Effects of compost enriched with human urine on the biochemical quality of potatoes in the Urban Municipality of Faranah (Republic of Guinea)

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ABSTRACT

In order to valorize liquid waste in the fertilization of crops and to minimize the negative impact of chemical fertilizers on renewable natural resources in the farms of the Urban Municipality of Faranah, a fertilization test involving compost enriched with human urine was carried out in the market gardening perimeter of Sagbaya, on acidic soil (pH = 5.3), silty-clayey-sandy, rich in nutrients with 7.60% organic matter, a C / N = 11.63; and an average saturation rate (V = 45%). The experiment was conducted from 29/11/2019 to 11/02/2020. Analyzes at the Laboratory of the National Soil Service of Guinea revealed that the compost has an alkaline pH (pH = 6.90) and rich in nutrients with 0.04% nitrogen, 0.01% potassium and 0, 12% phosphorus. The experimental device used is the Randomized Complete Block (4x4). The plant material used is the mandola potato variety. The treatments studied are the 4 increasing doses of compost added at a rate of 0t / ha, 15t / ha, 30t / ha and 45t / ha. The analysis of compost demonstrated that it was enriched by supplementation with human urine. After the statistical analyzes of the biochemical parameters, the dry matter, moisture, mineral matter and protein showed no significant difference between the doses tested; unlike fat and carbohydrate showed a significant difference with two classes each of which the 30t / ha dose was found to be better compared to the other doses.

Key words: *Solanum tuberosum, Compost, Urine, Human, Effect, Quality, Biochemical, Faranah.*

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1. Introduction

Tropical agriculture faces a number of constraints including low level of soil fertility, the less rate of use of agricultural inputs, a low level of financing and technical equipment, and inappropriate agrotechnical practices. In addition to these rather technical-economic constraints, there is a rainfall deficit [1]. According to Mathieu 1991, the fertility of soil represents, in a given climate, the ability to ensure regular and repeated growth of crops and obtaining desired harvests [2]. It is then the result of various components which lead to a distinction: chemical, physical and biological fertility. Fertilizers are organic or mineral substances of natural or synthetic origin applied to the soil to make up for one or the other deficiency observed in one or more elements [3]. Fertilizers can be mineral when produced in liquid or solid form, generally industrially [4] and organic when they are of animal origin (farmyard manure, compost, crushed horn, dried blood, guano, bones, fish bones) or plants (seaweed, wood ash) [5]. According to Blaise 2012, the latter appeared in 1981 and are made useful to plants and soils through microbial activities and physical factors in the soil [6]. Sangbaramou 2013 has defined, compost as being is a mixture of various residues of animal or vegetable origin put in slow fermentation, in order to ensure the decomposition of organic matter and used as fertilizer and amendment [7]. It has been demonstrated that compost is well-decomposed organic material containing humus and nutrients. It is used as an organic fertilizer, which can be incorporated into the soil and bring on the leaves once its juice is extracted [8]. Urine is human or animal excreta (manure) used as a liquid, fast-acting, well-balanced, nitrogen-rich fertilizer. Its nitrogen content is estimated to be around 3-7g of nitrogen per liter of urine. The phosphorus it contains is in a form available to plants, making urine a phosphate fertilizer [9]. Fertilizers, whether chemical or organic, all have favorable effects on crops, but those of mineral fertilizers are of greater concern because they are expensive, short-term action, acidify the soil and pollute the

environment [10]. Those which are nitrogenous promote foliar development to the detriment of the seeds and reduce the rate of dry matter [11]. In order to develop, plants mainly need 16 nutrients which must come from air, water, carbon dioxide, solar energy and in the ground [4], [12]. It has been specified that the potato is the main non-grain foodstuff in the world [4], [13] and [14]. The potato prefers a balanced climate, demanding water, sensitive to prolonged periods of drought or humidity during the formation of flowers and tubers [15]. It requires soil with a suitable pH varying from 6 - 7 and the minimum planting temperature is estimated at 8 ° C and up to 10 ° C (never below 5 ° C) for [16].
As for CTA 2009, it likes light soils (sandy or sandy loam) with a slightly acidic pH of 5 to 6.5 and requires relatively a lot of water on average 50 to 80 m³ of water per day and per hectare [17]. The potato tuber is a storage organ containing on average 77.5% water, 19.4% of total carbohydrates (main starch, sucrose, glucose, fructose, crude cellulose and pectic substances), 2.0% of proteins (proteins, free amino acids and nitrogenous bases), 1.0% of ash (main potassium) and 0.1% of lipids [18]. The potato plays an appreciable nutritional role and adds that 100g of potato is composed of 72-75% water, 16-20% starch, 2-2.5% protein, 1-1.8% fiber and 0, 15% fatty acids [19]. The potato tuber cooked to a comparable chemical composition 70% starch, 3% cellulose, 8% protein [20] and the dry matter of potato tubers depends on the variety and can be ranged between 18.7 to 20.7% [21]. For 100 g of fresh matter, the chemical composition of the potato is estimated to be 77.5 g of water, 22.5 g of dry matter, 19.4 g of carbohydrate (sugar), 2 g of protein (amino acids), 0.1 g of lipids (fatty acids), 1 g of minerals and 40 mg of vitamin C [17]. Margot 2015 said that according to varieties, the low dry matter content can vary between 15 to 19.5% [22]. The application of a nitrogenous manure can lead to certain changes in the chemical composition of the tubers [23]. So, to better understand this effect, we proposed to use human urine as nitrogenous manure supplement in compost. The present work is rooted in our own observation made on the issue of the production cost of producers, the conservation of harvests in a given period and maintenance of the tuber phenotype.

2. Materials and methods

2.1. Site description

The urban commune of Faranah is one of the twelve decentralized communities that make up the Prefecture of Faranah. It is located between 10°30' and 11°35' of west longitude and between 10°02' and 10°42' of latitude north with an altitude of 417 m. It is located on both banks of the Niger River, covers a total area of 47 km^2 and it is part of the Niger Source sub-basin. Its relief is not very varied and presents itself as a vast monotonous plateau, notched by large plains and dotted with hills. The climate as a whole is a Sudano-Guinean type with the alternation of two seasons: dry and rainy. The vegetation is woody, shrub and herbaceous with tall herbaceous plants and woody species. The soil of this Urban Commune is characterized by three major classes: ferralitic soils, alluvial soils and hydro-morphic soils. The Municipality's hydrographic network is dense. The Niger is the most important river on which all the other rivers flow. Annual rainfall ranges from 1281.38 mm to 1629.82 mm of water per year during the season. The temperatures are high and fluctuate between 21 and 30 °C on average. The average relative humidity oscillates between 27.59 and 88.93%, while the prevailing winds are the harmattan and the monsoon.
The experiment was conducted in the market garden area of Sagbaya, Urban municipality of Faranah, located on the left strike of the Niger River and 30 m from the Faranah - Mamou national road. This perimeter covers an area of 8.50 ha. The geographical coordinates of the experimental field taken using the GPS (Garmin etrex 10 brands) indicated an average of 430 m altitude, located between 10^o02'26.7" and 10^o02'27.5" latitudes north and between 10^o45'00" and 10^o45'00.5" west longitude. The experimental site covers an area of 406.875 m². The soil of the test field is ferralitic with a Limono-clayey-sandy texture.

2.2. Experimental design and treatments

To assess the effect of compost supplemented with human urine on the biochemical quality of potatoes, the Randomized Complete Block (BCR) device was used with four variants repeated four times. The treatment D_0 = 0t / ha (control), D_1 = 15t / ha, D_2 = 30t / ha and D_3 = 45t / ha. The preparation of compost was performed with 1 286 kg of solid material supplemented with 44 liters of human urine and 220 liters of water. The variety « MANDOLA » obtained from Pita (Guinea) was used with a cycle of 75 days.

2.3. Observations and samples analysis

The meteorological readings are those of the automatic station of the ISAV of Faranah located on the campus of the university campus. In phenophagus, were observed: leaf development, tuberization and maturation.
The following parameters dry matter (%), moisture (%), mineral matter (%), fat (%), protein (%) and Carbohydrate (%) were determined as described by international methods [24].

2.4. Statistical analysis

Data analysis was performed using SPSS24 software. The ANOVA test was used to determine significant ($P \leq 0.05$) treatment effect and smallest significant difference (SSD) test to determine significant difference between individual means.

3. Results and discussion

3.1. Results

3.1.1. Soil chemical and physical properties

The chemical, physical and agrochemical analyses of soil are shown in the table 1 and 2.

Table 1: Soil analysis result for physical and chemical characteristics

Lab number	Reference	pH (H_2O)	Granulometry					Texture	Density (g/cm^3)		Porosity (%)
			A	Lf	Lg	Sf	Sg		App	Actual	
137	soil	5.30	23	12	12	21	32	s-c-s	1.06	2.56	43.60

From table 1, we can conclude that the soil where the experiment was conducted is characterized by a low apparent density compared to the standard (1.06 against 2.56). This indicates that the field was used by the market gardeners. The texture is silty-clayey-sandy and the soil is slightly acidic (pH = 5.30) with a relatively high porosity 43.60 which was corrected by compost used.

Table 2: Agrochemical analysis of soil

Lab number	Ref.	C%	M.O %	C/N %	S meq/100g	CEC meq/100g	V %	N. ass (NO_3) ppm	P. ass (P_2O_5) ppm	P. ass (K_2O) mg/Kg
137	Sol	4.42	7.60	11.63	7.30	16.22	45	190	6.24	583.27

In table 2, the results prove that the percentage of organic matter in the soil is low (7.60%) and an evolving level of decomposition with a C / N = 11.63%. It is alkaline (V = 45%) and its reserve in chemical element is on average high (S = 7.30 meq / 100g). Its ability to retain nutrients is high (CEC = 16.22%) and low in the assimilation of nitrogen (190 ppm), phosphorus (6.24 ppm) and potassium (585.27 ppm). Based on available nutrient concentrations, the addition of 15t /ha, 30t /ha and 45t /ha contributed to compensate the deficit for the needs of the crop (potato).

3.1.2. Agrochemical properties of compost enriched with human urine

The compost prepared was analysed to determine its different properties. The result of the agrochemical parameters is indicated in table 3.

Table 3: Agrochemical analysis of compost samples

Lab number	Reference	pH		C %	S meq/100g	CEC meq/100g	N. ass (NO_3) ppm	P. ass (P_2O_5) ppm	P. ass (K_2O) mg/Kg
		H_2O	KCl						
137	Compost	6.90	6.80	9.34	15.00	32.92	397.50	92.59	1198.50

From the analysis of this table, the compost is slightly basic with a pH = 6.90. Its capacity to retain usable nutrients is good (S = 15.00%) with a capacity to retain nutrients is 32.92% (CEC). It is rich in nutrients with 397.5 ppm (nitrogen), 92.59 ppm (potassium) and 1198.5 ppm (phosphorus). It has been demonstrated that the addition of compost significantly increases the physical, chemical and biochemical proprieties of soil at the highest dose, while at the low percentage the effect is not significant.

3.1.3. Tuber biochemical quality assessments

The evaluation of the effect of compost supplemented with human urine was observed through some biochemical parameters of potato tubers quality. The result of the analysis of variance is summarized in table 4.

Table 4: Summary of analysis of variance of the biochemical parameters studied

Sources of variation	df	F. Calculated of biochemical parameters analysed						F. Theoretical
		Dry matter (%)	Moisture (%)	Mineral matter (%)	Fat (%)	Protein (%)	Carbohydrate (%)	5%
Replicates	3	0.57[NS]	0.43[NS]	1.63[NS]	0.038[NS]	1.01[NS]	1.198[NS]	3.86
Treatment	3	1.24[NS]	1.41[NS]	0.75[NS]	5.380*	2.07[NS]	4.397*	3.86
Error	9	-	-	-	-	-	-	-
C.V.	-	8.10%	2.59%	26.43%	1.37%	13,91%	5.99%	-
C.M.V.	-	9.73%						-

From this table, we notice that at the level of the replicates, the difference is not significant between the replicates for all the parameters studied, which proves that the experimental soil was homogeneous in terms of fertility. While the difference was not significant between the treatments for dry matter, humidity, mineral matter. On the contrary, the difference was significant for fat and carbohydrate content. This proves that compost enriched with human urine applied in different doses positively influenced the soil fertility for the two parameters. With a Coefficient of Variation (CV) including between 1.37 and 26.43% and CVM equal to 9.73%, less than 15%, indicating that the test is of good precision.
To better demonstrate this positive influence between the treatments, the comparison of the means by the smallest significant difference test performed. The results of this comparison appears in table 5.

Table 5: Summary of means comparison of the biochemical parameters analysed

Treatment	Parameters					
	Dry matter (%)	Moisture (%)	Mineral matter (%)	Fat (%)	Protein (%)	Carbohydrate (%)
D_1	19.89[a]	80.11[a]	1.24[a]	0.12[a]	2.25[a]	16.28[ab]
D_2	20.84[a]	78.41[a]	0.94[a]	0.18[b]	2.82[a]	16.93[b]
D_3	18.92[a]	81.08[a]	1.02[a]	0.11[a]	2.69[a]	15.11[a]
D_0	19.04[a]	80.96[a]	1.07[a]	0.10[a]	2.80[a]	14.81[a]
PPDS (5%)	2.54	3.32	0.45	0.04	0.58	1.51

This comparison table shows that utilisation of compost enriched with human urine doesn't have any effect on the dry matter, moisture, mineral matter and protein statistically; although the highest value of dry matter and protein was obtained with D_2. On the contrary, the biochemical parameters (fat and carbohydrate) presented different classes statistically, demonstrating that the supplementation of the compost with human urine influences the two parameters. For fat, two classes were observed with the first class occupied by D_0 (0t/ha), D_1 (15t/ha) and D_3 (45t/ha). In the content of carbohydrate, two classes also were observed with D_0 (0t/ha), D_1 (15t/ha) and D_3 (45t/ha) in the first class and D_1 (15t/ha) and D_2 (45t/ha) in the second class. This denotes that the dose D_1 occupied an intermediary class.
In order to better understand the effect of compost enriched with human urine on the biochemical proprieties of potatoes, we represented different biochemical parameters (Figure 1 and 2).

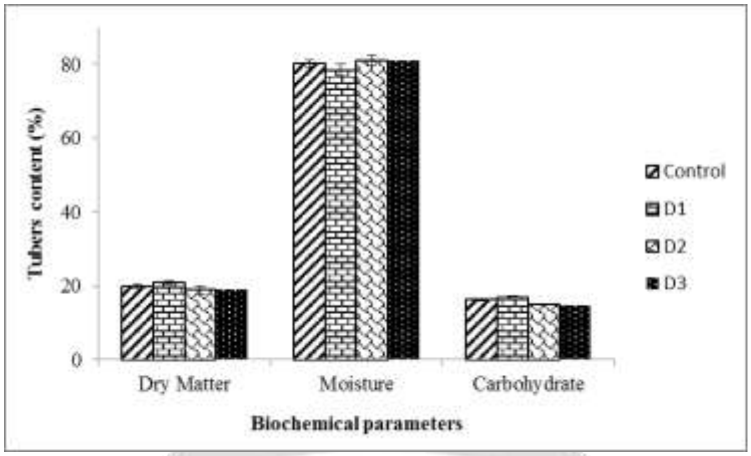

Figure 1: Biochemical parameters with the dry matter, moisture and carbohydrate (%).

This figure shows that the plants from the treated plot with compost at a dose of 30t / ha provided the tubers rich in dry matter (20.84%) and contains less moisture (78.41%). This explains that the tubers from dose D2 can be conserved for a long time than the doses D_0, D_1 and D_3. For the carbohydrate where the difference was significant, the tubers form D_2 contains more with 16.93%.

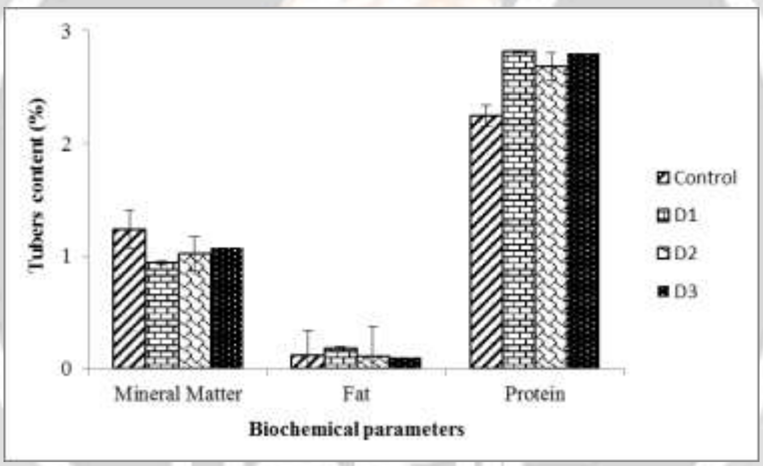

Figure 2: Biochemical parameters with mineral matter, fat and protein (%)

The tubers from D_2 presented the lowest content in mineral matter (0.94%) and the highest rate of fat (0.18%) and protein (2.82%). This denote that utlisation of compost enriched with human urine at 30t/ ha increased significantly the content of fat. The control presented a percentage of protein (2.8%) better than the treats with 15t / ha (2.25%) and 45t /ha (2.69%).

3.2. Discussion

The results obtained during this research allowed us to have information relating to the favorable conditions on the biochemical parameters of the mandola variety potato.

The meteorological data recorded during the test were favorable for the growth and good development of the potato.

The minimum temperature for the test (23.36 °C) is above that indicated previously where the minimum temperature for the development of the potato varies from 8 to 10 °C [16] and [15]. The average temperature during the test was 23.79 °C higher than that denoted in previous work which states that the potato develops well under an average temperature of 20 °C [16]. During the test period, the amount of rain that fell (117.71 mm or 1177.71 m^3) is much greater than that given by previous authors which specify that depending on the areas, the pluviometric conditions are from 50 to 80 m^3 [16]. The pH of the soil 5.30 is acidic to that of the compost 6.90 are included in the interval recommended for the pH of the potato crop (from 5 to 6.9) [15].

The compost content of assimilable NPK (397.5 ppm, 92.59 ppm 1198.5 ppm) is high compared to that of the test

soil (190 ppm, 6.24 ppm and 583.27 ppm), this justifies the need to add compost to compensate the nutrient deficit observed in the experimental site soil. The quantity of nitrogen determined in compost (397.50 ppm) is three times higher than that described previously where the quantity was equal to 120 ppm [25]. This indicated that the compost was enriched in nitrogen true the supplementation with human urine. In the previous work, it has been demonstrated that nitrogen is one of the most crucial macronutrients for plant growth and biomass development and can be used by plants from major sources as ammonium (NH_4^+) and nitrate (NO_3^-) [26], [27]. The sum of the exchangeable bases "S" of the compost (15.00 meq / 100g) is doubly higher than that of the soil which proves that the compost has more usable element than the soil (7.30 meq / 100g) and are in conformity for the value required in the culture of potato. The cation exchange capacity "CEC" of the compost is much higher than that provided by the soil (32.92 meq / 100g) against (16.22 meq / 100g) for soil this appreciates the quality of compost to conserve nutrients better than the soil.
The analysis of tubers biochemical qualities revealed that the dry matter content of the tubers varies from 18.92 - 20.84% and did not presented any difference statistically between the treatments. Similarly, Taheri et al., 2012 showed that compost and phosphorus fertilizer application had no significant effect potato shoot dry matter [28]. The values found are lower than that described previously for 100 g of fresh matter, the tubers contain 22. 5% [22] and are in the vicinity given by Arvalis, 2018 which says that depending on the variety, the low dry matter content can vary between 18.7 to 20.7% [21]. Previous work has been demonstrated that potato tuber starch concentrations can decreasing with high concentration of N supplied [26]. The tuber dry matter yield per unit of applied nitrogen of potatoes can be regarded as low compared to other crops. This can be attributed to the shallow rooting system of potatoes that leads to a restricted uptake and, thus, use of nitrogen (N) [29]. The moisture content in the tubers ranges from 78.41 to 81.08%. This interval is much higher than the values reported previously where the moisture content of mature potato tubers is 72-75% water for a 100g sample [19]. Regarding the carbohydrate content of the tubers, we obtained values ranging from 14.81 to 16.93%. These results are lower than those obtained in 100 g of material fresh potato corresponding to 19.4% [19] and [17]. The percentage of mineral matter ranged from 0.94% to 1.24% corroborates with the previous idea where the content of the potato tubers rises to 1g in 100g [17]. As for the fat, the results which we obtained vary from 0.105 to 0.18%, these rates are higher than that given by [17] who predicted that the content of 100g of potato tubers amounts to 0.1g. The protein content in the tubers is lower than that given by Decruyenaerev et al. 2005 which states that the potato tuber cooked to a chemical protein composition is equal to 8% [20] and greater than the margin given by Francesco 1983 who found protein levels in 100g ranging from 2.0 to 2.5% [19].

4. Conclusions

From the analysis of our results, we found that the compost supplemented with human urine enriched it in nutritive elements as nitrogen (N) which concomitantly increased the soil chemical properties and nutritional value.
Compost enriched with human urine increased to the level of 30t of compost per hectare, the content of the tubers in carbohydrate and fat without crescendo compared to other doses of compost.
The rate of dry matter, moisture, mineral matter and protein in the tubers marked their qualitative and quantitative presence but without significant difference between the treatments after analysis of variance. In the contrary, the percentage of fat and carbohydrate showed the effect of compost enriched with human urine on the biochemical quality of potatoes.

5. References

[1]. BARRY A. B., SIVAKUMAR MVK. 1997. Agro-climatologie de l'Afrique de l'Ouest: la Guinée. Rapport ICRISAT-ACMAD, France. Direction Nationale de la Météorologie. 85p.
[2]. MATHIEU P., 1991. Manuel d'agronomie tropicale: Appliquée à l'agriculture Haïtienne: 489 pages.
[3]. CHABALIER P. F.1989. Engrais. Paris. France. 14 p.
[4]. FAO 1999. Guide pour une gestion efficace de la nutrition des plantes. Rome, Italie. 20 p.
[5]. www.wikipidia.com 20 mars 2016, 09 :30
[6]. BLAISE L. 2012. Les engrais organiques. Paris. France. 4 p.
[7]. SANGBARAMOU R. 2013. Influence de l'extrait de compost à base d'ordures ménagères sur les maladies cryptogamiques en culture d'aubergine », Master, production Végétale, ISAV/F, 67p.
[8]. MADELEINE I. et PETER S. 2005. La fabrication et l'utilisation du compost, 2ème trimestre. Tom Veldkamp. 6ème édition, Pays-Bas. 72 p.
[9]. ANNA R. GENSCH R. JÖNSSON H., STENSTRÖM T. et DAGERSKOG L. 2011. Conseils pratiques pour une utilisation de l'urine en production agricole. ISBN 978-91-86125-37-0. Stockholm. Suède. 73 p.
[10]. GUILBAUT P. 2011. L'Azote: un élément clé en viticulture et en œnologie. Bordeaux, France. 12 p.

[11]. N'DIAYE M.K., GUINDO D., DICKO M.K. 1994. Gestion de la fertilité des sols rizicoles de l'O.N. IER Niono Mali.
[12].TESSIER M., 2005. Quelques notions de fertilisation. Faranah. Guinée. AEMIP. 7-28 p.
[13] BOSSY D. 2013. Engrais : un atout pour les plantes, un fléau pour le sol. Paris, France. 2 p.
[14]. FAO. 2008. Sélection des plants de pomme de terre. Rome. Italie. 4 p.
[15] .AAN, 2007.*Pommes de terre-culture.* Suisse. 17 p.
[16]. GOSSELIN J. L. et Col. 2011. Le guide de la pomme de terre de consommation. 15 p.
[17]. CTA. 2009. Guide technique de la culture de la pomme de terre en Afrique de l'Ouest. 80 p.
[18]. DELAPLACE P. 2007.Caractérisation physiologique et biochimique du processus de vieillissement du tubercule de pomme de terre (*Solanum tuberosum* L.). 211 p.
[19]. FRANCESCO. 1983. La pomme de terre. Paris. France. 36 p.
[20]. DECRUYENAEREV et *al.* 2005. Valorisation des coproduits de la pomme de terre en production animale. 12 p.
[21]. ARVALIS. 2018. Pomme de terre : résultats d'essais 2018 et préconisation 2019. Paris. France. 62 p.
[22]. MARGOT J.D. 2015. Les solanacées : pomme de terre. Paris. France. 13 p.
[23].TRECHE S. et GUIQIV P. 2001. Influence d'apports moderes d'engrais azote sur la valeur nutritionnelle de tubercules de dioscorea rotundata. Yaoundé. Cameroun. 16 p.
[24]. AOAC 2000. AOAC official methods of analysis. Washington, D.C: Association of Official Analytical Chemists.
[25] El-Sayed S. F., Hassan H. A. and El-Mogy M. M. 2014. Impact of Bio- and Organic Fertilizers on Potato Yield, Quality and Tuber Weight Loss After Harvest. Potato Research. DOI 10.1007/s11540-014-9272-2.
[26] Koch M., Naumann M., Pawelzik E., Gransee A. and Thiel H. 2019. The Importance of Nutrient Management for Potato Production Part I: Plant Nutrition and Yield. Potato Research, 63:97–119.
[27] Silva J.G., França M. G. C, Gomide F. T. F., Magalhaes J. R. 2013. Different nitrogen sources affect biomass partitioning and quality of potato production in a hydroponic system. Am J Potato Res 90:179–185.
[28] Taheri N., Sharif-Abad H.H., Yousefi K. and Roholla-Mousavi S. 2012. Effect of compost and animal manure with phosphorus and zinc fertilizer on yield of seed potatoes. Journal of Soil Science and Plant Nutrition, 12 (4), 705-714.
[29] Iwama K. 2008. Physiology of the potato: new insights into root system and repercussions for crop management. Potato Res 51:333–353.