Cultivos Tropicales, Vol. 44, No. 3, July-September 2023, e-ISSN: 1819-4087, p-ISSN: 0258-5936, https://ediciones.inca.edu.cu

Cu-ID: https://cu-id.com/2050/v44n3e07

Short communication

Agroecological production of potato (*Solanum tuberosum* L.) with sexual seed and use of nutritional alternatives

Producción agroecológica de papa (*Solanum tuberosum* L.) con semilla sexual y uso de alternativas nutricionales

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ABSTRACT: With the aim of producing potato tubers from the botanical seed for later reproduction for consumption, an experiment was carried out at the National Institute of Agricultural Sciences (INCA). Organic nutritional variants were included: soil plus manure and soil plus earthworm humus in a 2:1 ratio and a soil core without additives. In the seedbed at 15 days had already germinated 100 % of the seeds planted. In conditions of stonemasons the plant height was higher with the manure, doubling the control, the yield in number of tubers per plant and total mass were efficient in both variants, although the manure seems to exceed it. The inclusion of charcoal in worm humus showed no influence on the compound.

Key words: sustainability, organic fertilizers, agronomy, food sovereignty.

RESUMEN: Con el objetivo de producir tubérculos de papa, a partir de la semilla botánica, para su posterior reproducción destinada al consumo, se llevó a cabo un experimento en el Instituto Nacional de Ciencias Agrícolas (INCA), en el que se incluyeron variantes nutricionales orgánicas: suelo más estiércol y suelo más humus de lombriz, en una relación 2:1 y un testigo de suelo sin aditivos. En el semillero, a los 15 días, ya había germinado el 100 % de las semillas plantadas. En condiciones de canteros, la altura de la planta fue superior con el estiércol, duplicando al testigo; el rendimiento en número de los tubérculos por planta y masa total, resultaron eficientes en ambas variantes, aunque la del estiércol parece superior. La inclusión de carboncillo al humus de lombriz no mostró influencia al compuesto.

Palabras clave: sostenibilidad, abonos orgánicos, agronomía, soberanía alimentaria.

INTRODUCTION

All potato (*Solanum tuberosum* L.) production in Cuba is carried out using tubers as planting material, as in the rest of the world. A disadvantage of this production system for the country is that this propagation material is mainly imported from Europe, together with a technological package based on chemical fertilizers and pesticides that increase production costs. This complexity makes it impossible to acquire it in order to meet the demand for this food for the entire population of the country (1) and as a sustainable option within Food Sovereignty (2).

A possible proposal to complement these problems would be the production of potatoes from their botanical seed. This production modality is only given importance within the scientific world in the specialty of genetics, to obtain new varieties by crossbreeding (3), but there is currently no technology recognized on a world scale for potato production using sexual seed, which would also strengthen the option of ecological potato production in Cuba.

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Received: 05/08/2021

Accepted: 14/11/2021

Conflict of interest. The authors declare that they have no conflict of interest.

Authors' contribution. Conceptualization: Ángel Leyva Galán; Jorge Luis Salomón Díaz, Elein Terry Alfonso. **Research, design and methodology:** Ángel Leyva Galán, Yadira López Ramos, Jorge Luis Salomón Díaz. **Supervision:** Ángel Leyva Galán, Jorge Luis Salomón Díaz. **Initial draft writing, final writing and editing, and data processing:** Ángel Leyva Galán, Yadira López Ramos, Jorge Luis Salomón Díaz. *Final revision:* Yadira López Ramos, Elein Terry Alfonso and Ángel Leyva Galán.

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Previous studies in this field (4) have included organic nutritional variants combined with mycorrhizae; however, these studies have not been continued and, therefore, the subject has been at a standstill. For this reason, the aim of this work was to obtain potato tubers for breeding, by means of botanical seed and the use of organic nutritional alternatives, to achieve tubers suitable for organic production and also for local consumption and commercialization.

MATERIALS AND METHODS

The experiment was carried out at the National Institute of Agricultural Sciences (INCA), located in San José de las Lajas, Mayabeque province, on a Ferrallitic Red Agrogenic leached soil (5) and sowing was carried out in the first decade of December 2018.

Sexual seeds of the imported, open-pollinated Zinared variety, obtained from berries harvested the previous year, were used.

The experiment had two stages: (i) greenhouse seedbed and (ii) transplanting in outdoor beds.

(i) *Seedbed preparation:* Eight trays were used, in which the seeds were sown by hand, at a rate of three seeds per alveolus and two trays per treatment, for four treatments that were repeated four times. The different combinations of nutritional alternatives represented the treatments (Table 1).

Both the bovine manure and the earthworm humus were fully decomposed, and Table 2 shows their contents, according to the results of the chemical analysis, showing little difference between them.

After sowing, the trays were placed in a greenhouse where humidity was maintained at field capacity until they were taken to the bed. The only variable evaluated in the seedbed was germination 10, 12 and 15 days after sowing, which was expressed as a percentage.

(ii) Preparation of the beds where the seedlings obtained from the seedbed were established: they were 10 m long and 1.2 m wide, three beds were prepared, each with 36 seedlings per treatment, for a total of 138 seedlings per bed. The seedlings were placed in the beds after hoeing the soil to a depth of 20 cm and moistened two days before transplanting, which took place 30 days after sowing in the trays. The conditioning was done under a randomized block design, with three replications and four treatments.

No additional product was applied at sowing and the root system was maintained with the soil composition plus the nutritional alternative applied in each alveolus of the tray. Planting was carried out at a distance of 30 x 10 cm.

However, visual observation revealed the need for a fertilizer application, complete NPK formula (9-13-17), 34 days after planting, at a rate of 129 g m^2 (6) in all the beds, after which a hilling was carried out. No pest management with agrochemicals was carried out.

Harvesting was carried out per treatment on April 11, 2019 and at the time of harvesting, the following assessments were made: *(i)* number of plants harvested; *(ii)* plant height (cm); *(iii)* number of tubers per plant per size (< to size I and > to size I) and *(iv)* total mass of tubers harvested per treatment. The data were statistically processed in the Statgraphycs program, according to Tukey's test.

RESULTS AND DISCUSSION

Germination period in the seedbed

Although not all seeds had germinated by 10 and 12 days, 100 % germination had occurred by 15 days, with no increase in germination observed on subsequent days.

The nutritional alternatives did not show a high influence on seed germination, because although there was a tendency to be higher in treatment three (soil + worm humus + charcoal) with 27 %, this did not differ from the

Table 1. Combinations of nutritional alternatives

Treatments	Description	Ratio
1.	Soil + cattle manure	2 : 1
2.	Soil + earthworm humus	2 : 1
3.	Soil + earthworm humus + charcoal*	2 : 1 : 1
4.	Soil without additives (control)	-

*Rice chaff burned and applied to earthworm humus to improve soil properties

Table 2. Chemical composition of the soil and substrates used

Code	Na	K	Ca	Mg	P	MO	pH	SST
		(cmol(+) kg^{-1})			(mg L^{-1})	(%)		(g L^{-1})
Soil	0.08	1.02	18.0	4.50	450	2.10	7.60	
Code	**Na (%)**	**K**	**Ca**	**Mg**	**P**	**N**	**MO**	**pH**
Manure	Trace	0.31	8.0	3.04	0.81	0.96	18.60	6.9
Charcoal	Trace	0.12	5.0	3.04	0.06	Traza	6.10	7.5
Earthworm humus	0.08	0.38	9.0	2.43	1.00	1.13	18.40	7.6

control (25 %). However, the results are not conclusive, as there was no repetition over time, something that will be necessary to demonstrate whether the trends are maintained or whether there is simply no influence.

A low germination rate was observed (between 22 and 27 %), lower than the average (7). It will be necessary to elucidate the causes of poor germination, perhaps linked to the variety used or loss of viability over time. No references to previous work on this subject were found.

Development period of the plants in the beds

Plant height showed its best performance in treatments one and two (soil+cattle manure and soil+worm humus), which reached values above nine, although the highest numerical value (>11 cm), almost doubled the height of the control, but plant height does not always correlate with yields (8).

The final results of the yield indicators are shown in Table 5.

Although the resulting final production data are interesting, with a trend enhancing treatments given the organic alternatives, differences were not large enough to show significant differences with the control, with no applications. Such a result can have several readings. One could be that, depending on the soil richness and the additional dose of inorganic nutrients in tuber production for this initial phase, it provides favorable results without applications of organic alternatives. Another reading would be that the doses of organic fertilizers applied as organic alternatives were insufficient. This final analysis is closer to the result obtained, taking into account that there was a tendency that enhanced the treatment where manure was applied with respect to the others, which, at the same time, numerically surpassed the control, both in number of tubers and in their mass.

Another possibility is related to the number of treatment repetitions, since a greater number of repetitions can be carried out to detect differences. The fact that no significant differences were found suggests that they could be repeated in subsequent studies, and above all it will be necessary to increase the number of replications, as well as nutrient supply levels, with an increase in the volume of organic fertilizers in relation to the volume of soil.

The application of manure in the flower bed should play a favorable role in any of the variants studied, which could also be more efficient when combined with other organic alternatives available in the locality, seeking sustainability and Food Sovereignty.

It should be noted that few international studies have been carried out on the topic addressed in this work, hence the scarce bibliography found to support the results; nevertheless, it is undoubtedly a novel topic for potato production from its botanical seed.

Table 3. Germination 15 days after sowing

Treatments	Germination (%)
Soil + cattle manure	21.25 b
Soil + earthworm humus	22.50 ab
Soil + earthworm humus + charcoal*	27.25 a
Soil without additives (control)	25.00 ab
SE $\bar{x}$	1.12**

Means with common letters do not differ significantly, according to Tukey's test (p≥0.05)

Table 4. Height of plants (cm)

Treatments	Height (cm)
Soil + cattle manure	11.15 a
Soil + earthworm humus	9.40 ab
Soil + vermicompost + charcoal*	7.05 bc
Soil without additives (control)	6.15c
SE $\bar{x}$	0.57 **

Means with common letters do not differ significantly, according to the Tukey test (p≥0.05)

Table 5. Number of tubers (m^2 produced and total mass (g m^2)

Treatments	Tuber (m^2)	Total mass (g m^2)
Soil + cattle manure	124.3	1.71
Soil + earthworm humus	114.6	1.56
Soil + humus + charcoal*	121.0	1.43
Soil without additives (control)	110.6	1.22
SE $\bar{x}$	0.18 NS	10.17 NS

*Means with common letters do not differ significantly, according to Tukey's test (p≥0.05)

CONCLUSIONS

- The production of potato tubers through sexual seed provided adequate yields of tubers suitable for breeding and consumption.
- The variable plant height seems to correlate with yields.
- The organic alternatives used were insufficient to influence yields, expressed in number and mass of tubers harvested in beds.
- There was a numerical trend in favor of the alternatives used, with a greater response to the use of manure, which makes it necessary to repeat the study in order to elucidate the unknown that has arisen.

RECOMMENDATIONS

Repeat the experience, raising the nutrient levels in the soil, with increased amounts of organic fertilizer in relation to those in the soil.

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