectively.

In general, we observed low incidence of pests and diseases in all the "type farms" evaluated (Fig. 1). Under controlled conditions, infestations of 4% of *P. citrella* have been reported (Salas *et al*., 2006) and less than 5% for *P. oleivora* (Silva *et al*., 2017). When comparing the annual averages of the incidence of pests and diseases between the "type farms", we observe that, in almost all cases, the incidence is high in FT1, in which a higher incidence of *P. citrella, P. oleivora,* and *A. fraterculus* has been found, with values statistically different from those reported in the other "type farms". On the contrary, in FT2 a lower presence of these pests was found. The low incidence of pests and diseases in all farms suggests good management of pests and diseases by farmers. One of the main characteristics of FT1 producers is their low concern in pest and disease management, which would be closely related to the levels of investment in the farm (Table 1).

Fruit quality. The weight and diameter of the fruit are the variables that determine the quality of the Valencia orange and that is why they have been used by other researchers who have evaluated the quality of this fruit (Pasache Campos, 2017). Table 3, the weight of the fruit varied over time; but in all the months, the fruits with the greatest weight corresponded to the FT2. This farm also had the highest average weight (303 g), a value that was significantly higher than the values reached in the other farms, such as FT3 (201 g), FT1 (198 g), and FT4 (172 g).

Table 3 shows that the diameter of the fruit varied over time; but in all the months, the fruits with the largest diameters corresponded to the FT2. This farm also had the largest average diameter (7.7 mm), a value that was significantly higher than the values reached in the other farms, such as FT1 (6.8 mm), FT3 (6.8 mm), and FT4 (6.7 mm). The brix of the fruits also varied over time; but there was no farm that will stand out from the others always, although in four of the twelve months, the fruits with the largest brix, corresponded to the FT4. But no statistical differences were found between the average values, in Table 3.

The size and weight of the fruit significantly influence the yield, some researchers such as; (K Ahmed and F Ahmed (2020), have reported that the greater the weight and diameter of the fruit, there is higher the yield in orange cv. Valence.

Yield. In this trial, statistical differences in yield were found between the "type farm" evaluated, in Table 4.

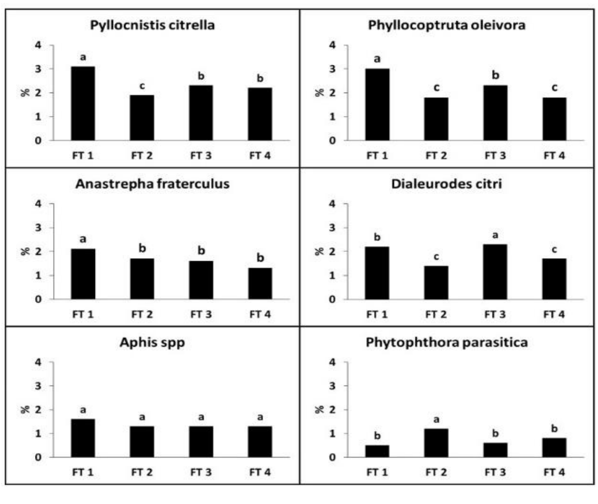

Fig. 1: Annual averages of pest and disease incidence in the "type farms" of orange Valencia in Chanchamayo, Peru

Table 2: Characteristics of the soils in "type farms" of orange Valencia in the province of Chanchamayo, Junín, Peru

Type of farm	pH	N (ppm)	P (ppm)	K (meq/100 mL)	Ca (meq/100 mL)	Mg (meq/100 mL)
Farm I	5.8±0.0057	16±0.00950	3.4±0.0090	39±0.41	6.90±0.055	2.71±0.018
Farm II	5.6±0.0049	14±0.01100	3.5±0.0029	38±0.39	6.85±0.069	2.62±0.021
Farm III	5.4±0.0051	15±0.01300	3.3±0.0410	36±0.45	6.40±0.033	2.53±0.033
Farm IV	5.2±0.0043	16±0.00990	3.4±0.0350	35±0.09	6.04±0.029	2.31±0.011

Table 3: Weight, diameter, and brix degrees in Valencia orange fruits in "type farms" in Chanchamayo, Peru

	Month												
Farms	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Fruit weight (gr)													
FT1	171^{b}	177^{c}	177^{c}	189^{b}	184^{c}	190^{c}	198^{b}	192^{b}	199^{b}	227^{b}	230^{b}	243^{b}	198^{c}
FT2	249^{a}	267^{a}	298^{a}	304^{a}	300^{a}	319^{a}	313^{a}	309^{a}	311^{a}	319^{a}	332^{a}	322^{a}	303^{a}
FT3	213^{a}	207^{b}	207^{b}	197^{b}	207^{b}	202^{b}	193^{b}	193^{b}	190^{b}	179^{c}	171^{c}	183^{c}	201^{b}
FT4	171^{b}	167^{c}	167^{c}	189^{b}	180^{c}	167^{c}	167^{b}	173^{b}	174^{c}	179^{c}	162^{c}	166^{c}	172^{c}
Fruit diameter (cm)													
FT1	6.5^{b}	6.6^{b}	6.7^{b}	6.7^{c}	6.8^{b}	6.9^{b}	6.9^{b}	6.9^{c}	6.8^{b}	6.8^{b}	6.8^{b}	6.8^{c}	6.8^{b}
FT2	7.5^{a}	7.7^{a}	7.5^{a}	7.5^{a}	7.7^{a}	7.6^{a}	7.8^{a}	7.7^{a}	7.8^{a}	8.0^{a}	8.0^{a}	8.0^{a}	7.7^{a}
FT3	6.5^{b}	6.7^{b}	6.7^{b}	6.6^{c}	6.9^{b}	6.9^{b}	7.0^{b}	7.1^{b}	7.0^{b}	6.9^{b}	6.8^{b}	6.7^{c}	6.8^{b}
FT4	6.4^{b}	6.5^{b}	6.7^{b}	7.0^{b}	6.6^{b}	6.6^{b}	6.6^{b}	6.7^{c}	6.7^{b}	6.8^{b}	7.0^{b}	7.0^{b}	6.7^{b}
Brix degrees in fruit (%)													
FT1	11.0^{a}	10.2^{a}	10.4^{b}	10.1^{b}	10.3^{b}	10.3^{b}	10.3^{b}	10.1^{a}	10.1^{b}	10.1^{a}	10.1^{b}	10.1^{b}	10.3^{a}
FT2	11.0^{a}	10.3^{a}	11.0^{a}	11.0^{a}	10.3^{b}	10.9^{a}	10.3^{b}	10.3^{a}	10.3^{b}	10.5^{a}	10.5^{b}	10.5^{b}	10.6^{a}
FT3	11.0^{a}	10.4^{a}	10.4^{b}	10.8^{a}	10.3^{b}	10.3^{b}	10.8^{a}	11.5^{a}	10.8^{a}	11.0^{a}	10.1^{b}	10.4^{b}	10.6^{a}
FT4	11.0^{a}	11.0^{a}	10.4^{b}	10.2^{b}	10.9^{a}	10.1^{b}	10.9^{a}	10.4^{a}	10.4^{b}	10.1^{a}	10.8^{a}	10.8^{a}	10.6^{a}

Table 4: Valencia orange yield in "type farms" in the province of Chanchamayo, Junín, Peru

Farms type	Investment (S/./ha/year)	Income (S/./month)	Yield (Kg/plot)[1]	Performance (t/ha)[2]
FT1	1049	850	1798.5^{d}	10
FT2	4860	2375	5395.5^{a}	30
FT3	2000	1752	2698.0^{c}	15
FT4	1140	920	3237.5^{b}	18

1/Duncan test at 95%, for testing stockings on farms

2/Estimated with 400, 278, 400, 400 plants/ha, for farms I, II, III, and IV, respectively

The FT2 (30 t^{ha-1}), was the one that had the highest performance followed by the FT4 (18 t^{ha-1}), the FT3 (15 t^{ha-1}), and the FT1 (10 t^{ha-1}). These differences in yield would not be associated with edafo-climatic factors but with other factors such as the level of investment, which implies greater care and a better crop on the corresponding farm. Table 4 shows that investment in FT 2 was 4.6 times higher than in FT1, 4.26 times more than in FT4, and 1.67 times more than in FT3; therefore, in FT2, there was also the lowest incidence of pests (Fig. 1) and the highest fruit quality (Table 3). Tello (2016), points out that investment of resources is a determining factor in agricultural productivity; while says that greater investment can potentially improve the competitiveness of productive units in the agricultural sector. This direct relationship between investment and increased productivity in citrus cultivation has also been reported by other researchers such as Santistevan Méndez *et al.* (2017), for the case of lemon in Santa Elena, Ecuador. Greater investment in the farm ends up generating greater profitability, as has been reported in other crops in the Peruvian tropics, such as pineapple, where the increase in investment allowed greater productivity and, greater profitability (Marca-Huamancha *et al*., 2018).

It is also important to underline that the yields achieved by the four "type farms" in Chanchamayo, are above the reported orange cv. Valencia in other regions of Peru, such as Arequipa, Ayacucho, and Apurímac (INEI, 2018). These high yields may be related to the best climatic conditions in the area, added to adequate agronomic management of the crop. Chanchamayo and the central jungle in general, are considered the Peruvian tropical region, where the technological level of agriculture is higher, with respect to other tropical areas of the country.

Conclusion

The pH was slightly acidic. Nitrogen (N), Potassium (K), Calcium (Ca), and Magnesium (Mg) presented values similar to those reported in soils dedicated to orange cultivation. In the case of phosphorus, values are lower than those found in other tropical soils with orange plantations. There were no large variations in levels found for N, P, K, Ca, and Mg. In general, a low incidence of pests and diseases was observed, which suggests good phytosanitary management of the crop. The weight and diameter of the fruit varied with time. Fruits with the greatest weight and diameter corresponded to FT2 farming. In this trial, statistical differences in yield were found between the "types of farming" evaluated. FT2 (30 t^{ha-1}) was the one with the highest performance followed by the FT4 (18 t^{ha-1}), the FT3 (15 t^{ha-1}), and the FT1 (10 t^{ha-1}). These differences in yield would be associated with factors such as the level of investment of resources and greater care and a better crop on the corresponding farm.

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Author’s Contributions

All authors equally contributed to this study.

Ethics

All statements related to enriching this scientific journal have been included in the bibliography.

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