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IMPROVING THE QUALITY OF POTATO MINI TUBERS BY SUSTAINABLE CULTIVATION

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Abstract

This study aimed at improving the quality of potato tubers using vermicompost and plant extracts. It employed the RCBD design with three replicates within the factorial experiment (3*5). The factors included vermicompost at two levels of 0.5 and 1% designated V1 and V2, respectively, and treatment without vermicompost (V0). The second treatment involved foliar application of *Cyperus Rotundus* root extracts at 5 and 10 g L^{-1} designated T1 and T2, respectively, and *Silybum marianum* leaf extract at 5 and 10 g L^{-1} (T3 and T4 respectively), and spraying the control treatment with water (T0). The results showed significant improvements in treatment involving vermicompost and spraying with *Silybum marianum* leaf extract (V2T3) in terms of dry matter percentage of the tubers, their specific density, and percentages of starch, nitrogen, protein, carbohydrates and phenols at 28.55, 1.119, 21.44, 1.71, 10.68, 11.43% and 3.13 mg 100 g, respectively. This did not differ significantly in the percentage of dry matter and specific density of the tubers, their percentage of starch from the V0T3 treatment, the percentage of nitrogen and protein in the tubers for treatments V2T4, V1T3, V2T2, and V1T4, in carbohydrates for treatment V1T4, and in total phenols for treatment V2T2, V1T3, and V0T3

compared to the measured plants, which recorded 21.71, 1.087, 15.34, 1.35, 8.43, 5.56%, and 1.14 mg 100 g, respectively. Therefore, the application of 1% vermicompost and spraying of 5 $g.L^{-1}$ *Silybum marianum* leaf extract is recommended for improving the quality of potato tubers and for sustainable cultivation. This will also promote recycling and preserve the environment.

Keywords: Cyperus esculentus L, Silybum marianum, Organic fertilizers, Solanum tuberosum L.

تحسين جودة دُرينات البطاطا بالزراعة المستدامة

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الخلاصة

نفذت الدراسة في حقول كلية علوم الهندسة الزراعية – جامعة بغداد في الموسم الربيعي 2022– 2023 بهدف تحسين جودة درنات البطاطا عند الزراعة في سماد دودة الارض والرش بالمستخلصات النباتية، ونفذ البحث كتجربة عاملية (3*5) ضمن تصميم RCBD وبثلاثة مكررات وشملت العوامل زراعة الدُرينات باستعمال سماد دودة الارض Vermicompost بمستويين 0.5 و1% والتي رمز لها V1 وV2 على الترتيب فضلا عن المعاملة بدون اضافة V0 ثم رشت النباتات ورقيا بالمستخلص المائي لجذور السعد بالتركيز 5 و10 غم لتر$^{-1}$ رمز له T1 وT2 على الترتيب والمستخلص المائي لأوراق الكلغان بالتركيز 5 و10 غم لتر$^{-1}$ رمز له T3 وT4 على الترتيب فضلا عن معاملة الرش بالماء والتي رمز لها T0، اظهرت النتائج تفوقا معنويا لمعاملة الزراعة بسماد دودة الارض والرش بمستخلص اوراق الكلغان (V2T3) في النسبة المئوية للمادة الجافة في الدرنات والكثافة النوعية للدرنة والنسبة المئوية للنشأ والنتروجين والبروتين والكاربوهيدرات والفينولات إذ بلغت 28.55 و1.119 و21.44 و1.71 و10.68 و11.43% و3.13 ملغم 100 غم على التتابع والتي لم تختلف معنويا في النسبة المئوية للمادة الجافة والكثافة النوعية للدرنة والنسبة المئوية للنشأ عن المعاملة V0T3 وفي النسبة المئوية للنتروجين والبروتين في الدرنات عن المعاملة V2T4 وV1T3 و V2T2 وV1T4 وفي الكاربوهيدرات عن المعاملة V1T4 وفي الفينولات الكلية عن المعاملة V2T2 وV1T3 وV0T3 مقارنة بنباتات القياس التي سجلت 21.71 و1.087 و15.34 و1.35 و8.43 و5.56% و1.14 ملغم 100 غم على التتابع، لذا

نوصي بتحسين الصفات النوعية لدرنات البطاطا باستخدام الزراعة المستدامة واستعمال سماد دودة الارض 1% والرش بمستخلص اوراق الكلغان 5 غم لتر$^{-1}$ كوسيلة لإعادة التدوير والمحافظة على البيئة.

كلمات مفتاحية: نبات السعد، نبات الكلغان، اسمدة عضوية، البطاطا.

Introduction

Sustainable cultivation has become a critical requirement for mitigating the negative effects of environmental pollution caused by improper agricultural practices and the extensive use of mineral fertilizers. The challenges presented by sustainable cultivation is more serious in developing countries, as global population growth and improved living conditions have led to an increase in demand for food production. This has placed tremendous pressure on agricultural production leading to negative impacts such as excessive use of pesticides and chemical fertilizers, and the production of agricultural waste, which not only pollutes and harms the environment, but also poses a potential danger to human health (16). In recent years, there is increasing scientific evidence that the quality of food and its components directly affect human health and well-being. Many consumers believe that the quality of food has a close relationship with health, as it constitutes a protection factor against diseases resulting from nutritional deficiency, in addition to improving mental and physical health. Types of food that improve the general health of the body or reduce the risk of or treats disease is known as functional food, which is defined as any ingredient that provides health benefits that exceed its nutritional value.

Vegetables are characterized by short growth cycles and high fertilizer requirements. For this reason, providing nutrients in a balanced manner is necessary to ensure productivity and product quality. Studies show that organic or animal-origin fertilization of plants improves soil fertility, increases productivity, and improves the qualitative traits of the crop (27). (17 and 18) indicated that adding different concentrations of vermicompost produced statistical differences in terms of percentage of dry matter, TSS, phenols, and polysaccharides in the roots of red, dark red, and cylindra beet cultivars. Compared to plain soil cultivation, using vermicompost and cow manure had a significant effect on the percentage of nitrogen in beet roots. (19) concluded that compared to the control treatment, fertilizing potatoes with vermicompost (3 tons ha^{-1}) had a significant effect on their marketable and total yields.

Recently, research interest has focused on harnessing plant extracts to produce value-added crops, where there is a need to implement a sustainable method to remove jungle and plant residues and avoid environmental pollution and odor (14). One of the most promising applications in the agricultural and horticultural sectors is recycling waste. These plants are used as plant extracts, soil improvers, and organic fertilizers due to their rich nutrient content (6 and 8). In this regard, plant extracts are seen as possible partial or total replacements for inorganic chemical nutrients in agricultural practices. Spraying lettuce plants with lemongrass water extracts showed higher Vit.C. and total carotene, beta carotene, and protein content compared to the control treatment (23)

(25) studied two cultivars of potatoes (Burren and Riviera) using combinations of organic fertilizers and spraying with neem leaf extract, as well as a measurement treatment. They concluded that the irrigation treatment with neem leaf extract at 50% solution concentration + 5% cow waste, and spraying treatment with neem leaf extract at 7.5 $g.L^{-1}$ + 5% cow waste for the Burren cultivar, had a significant effect in increasing starch content. Abdulraheem and Estefo (20) noted that of the three types of plant extracts sprayed on two cultivars of peas, the nettle leaf extract treatment improved the quality yield of both cultivars compared to the control treatment.

The potato (*Solanum tuberosum* L.) is a major starch crop and staple food for more than a billion people and has various health benefits (3). As such, improving the quality of this tuber is considered a priority to ensure food security (24). The aim of this research is to promote sustainable development through responsible consumption and production by improving the quality of mini tubers using vermicompost and the foliar application of aqueous extracts of plants as a means to recycle plant waste.

Materials and Methods

This study was conducted during Spring 2022-23 at B Station of the College of Agricultural Engineering Sciences, University of Baghdad, Al-Jadriya. It sought to improve the quality of mini tubers resulting from the cultivation of Arizona potato tubers (weight 5g) on 2/1/2023. It used vermicompost at 0.5 and 1% levels, designated V1 and V2, respectively, and a control treatment without the addition (V0). It also involved spraying water concentrations of 5 and 10 g L^{-1} of the *Cyperus Rotundus* (designated T1 and T2) root extract and *Silybum marianum* leaf extract before the plant flowered (T3 and T4), respectively. The control treatment (T0) involved spraying distilled water thrice on the plants until drop point, with an interval of 10 days between spraying. Table 1 shows the chemical components of the foliar spraying treatments. A 3 * 5 factorial experiment was adopted within a completely randomized block design (RCBD) with three replicates. The experimental unit included 20 plants spaced 20 cm apart and 75 cm between each line.

Table 1: Chemical analysis of the aqueous extract treatments.

Aqueous extract	N	P	K	Ca	Mg	Fe	Zn	Mn	Cu	B
	mg L^{-1}									
***Cyperus Rotundus* roots 1%**	**21.0**	**1.7**	**38.0**	**56.3**	**14.6**	**0.26**	**0.06**	**-**	**-**	**2.1**
***Silybum marianum* leaves 1%**	**84.0**	**5.1**	**378.0**	**150.0**	**25.3**	**0.33**	**0.20**	**0.08**	**0.92**	**4.5**

A known fresh weight was taken from five randomly selected tubers for each experimental unit. After washing them, they were cut into slices and dried in an electric oven. When the weight was stable, the percentage of dry matter, specific density of the tubers (10), percentage of starch according to (5), and nitrogen (%) were calculated using a Kjeldahl device (13), protein (%) according to (5), carbohydrates (%) (15), TSS (%) (12), total phenols (%) (26).

Results and Discussion

Table 2 shows that the tubers grown in 1% vermicompost (V2) had significantly higher percentages of dry matter, specific density, starch, nitrogen, protein, TSS, and phenols, reaching 25.14, 1.102, 18.40, 1.64, 10.27, 5.24% and 2.56 mg 100g compared to the controls at 23.51, 1.095, 16.94, 1.40, 8.75, 4.20% and 1.82 mg 100g, respectively.

The foliar application of the 5 g. L^{-1} aqueous extract of the *Silybum marianum* leaves (T3) was significant in terms of the tubers dry matter, specific density, starch, nitrogen, protein, carbohydrates, TSS, and phenols, reaching 27.76, 1.115, 20.74, 1.62, 10.12, 8.64, and 5.41%, and 2.93 mg 100 g respectively. This was not significantly different from the 10 g L^{-1} spraying treatment (T4) for the carbohydrates and TSS percentages compared to the control which recorded 22.26, 1.089, 15.84, 1.46, 9.16, 5.97, and 4.08%, and 1.89 mg 100 g while the values decreased in the treatment control.

Table 2: Effect of planting with vermicompost and spraying plant extracts on the qualitative traits of potato tubers.

Treatment	Dry matter	Specific density	Starch	N	Protein	Carbohydrates	TSS	Total phenols
	%							mg .100g
V0	23.51	1.095	16.94	1.40	8.75	7.13	4.20	1.82
V1	23.73	1.096	17.15	1.61	10.08	7.45	4.95	2.26
V2	25.14	1.102	18.40	1.64	10.27	7.68	5.24	2.56
LSD 5%	0.51	0.002	0.22	0.02	0.15	N.S	0.20	0.23
T0	22.26	1.089	15.84	1.46	9.16	5.97	4.08	1.89
T1	22.88	1.092	16.39	1.52	9.49	6.91	4.41	1.67
T2	23.16	1.093	16.64	1.57	9.83	7.21	4.83	2.16
T3	27.76	1.115	20.74	1.62	10.12	8.64	5.41	2.93
T4	24.56	1.100	17.88	1.58	9.91	8.36	5.25	2.41
LSD 5%	0.66	0.003	0.29	0.03	0.19	0.63	0.26	0.30

Table 3 shows that the treatment interaction between planting in 1% vermicompost and 5 g L^{-1} of *Silybum marianum* leaves extract (V2T3) had a significant effect on the tubers dry matter, specific densities, starch, nitrogen, protein, carbohydrates, and phenols, reaching 28.55, 1.119, and 21.44. 1.71, 10.68, 11.43%, and 3.13 mg 100 g, respectively. This was not significantly different from the dry matter volume, specific density, and starch content of the tubers compared to the V0T3 treatment, and in the nitrogen and protein percentages of the V2T4, V1T3, V2T2, and V1T4 treatments, the carbohydrates for treatment V1T4 and total phenols for treatments V2T2, V1T3, and V0T3 compared to the control which recorded 21.71, 1.087, 15.34, 1.35, 8.43, 5.56%, and 1.14 mg 100 g, respectively.

Table 3: Effect of planting with vermicompost and spraying plant extracts on the qualitative traits of potato tubers.

Treatment	Dry matter	Specific density	Starch	N	Protein	Carbohydrates	TSS	Total phenols
				%				mg .100g
V0T0	21.71	1.087	15.34	1.35	8.43	5.56	3.75	1.14
V0T1	22.49	1.090	16.04	1.38	8.62	7.00	3.75	1.29
V0T2	22.09	1.088	15.68	1.40	8.75	9.30	4.25	1.52
V0T3	28.05	1.117	20.99	1.47	9.18	7.30	4.75	2.76
V0T4	23.21	1.094	16.68	1.41	8.81	6.49	4.50	2.40
V1T0	22.31	1.089	15.88	1.48	9.25	6.33	4.25	2.10
V1T1	22.58	1.091	16.12	1.60	10.00	6.34	4.50	1.89
V1T2	22.90	1.092	16.40	1.65	10.31	6.38	5.00	2.06
V1T3	26.70	1.110	19.79	1.68	10.50	7.20	5.50	2.92
V1T4	24.18	1.098	17.54	1.66	10.37	11.00	5.50	2.37
V2T0	22.78	1.092	16.30	1.57	9.81	6.02	4.24	2.45
V2T1	23.59	1.095	17.02	1.58	9.87	7.40	5.00	1.85
V2T2	24.51	1.100	17.84	1.67	10.43	5.96	5.25	2.92
V2T3	28.55	1.119	21.44	1.71	10.68	11.43	6.00	3.13
V2T4	26.29	1.108	19.42	1.69	10.56	7.60	5.75	2.48
LSD 5%	1.15	0.005	0.50	0.05	0.34	1.09	N.S	0.53

Improving the quality yield traits of the Arizona cultivar grown in the Spring maybe due to the use of fertilizer formulations with improved roles, such as non-traditional, environmentally friendly organic fertilizers. These include vermicompost, which is characterized by its rich content of vitamins, enzymes, and large amounts of humic substances, in addition to the presence of humic acid, which is a vital and sustainable fertilizer (7). It also contains polysaccharides that improve soil aeration and drainage as seen in the effectiveness of the roots and their ability to absorb nutrients better (11), in addition to being rich in nitrogen-fixing bacteria and phosphate-dissolving fungi (22). It also releases plant hormones (21), provides nutrients slowly and steadily in the soil, allowing plants to absorb them and increase their concentration, which in turn enters directly and indirectly in the manufacture of chlorophyll. This activates a number of carbon metabolism enzymes that contribute to the production of larger quantities of carbohydrates. Storing it provides the energy compounds necessary for vital activities thereby increasing the tubers' dry matter content, which in turn affects the percentage of starch, specific density, and TSS. The richness of this fertilizer in nitrogen makes it one of the most important types of organic fertilizers used as a source for it. It affects the plant's content and its role in manufacturing amino and organic acids, thus increasing its protein content (Table 2).

The improved tuber quality from spraying *Silybum marianum* leaf extract compared to *Cyperus Rotundus* root extract maybe due to its high essential nutrient content (Table 1), which enhanced their readiness and absorption with the application of foliar spraying. It has an important role in the functioning of vital processes within the plant as seen in the strength of the vegetative growth, increased rates of carbon assimilation, and the production of complex compounds, including carbohydrates, amino acids, and organic acids. Also, their transfer from the production sites in the

leaves to the final destination in the tubers (1) and storing them in the form of dry matter, which is the final product of the processes of carbon assimilation and metabolism, leads to higher percentages of starch and protein, which are directly proportional to the increase in the percentage of dry matter in the tubers (Table 2). This increases the TSS, which is an important indicator of the high nutritional value of the tubers and their increased storage capacity (2). The specific density of the potato tubers is one of their important quality standards and mainly associated with an increase in the percentage of starch and dry matter (4). Nitrogen and magnesium absorbed from the aqueous extract increase plant pigments, while potassium works to produce better quality of crops, which stimulates the process of carbon metabolism and transport to other parts of the plant (9), similar to boron. Phosphorus works to provide energy while iron is involved in the synthesis of several vital compounds related to carbon assimilation activities.

The positive effect of the vermicompost treatment and spraying with *Silybum marianum* leaf extract could possibly be due to the plants exploiting the surrounding environmental conditions and the nutrients growing within (Table 3). Such spraying and use for the growth of healthy and sound plants is reflected in the products of the carbon assimilation process, increasing their transfer, and improving the quality of the product to obtain clean tubers produced in sustainable methods with nutrients. They are environmentally friendly, can lower costs, address current and future consumer needs, as well as mitigate risks to the environment for achieving sustainable development. Therefore, we recommend planting potato mini tubers produced from tissue culture that are free of disease and viral infections and of a high grade. The quality of their yield can be improved through the application of 1% vermicompost concentration and by spraying them with a 5 $g.L^{-1}$ concentration of *Silybum marianum* leaf aqueous extract. This will also help promote recycling and contribute to sustainable cultivation practices.

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Author 1: methodology, writing, and original draft preparation. Author 2, Author 3 and Author 4 writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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