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THE INFLUENCE OF THE CULTIVAR, SEEDING TIME AND THE DENSITY OF QUINOA LEAVES ON THE YIELD INDICATORS

INFLUENȚA CULTIVARULUI, A EPOCII DE ÎNFIINȚARE ŞI A DENSITĂȚII LA CULTURA DE QUINOA PENTRU FRUNZE ASUPRA UNOR INDICATORI DE PRODUCȚIE

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Abstract. *Quinoa (Chenopodium quinoa Willd.) is known in the world for its grain and almost not for leaf consumption. In Romania there are no technological elements of cultivation to ensure the sustainability of the leaves crops. Quinoa is not a cosmopolitan species, rarely cultivated, without knowing the nutritional qualities of the leaves. The aim of the experiment was to study some technological measures regarding the cultivation of quinoa species for leaves under the conditions in eastern Romania. The best yield results were obtained by Titicaca cultivar (34.12 t/ha), the density of 7.7 million plants/ha (34.37 t/ha) and the crop established were on 3.04 of each year (47.46 t/ha). Except for Puno cultivar, there is no direct correlation between the foliar surface and the production achieved.*
Key words: *Chenopodium quinoa* Willd., technological measure; area measure; yield

Rezumat. *Quinoa (Chenopodium quinoa Willd.) este cunoscută în lume pentru semințe şi aproape deloc pentru consumul de frunze. În țara noastră nu sunt cunoscute elemente tehnologice de cultivare, care să asigure sustenabilitate culturii pentru frunze. Quinoa nu este o specie cosmopolită, cultivându-se foarte puțin, fără a fi cunoscute calitățile nutritive ale aparatului vegetativ. Scopul studiului a fost acela de a stabili unele măsuri tehnologice privind cultivarea speciei quinoa pentru frunze în condițiile din estul României. Cele mai bune rezultate de producție au fost obținute de cultivarul Titicaca (34.12 t/ha), densitatea de 7.7 milioane plante/ha (34.37 t/ha) şi culturile care au fost înființate la data de 3.04 a fiecărui an (47.46 t/ha). Cu excepția cultivarului Puno nu se observă o corelație directă între suprafața foliară şi producția realizată.*
Cuvinte cheie: *Chenopodium quinoa* Willd., măsuri tehnologice, suprafață foliară, producție

INTRODUCTION

In the world, quinoa (*Chenopodium quinoa* Willd) is known as a pseudocereal and is cultivated only for seeds (Wilson and Heiser, 1979). The

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breeding of the species in Europe and North America has given the specialists the opportunity to develop framework technologies for the cultivation of the quinoa species for grain (Mastebroek *et al*., 2002). Many biochemists have studied the nutritional and antinutritional factors of seeds, discovering the unique dietary value of quinoa seeds (Vitănescu *et al*., 2019).

In its original area, the leaves are consumed as spinach substitute being used as an ingredient in cooking and in salads (Vitănescu et al., 2017). The nutritional and antinutritional factors of the leaves have been studied very little worldwide (Stoleru *et al.*, 2019). Also, there is no framework technology for cultivating quinoa as a leaf vegetable.

In our country, quinoa is not cultivated on specialized farms and it is not known to develop a framework crop technology (Vitănescu *et al*., 2018). The most farmers had no results after attempts to cultivate it.

The purpose of the experiment was to study the influence of some technological measures on the quantity of quinoa yield grown as a leaf vegetable.

MATERIAL AND METHOD

The experiment was carried out over a period of two years, 2017-2018, on three quinoa cultivars approved in Denmark, namely: Titicaca, Puno and Vikinga. The experimental research was organized in a split plot design with three factors on commercial farm from the Cudalbi, Galați County.

Factor A was represented by cultivar: Titicaca, Puno and Vikinga; factor B was represented by seeding time: - 03.04; 10.04 and 17.04, respectively; factor C was represented by crop density with three graduations: - 7.7; 3.2 and 1.6 million pl/ha.

The applied care works were those leaves vegetable crops recommended by scientific literature (Razzaghi *et al*., 2012; Vitănescu *et al*., 2018).

Biometric determinations

In order to quantify quinoa leaf yield, the following determinations were made: determining the leaf surface, leaves mass and total yield.

The determination of the foliar surface was done with the LI-3100 AREA METER apparatus (Nebrasca USA), manually detaching each leaf from the plant stem after which it was inserted into the equipment (fig. 1).

Fig.1 Area surface determination (original)

The determination of the foliar mass was performed by weighing all the leaves on a plant, using the NJW-300 scale with an accuracy of 0.01g (fig. 2).

Total production was obtained by multiplying the weight of the leaves on a plant with the density of the version.

Statistical analysis

All analyses were performed in the three replications. Standard error (± SE) was calculated for each data series as an indicator of data scatter (n=3) using ANOVA were performed through Tukey's test using a SPSS version 21, referring to $p \leq 0.05$ probability level.

Fig. 2 Scales NJW-300 (original)

RESULTS AND DISCUSSIONS

During 2017-2018 the research were carried out regarding the influence of the cultivar, the periods of time establishing and crop density on the biometric indicators of the quinoa leaves, for each individual technological factor and their interaction.

The influence of the cultivar on the foliar area and production is shown in Table 1. The values obtained regarding the foliar surface ranged from 125.78 mm^2 in Puno to 175.11 mm^2 at Vikinga, the difference between cultivars was of 28.2%. The average values were obtained at the Titicaca variety, respectively 150.42 mm^2. All cultivars analysed showed significant differences for $p \leq 0.05$.

Table 1

The influence of the cultivar on the foliar area and the production of quinoa

No.	Cultivar	Area measure (mm^2)	Yield (t/ha)
1	Titicaca	150.42±5.58b	34.12±2.84ns
2	Puno	125.78±5.36c	23.67±2.09ns
3	Vikinga	175.11±5.73a	30.14±2.36ns

Values represent the average ± standard error. The lower case letters represent the results of the Tukey's test for p≤0.05 (a - represents the largest value; ns - nonsignificant).

The quinoa leaf production ranged from 23.67 t/ha in Puno variety to 34.12 t/ha in Titicaca variety. As can be seen from table 1, the yield differences between cultivation are no significant. The average yields, during the period 2017-2018 were obtained by the Vikinga variety, respectively 30.14 t/ha.

With the exception of the Puno variety, it can be observed that there is no direct correlation between the leaf surface and the leaves yield.

Under the influence of the seeding time of quinoa crop, the leaf surface had values between 91.05 mm^2 obtained in the third epoch (17.04) and 232.07 mm^2 in the first epoch (3.04). There are significant differences between all three establishment times. The average values were recorded in the second epoch (10.04), respectively 128.20 mm^2 (tab. 2).

Table 2

The influence of seeding time on the foliar surface and yield of quinoa

No.	Seeding time	Area measure (mm^2)	Yield (t/ha)
1	Ep_1	232.07±8.87a	34.37±2.35a
2	Ep_2	128.20±3.55b	29.50±1.45ab
3	Ep_3	91.05±8.07c	24.04±2.79b

Values represent the average ± standard error. The lower case letters represent the results of the Tukey's test for $p \leq 0.05$ (a - represents the highest value; Ep1 - 3.04; Ep2 - 10.04; Ep3 - 17.04).

The obtained yield had values between 24.04 t/ha achieved in the third epoch of setting up the crop (17.04) and 34.37 t/ha in the first epoch (3.04). The data from table show the positive aspect of the earlier establishment of the quinoa crop for the leaves on the yield, through significant differences between the first and third ties of establishment.

The foliar surface varied from 125.11 mm^2 obtained at the density of 1.6 mil. pl/ha to 187.70 mm^2 at the density of 3.2 mil. pl/ha. From the statistical point of view between the density of 3.2 mil. pl/ha and the densities of 7.7/1.6 mil. pl/ha there were significant differences (tab. 3).

The yield obtained under the influence of the different density graduations had values between 13.02 t/ha achieved at the density of 1.6 mil. pl/ha and 47.46 t/ha registered at the density of 7.7 mil. pl/ha, the results obtained are significant for $p \leq 0.05$.

Table 3

The influence of the crop density on foliar area and quinoa yield

No.	Crop density	Area measure (mm^2)	Yield (t/ha)
1	D_1	138.49±2.11b	47.46±5.76a
2	D_2	187.70±3.46a	27.43±1.56b
3	D_3	125.11±4.40b	13.02±0.77b

Values represent the average ± standard error. The lower case letters represent the results of the Tukey's test for $p \leq 0.05$ (a - represents the highest value; D_1-7.7 mil. pl/ha; D_2-3.2 mil. pl/ha; D_3-1.6 mil. pl/ha).

The foliar surface varied wider from 56.31 mm^2 on the Puno variety in the third epoch (17.04) at the density of 1.6 mil. pl/ha to 327.34 mm^2 obtained on the Vikinga cultivar at the first epoch (3.04) and at a density of 3.2 mil. pl/ha.

Under the influence of the three technological factors, the obtained yield varied, within really wide limits, from 6.78 t/ha obtained by the Vikinga cultivar on the third epoch of seeding time (17.04) on a density of 1.6 mil. pl/ha to 62.69 t/ha obtained from the same variety but in the first epoch (3.04) at the density of 7.7 mil. pl/ha (tab. 4). The significant difference of yield is given by the influence of the time and the density.

At the Titicaca and Puno cultivars, between the versions with the same densities, regardless of the seeding time, there are no significant differences for $p \leq 0.05$.

At the Vikinga variety, between the variants sown in the first and second epochs at the density of 7.7 mil. pl/ha, there are no significant differences.

Table 4

The influence of the cultivar, seeding time and crop density interaction on the leaf surface and yield of quinoa

No.	Interaction	Area measure (mm^2)	Yield (t/ha)
1	T x Ep_1 x D_1	211.04±33.28abcde	54.84±4.56ab
2	T x Ep_1 x D_2	308.34±34.93ab	38.74±3.41bcdef
3	T x Ep_1 x D_3	212.98±39.35abcde	17.41±1.36hijk
4	T x Ep_2 x D_1	115.57±6.91efgh	51.42±6.97abc
5	T x Ep_2 x D_2	155.12±1.46cdefgh	34.87±1.95cdefg
6	T x Ep_2 x D_3	103.37±10.77efgh	15.24±1.281hijk
7	T x Ep_3 x D_1	64.92±3.48gh	48.66±3.33abc
8	T x Ep_3 x D_2	108.19±14.60efgh	28.63±1.41efghi
9	T x Ep_3 x D_3	74.28±1.44gh	17.22±1.99hijk
10	P x Ep_1 x D_1	152.75±11.81cdefgh	45.80±5.56bcd
11	P x Ep_1 x D_2	206.56±20.67abcdef	24.63±1.40fghij
12	P x Ep_1 x D_3	128.85±8.89efgh	16.50±1.37hijk
13	P x Ep_2 x D_1	82.82±3.95fgh	41.08±3.61bcdef
14	P x Ep_2 x D_2	145.58±10.45defgh	20.67±1.62ghijk
15	P x Ep_2 x D_3	107.01±14.01efgh	12.36±1.67ijk
16	P x Ep_3 x D_1	94.36±4.76efgh	30.16±1.68defgh
17	P x Ep_3 x D_2	157.77±72.75cdefgh	14.88±1.251hijk
18	P x Ep_3 x D_3	56.31±1.82h	6.97±0.47k
19	V x Ep_1 x D_1	263.38±48.13abcd	62.69±3.08a
20	V x Ep_1 x D_2	327.34±24.19a	34.80±4.04cdefg
21	V x Ep_1 x D_3	277.41±11.05abc	13.95±1.69hijk
22	V x Ep_2 x D_1	185.08±10.46bcdefg	51.05±4.25abc
23	V x Ep_2 x D_2	170.78±24.31cdefgh	27.98±2.46efghi
24	V x Ep_2 x D_3	88.42±7.50efgh	10.81±0.85jk
25	V x Ep_3 x D_1	76.53±7.44gh	41.45±5.62bcde
26	V x Ep_3 x D_2	109.66±6.39efgh	21.68±1.21ghijk
27	V x Ep_3 x D_3	77.40±12.04gh	6.78±0.57k

Values represent the average ± standard error. The lower case letters represent the results of the Tukey's test for $p \leq 0.05$ (a - represents the highest value; T - Titicaca; P - Puno; V - Vikinga; Ep1 - 3.04; Ep2 - 10.04; Ep3 - 17.04; D_1-7.7 mil. pl/ha; D_2-3.2 mil. pl/ha; D_3-1.6 mil. pl/ha).

CONCLUSIONS

1. Titicaca variety obtained the highest yields of leaves per hectare, followed by Vikinga and Puno cultivars.

2. Leaf production at quinoa was influenced by the crop time of establishment, sowing at 3.04 favoured obtaining the highest yield followed by the second (10.04) and third (17.04) epochs.

3. Under the influence of density, the highest quinoa leaf yield was obtained at the higher density of plants/ha, followed by the density of 3.2 and 1.6 million plants/ha.

4. The highest yield was obtained by the Vikinga cultivar sown on 03.04 at a density of 7.7 million plants/ha, with no strictly positive correlation with the leaf surface.

5. The highest values in terms of leaves surface were obtained by the Vikinga variety sown at 3.04 at a crop density of 3.2 million plants/ha.

REFERENCES

1. **Mastebroek H.D., Van Loo E.N., Dolstra O., 2002 -** *Combining ability for seed yield traits of Chenopodium quinoa breeding lines*. Euphytica Journal, vol. 125, no.1, pp. 427-432.
2. **Razzaghi F., Plauborg F., Jacobsen S-E., Jense C., Andersen M., 2012 -** *Effect of nitrogen and water availability of three soil types on yield, radiation use efficiency and evapotranspiration in field-grown quinoa*. Journal of Agricultural Water Management, vol. 109, pp. 20-29.
3. **Stoleru V., Slabu C., Vitanescu M., Peres C., Cojocaru A., Covasa M., Mihalache G., 2019 -** *Tolerance of three quinoa cultivars (Chenopodium quinoa willd.) to salinity and alkalinity stress during germination stage*. Agronomy-Basel, vol. 9, no. 6, 287, pp. 1-14.
4. **Vitănescu M., Munteanu N., Cojocaru A., Stoleru V., 2017 -** *The influence of the storage period of pea seeds on their germination capacity*. Scientific Papers, USAMV Iasi, Horticulture Series, vol. 60.
5. **Vitănescu M., Stoleru V., Munteanu N., Teliban G., Cojocaru A., Mangalagiu I., Mantu-Amăriucăi D., Vlase L., 2018 -** *Preliminary studies regarding nutritional performance of quinoa crop as leaf vegetables*. XIIIth International Conference of Food Physicists - ICFP, Antalya 23-25 October, p. 51.
6. **Vitănescu M., Teliban G., Cojocaru A., Stoleru V., 2019 -** *Physico-chemical characteristics of quinoa seeds*. Scientific papers-series B-horticulture, vol. 63, no. 1, pp. 385-390.
7. **Wilson H.D., Heiser C.B. Jr., 1979 -** *The origin and evolutionary relationship of huauzontle (Chenopodium nuttaliae) domesticated chenopod of Mexico*. The American Journal Botany, vol. 66, pp. 198-206.