Revista de Investigación Científica Siglo XXI (2023)
Vol. 3, Núm. 2, pp. 42 - 48
https://doi.org/10.54943/rcsxxi.v3i2.350

ARTÍCULO ORIGINAL

eISSN: 2955-8409

Effect of human urine enriched with Efficient Microorganisms on the yield of potato (Solanum tuberosum L.) Peruanita variety

Effect of human urine enriched with Efficient Microorganisms on the yield of potato (Solanum tuberosum L.) Peruanita variety

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Recibido: 02 de Junio del 2023 / **Aceptado:** 12 de Julio del 2023

RESUMEN

This research was conducted in the community of Tranca Pampa- District of San Marcos de Rocchac, province of Tayacaja Department of Huancavelica, Peru; in the agricultural campaign 2019- 2020, with the objective of evaluating the effect of human urine enriched with efficient microorganisms on the yield of potato, peruanita variety. A randomized complete block experimental design with three replications was used to test the effect of 5 liters of urine plus EM, 10 liters of urine plus EM, 15 liters of urine plus EM and a witness without application. Plant height at 120 and 210 days, number, and weight of tubers per plant at harvest were evaluated. Analysis of variance and Duncan's multiple comparison tests of means at □=0.05 were performed. The best yields were obtained with the application of 15 liters of urine plus EM (75.53 t ha-1) and 10 liters of human urine plus EM (73.48 t ha-1), significantly exceeding the other treatments; it is concluded that the application of liquid organic fertilizer based on human urine plus effective microorganisms contributes to a significant and favorable increase in the yield of the potato crop, Peruvian variety.

Palabras claves: Liquid organic fertilizer, Native potato, Beneficial biota.

ABSTRACT

Esta investigación se realizó en la comunidad de Tranca Pampa- Distrito de San Marcos de Rocchac, provincia de Tayacaja Departamento de Huancavelica, Perú; en la campaña agrícola 2019– 2020, con el objetivo de evaluar el efecto de la orina humana enriquecida con microorganismos eficientes sobre el rendimiento de la papa, variedad peruanita. Se utilizó el diseño experimental de bloques completos al azar con tres repeticiones, para probar el efecto de 5 litros de orina más EM, 10 litros de orina más EM, 15 litros de orina más EM y un control sin aplicación. Se evaluó la altura de la planta a los 120 y 210 días, el número y el peso de los tubérculos por planta en la cosecha. Se realizaron, el análisis de la varianza y las pruebas de comparación múltiple de las medias de Duncan a □=0.05. Los mejores rendimientos se obtuvieron con la aplicación de 15 litros de orina más EM (75.53 t ha-1) y 10 litros de orina humana más EM (73.48 t ha-1) superando significativamente a los otros tratamientos; se concluye que la aplicación del abono orgánico líquido a base de orina humana más microorganismos eficaces contribuye a un aumento significativo y favorable en el rendimiento del cultivo de papa, variedad peruanita.

Keywords: Abono orgánico, liquido, papa nativa, biota benéfica.

1. INTRODUCCIÓN

The district of Tayacaja - Huancavelica is a predominantly Peruvian potato-producing area. Its profitability is very low and sometimes does not even cover the cost of production due to the high cost of chemical fertilizers; therefore, it is necessary to look for new organic fertilization alternatives to generate better economic income. Farmers have seen the easiest way to counteract the low fertility of their soils through the application of synthetic fertilizers, but this apparently

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innovative practice is not sustainable because it generates dependence on synthetic fertilizers and in the future will lead to soil degradation, water pollution, air, and crops.

It is true that inorganic fertilization plays a fundamental role in the plant nutrition of crops, but its inadequate use causes alterations in soils, water, environment, and human health. An alternative is the use of organic residues, these residues, besides optimizing the physicochemical and biological properties of the soil, provide nutrients to crops, allowing in some cases, partially or totally cover the demand of some nutrients in the soil.
Currently, several countries use urine as an organic source in crop production. However, it is known that Inca cultures traditionally used human urine as a source of nutrients for plants. These hereditary practices motivate researchers to conduct studies on the importance of urine in crop production, which is gaining market share due to its high concentrations of N, P, K, S, Ca^{2+}, Mg^{2+}, Na, Cl and other micronutrients, thus, it is possible to reduce production costs in order to contribute to mitigate poverty and malnutrition. Although human urine has been used for centuries as a fertilizer, today it continues to flow through rivers carrying chemical substances that generate eutrophication and cause the death of organisms and irreversible damage to the ecosystem. The application of fermented human urine is carried out in three phases; the first in the prepared soil before planting, the second after plant emergence and the third in the formation of the flower bud or beginning of flowering, via the roots. The results show, greater fermentation of urine on soil fertility in the potato crop showing differences in the results due to the concentration of nitrogen that has fermented human urine (Condori et al., 2018).

According to Richert et al. (2011), the use of urine as a fertilizer can contribute to the alleviation of poverty and malnutrition and improve the trade balance of chemical fertilizer importing countries if adopted on a large scale. Food security can be expanded through the application of a fertilizer that is freely available to all, regardless of logistics and economic resources. Safe handling of urine, including its sanitization before use, is a key component of sustainable sanitation as well as sustainable agricultural production.
Urine is a well-balanced, fast-acting liquid fertilizer rich in nitrogen; the nutrient content of urine depends on the diet; if the nitrogen content of urine is unknown, a concentration of 3 to 7 grams of N per liter of urine can be expected. P in urine is practically (95 to 100%) inorganic and is excreted as phosphate ions (Lentner et al., 1981).

These ions are directly available to plants and so it is not surprising to find that their availability to plants is as good as that of the chemical phosphate Urine contains significant amounts of the major macronutrients required by plants; nitrogen (N), phosphorus (P) and potassium (K). Nitrogen is produced in high concentrations (mostly as urea), while phosphate and potassium are found in comparatively lower concentrations, in forms that are assimilable by plants.

Urine was tested as a fertilizer for barley in Sweden during the years 1997 to 1999 (Johansson et al., 2001; Rodhe et al., 2004). The results showed that the effect of urine N corresponds to about 90% of the same amount of ammonium nitrate mineral fertilizer, which is estimated to correspond to 100% of the same amount of ammonium fertilizer, after considering the loss of N in the form of ammonia from urine.
Given the growing interest in reducing the use of agrochemicals and the alternative of organic farming, efficient microorganisms (EM) constitute an alternative to the use of fertilizers and agrochemicals. Therefore, the task of conserving, optimizing, and restoring soils, which is one of the main challenges today. The use of efficient microorganisms in the agricultural production process has generated excellent results in our agroecosystem, providing nutrients through the production of bioactive compounds that stimulate crop growth, increase moisture retention through microbial action that degrades organic substrates, which decreases the pore space of coarse particles (sand) generating greater water availability, counteracting water stress in plants. This increases production in a natural way, improving soil quality, vigorous plant development, increasing yields and preserving healthy harvests for the consumer, leaving aside chemical fertilizers or artificial fertilizers. Microorganisms that help regenerate soils are called biofertilizers, since they increase the availability of nutritional elements for plants, being also advantageous for the biodiversity present in soils, controlling pollution levels and climate change mitigation (Lira, 2017).

Chavarría et al. (2005) mentioned that one of the key factors for the use of any product based on microorganisms are the climatic conditions, their viability and concentration; many can affect the appreciation of the product at the time of its use, and also mentions that the antagonistic strains to be used should also be taken into account, since greater results are obtained if native strains are used, because they are better adapted to the environmental conditions of the place.

Farmers in Tayacaja practice rainfed and irrigated agriculture, producing two crops annually. On the other hand, farmers are not accustomed to using organic fertilizers from their areas, so the objective of this research was to evaluate the effect of human urine enriched with efficient microorganisms on the yield of potato (Solanum tuberosum L.), Peruvian variety.

2. MATERIALS AND METHODS

Place of execution: The present research work was carried out in the Pampas Tayacaja province, district of San Marcos de Rocchac, place Tranca Pampa; altitude 3,400 masl, latitude south 13° 52' 22.92.92", longitude west 73° 34' 47.59", average temperature 10 °C, relative humidity 60%, average annual rainfall 800 mm. During the 2019-2020 cropping season.

Type of research: The present research work corresponds to the experimental type

Level of research: it belongs to the basic explanatory research lever

Population: The population of the present research was conformed by all the quantity of plants of the potato crop of the experimental field.

Sample: The sample consisted of 5 plants per experimental unit.

Sampling: The sampling used was simple - random.

Methodology: The experimental and deductive inductive method was used to evaluate the effect of liquid organic fertilizer and efficient microorganisms on the potato crop, peruanita variety; it was conducted with the Randomized Complete Block Design (RCBD), evaluating four treatments with three replications randomly distributed in each block, making a total of 12 experimental units having five potato furrows per experimental unit, 15 furrows per block and making a total of 60 furrows in all experimental units. The effect of 5 liters of urine plus EM (5 OH+EM), 10 liters of urine plus EM (10 OH+EM), 15 liters of urine plus EM (15 OH+EM) and a witness without application (witness) were tested.

Data collection: Plant height was evaluated at 120 and 210 days after sowing (dds), measured from the neck of the plant to the terminal apex; the number and weight of tubers per plant was evaluated at harvest in 5 randomly selected plant samples per experimental unit, and the yield per hectare was estimated taking into account the average weight of tubers per plant and the number of plants per hectare.

Human urine was collected in a 200 liter plastic container, fermented for 15 days, kept in a hermetically sealed dark container, with capacity according to the treatments, and applied at two times, via foliar application at 90 and 120 days after planting.

The EM was bought from the distributor in a 1 liter bottle. This was activated with cabuya chancaca and puquial water for 15 days until a pleasant odor was obtained; 25 liters of active ME and 75 liters of urine were used. Then it was kept in the container for 15 days, the dosage was made at the time of application to the plants.

The potato seed was acquired from a producer, then it was selected making sure that it corresponds to the Peruvian variety, and for its size, the acquired seeds were sprouted, with the appropriate sprout size of 1 cm, of uniform size and then proceeded to planting.

The data obtained were processed with the statistical software Infostat and the analysis of variance (ANVA) of the variables and the comparison of means with Duncan's multiple comparisons test at □ = 0.05 were carried out.

3. RESULTS AND DISCUSSION

Table 1. Duncan's test for height of plant at 120 days.

Table 1. Duncan's test for height of plant at 120 days.

Treatments	120 days dap		210 days dap	
	Average cm	Significance	Average cm	Significance
15OH+EM	15.33	a*	95.40	a*
10OH+EM	15.07	a	94.60	a
5OH+EM	14.53	b	67.80	b
TESTIGO	13.73	c	58.37	c

* The averages with equal letters do not differ significantly. dap=after at planting

Height of plant

The results of the Duncan's multiple comparison test of means (Table 1) at a margin of error of □ = 0.05 for plant height at 120 days and 210 dap, this test confirms that there is a significant difference between the means of potato plant height; the application of 15 and 10 liters of human urine plus EM have similar effects and significantly exceed the other treatments, likewise, the lower dose of human urine plus EM increases the height of potato plant compared to the control. These results indicate that the use of human urine plus ME favors the growth of the potato plant, peruanita variety.

The three treatments with human urine plus EM outperform the witness and as the dose of human urine increases the height also increases (Mamani et al., 2015); similar effects have been found in other crops such as barley, broad bean, lettuce, etc.

In this regard, essayists mention that this difference is due to the high concentration of nitrogen contained in human urine, which when used as an organic fertilizer influences the development of the plant (Campos et al., 2013), additionally Dossier (2006), states that, efficient microorganisms consent an impartial contribution of microelements for the needs of the totality of crops that helps to prevent deficiencies of these.

Nitrogen is in the form of ammonium and phosphorus is in a form that can be assimilated by the plant. In addition, 20% of the phosphorus P2O5 is in the form of polyphosphate, which provides nutrition during the root development stage. In addition, polyphosphate has a chelating effect on the micronutrients iron, zinc, manganese and copper, which effectively influenced plant growth and development.

Number of tubers per plant

Table 2 shows the result of the Duncan's multiple comparison of means test at a margin of error □ = 0.05 for the number of tubers at the time of harvest, this test confirms that there is significant difference in the number of tubers produced per plant.

In potato breeding studies it is common to apply the technique of quantum selection, which is referred to count the tubers of first, second, third, among other categories, in order to achieve a moderate intensity in the selection of characteristics that involve visual difference (Tai and Young, 1984). With this technique, the parameters of number of tubers per plant were evaluated in this study. The number of tubers per plant for each treatment ranged from 18 tubers/plant to 38 tubers/plant, with an overall average of 28 tubers per plant. Duncan's 5% significance test for treatments, in the evaluation of the number of tubers per plant, indicates that the highest number of tubers per plant was

Table 2. Duncan's test for the number of tubers per plant.

Treatments	Average Tubers/plant	Significance
15OH+EM	36.67	a*
10OH+EM	35.00	ab
5OH+EM	29.00	b
TESTIGO	20.00	c

* * The averages with equal letters do not differ significantly.

obtained in the treatments that received the highest application of liquid organic fertilizers 15, 10, 5 liters of human urine plus EM and finally the witness. These results are similar to work done by Saquinga (2012) which indicates that the highest number of tubers was obtained in the treatments that received higher application of Biol 60% of K (P2), with total average of 7.91 tubers, when placed in the first range, whereas, the treatments that received application of Biol 50% of P (P1), showed lower number of tubers per plant, with total average of 7.16 tubers, when placed in the second range. Therefore, according to the statistical evaluation of the number of tubers per plant, it is feasible to affirm that the addition of liquid organic fertilizers at higher doses increased the production of a greater number of tubers per plant.

Tuber weight per plant

The results of the Duncan's multiple comparison test of means

Table 3. Duncan's test for tuber weight per plant.

Treatments	Average kg/plant	Significance
15OH+EM	3.43	a*
10OH+EM	3.34	a
5OH+EM	1.97	b
TESTIGO	0.91	c

* The averages with equal letters do not differ significantly.

Therefore, the application of urine enriched with efficient microorganisms has a similar effect to synthetic products, the difference being that it is necessary to supplement them with grams of nutrient per liter at the request of each crop. Likewise, the results confirm what was reported by Saquinga, (2012) that the liquid organic fertilizer, in addition to increasing plant growth, improves crop production and productivity, increases resistance to pests and diseases, improves the activity of beneficial soil microorganisms and causes a better development of roots, leaves and fruits, it also increases the passivity to adverse climatic conditions such as frost, hailstorms and other limiting factors, it is ecological, compatible with the environment and does not pollute the soil, it is economical, it accelerates flowering, the plant adapts better in the field in almacigo conditions, it conserves better the NPK and Ca, complete to the process of anaerobic decomposition which takes full advantage of the nutrients; The N it contains is in ammoniacal form, which is easily assimilated and does not acidify the soil or affect its microbiology, and has the additional advantage of not being expensive (Manual de Agricultura Alternativa, 2004). Therefore, it is possible to affirm that the application of liquid organic fertilizer based on human urine plus EM has a favorable influence on the yield of the potato crop, Peruvian variety.

4. CONCLUSION

Human urine plus ME favors plant growth and increases the number and weight of potato tubers of the peruanita variety.

The application of liquid organic fertilizer based on human urine plus EM, positively influences the yield of potato crop of the peruanita variety.

The liquid organic sources of fermented human urine and efficient microorganisms used in combination become an alternative for the organic production of native potato variety peruanita and future research in other crops.

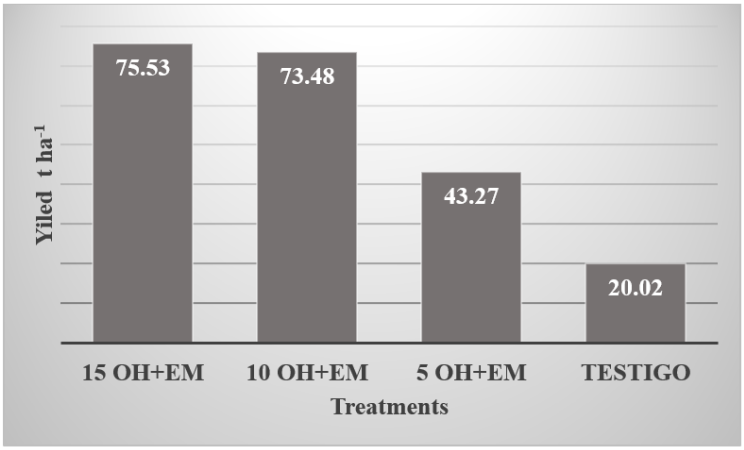

Figure 1. Yield t/ha-1 of potato crop, peruanita variety.

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5. ACKNOWLEDGEMENTS

We thank the inhabitants of the area of San Marcos de Rocchac for their support; the Faculty of Agronomic Sciences, National University of Huancavelica, Campus "Ciudad Universitaria" for supporting the experiment with instruments and study spaces.

6. REFERENCES

Agricultura Alternativa. 2004. Manual de Agricultura Alternativa. Principios. Fundación de Hogares Juveniles Campesinos. Carretera Central del Norte km 18. Bogotá. D.C. Colombia. Correo electrónico: fundacion@hogaresjuvenilescampesinos.org Página Web: www,hogaresjuvenilescampesinos.org.

Campos, R. & Gomez, V. Martinez, G. 2013. aplicación de orina como fertilizante en la composta escolar. México.

Chavarría, Marena; Uribe, Lidieth; Bolaños, Andrea. 2005. Microorganismos benéficos en el control de enfermedades en jengibre Agronomía Costarricense, vol. 29, núm. 3, pp. 145-155 Universidad de Costa Rica. San José, Costa Rica.

Condori Guarachi Daniel; Condori Mamani Pastor; Quispe Condori Efraín. 2018. Efecto de aplicación de abono orgánico y fertilizante liquido orina humana fermentada sobre la fertilidad del suelo en el cultivo de papa (Solanum tuberosum L.) en el municipio de el alto. Universidad Pública de El Alto-UPEA, Área de Ciencias Agrícolas, Pecuarias y Recursos Naturales, Ingeniería Agronómica. Laja - Los Andes. La Paz. Estado Plurinacional de Bolivia. Editado por: Selva Andina Research Society.

Dossier, R. 2006. Yaramila Hydrocomplex_ Calidad en tabaco. En línea. Consultado el 11 de abril del 2012. Disponible en http://www.YaraMila Hydrocomplex_ Calidad en Tabaco.mht.

Johansson, M., Jönsson, H., Höglund, C., Richert Stintzing, A. and Rodhe, L. 2001. Urine separation – closing the nutrient cycle. Stockholm Water Company. Stockholm, Sweden. Available at: http:// www.swedenviro.se/gemensamma_se/ documents/ Urinsep_eng.pdf.

Lentner C, Lentner C, Wink A. 1981. Units of Measurement, Body Fluids, Composition of the Body, Nutrition. Geigy Scientific tables. Ciba- Geigy, Basel, Switzerland.

Lira Saldivar, R. H. 2017. Uso de Biofertilizantes en la Agricultura Ecológica. Instituto para la Innovación Tecnológica en Agricultura (Intagri). https://www.intagri.com/articulos/agricultura-organica/uso-de-biofertilizantes-en-la-agricultura-ecologica

Mamani Mamani Virginia, Loza Murguia Manuel, Coronel Quispe Laoreano, Sainz Mendoza Humberto, Paye Huaranca Victor, Coronel Felipe. 2015. El uso de la orina humana como fertilizante en la producción de lechuga Waldmann green (Lactuca sativa L.). Selva Andina Biosphere; 3(1):24-38. Disponible en: http://ucbconocimiento.ucbcba.edu.bo/index.php/ JSAB/article/view/90/63

Richert A, Gensch R, Jönsson H, Thor-Axel S, Linus D. 2011. Guía práctica de uso de la orina en la producción Agrícola. Stockholm: EcoSanRes Programme. Guía, Stockholm Sweden. 73 pp.

Rodhe L, Richert Stintzing A, Steineck S. 2004. Ammonia emissions after application of human urine to clay soil for barley growth. Nutr Cycl Agroecosys. 68:191-198.

Saquinga, S. 2012. Producción de tubérculo semilla de papa (Solanum tuberosum),

categoría prebásica utilizando biol en sistema aeropónico en el cantón mejía, provincia de pichincha. Universidad Técnica de Ambato Facultad de Ingeniería Agronómica – Ecuador.

Tai G.C., Young D. A. 1984. Early generation selection for important agronomic characteristics in a potato breeding population. American Potato Journal 61:419-434.