Turkish Journal of Agriculture - Food Science and Technology, 12(8): 1254-1260, 2024
DOI: https://doi.org/10.24925/turjaf.v12i8.1254-1260.5612

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

Effect of Organic and Industrial Fertilizers on Reducing Sugar, Specific Gravity, Dry Matter and Starch Composition of Fresh Harvested Irish Potato Varieties in Musanze District Rwanda

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ARTICLE INFO

Research Article

Received : 16.10.2022
Accepted : 29.05.2024

Keywords:
Reducing sugars
Potato cultivars
Mineral fertilizers
Genotype
Industrial processing

ABSTRACT

Potatoes for use in industrial processing must have a low reducing sugar concentration. This study investigates the impact of organic and synthetic fertilizers on the composition of Irish potato cultivars' reducing sugar, specific gravity, dry matter, and starch. The research was conducted at Busogo Farm in Rwanda, using randomized complete block designs in seasons 2021 B and 2022 A with rate of ten tones per hectare under the doses of 100%, 50%, and 0% and three hundred kilograms per hector under the dose of 100%, 50% and 0% respectively for farmyard manure and NPK 17.17.17. Results showed significant effects of season and treatment on reducing sugar levels in potatoes. Twihaze and Kirundo varieties recorded high glucose (0.09%), while Gisubizo variety in control, recorded low glucose (0.01%). Additionally, the analysis of variance showed that Irish potato varieties with low to moderate and moderate to high glucose contents, respectively, experienced extremely significant (p 0.001) effects of farmyard manure and NPK on glucose content for the seasons 2021 B and 2022 A. The application of inorganic and organic fertilizers had a significant impact (p 0.05) on dry matter in seasons B and A, according to the analysis of variance. Additionally, the results demonstrated extremely significant ($p<0.01$) differences in specific gravity and starch in both seasons, with Kinigi variety having higher values of dry matter, specific gravity, and starch content in season B and A, respectively, of 24.58, 1.10, and 18.59%. Season 2022 A's high decreasing sugar levels were caused by meteorological conditions brought on by the soil's high moisture content as well as the maturity of the tubers. Due to its low level of reducing sugar, Gikungu, Kirundo, and Kinigi are excellent for chips whereas Twihaze variety is advised for boiling cooking methods.

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Introduction

In Rwanda, the second major crop consumed is a solanaceae, irish potato(Solanum tuberosum) after bananas,(MINAGRI, 2017). The average person in Rwanda consumes about 125 kg of potatoes each year (FAO, 2009). Its annual production is anticipated to be 973 408 tons on 107 590 ha of land, with an average productivity of 9.04tha-1 (FAOSTAT, 2019). İn Rwanda, the low potato production is in proportionally to the factors of absence of improved varieties, pests and diseases, poor soil fertility, inadequate storage, the low market price of tubers upon harvest, and most recently climate change (Muhinyuza et al., 2012).

The tendency of potato to generate acrylamide can be associated with the content of reducing sugars (Sun et al., 2020). The amount of reducing sugars in potatoes can influence their propensity to generate acrylamide (Sun et al., 2020). Because the maillard reaction (between reducing sugars and amino acids) results in darkening, high reducing sugar content in the tuber is undesirable. Low levels of reducing sugars produce pleasant light colors, thus they are chosen. Numerous elements, including genotype, growth-related environmental factors, horticultural techniques, and storage conditions, affect the sugar levels in potato tubers. The tuber's physiological development is also significant, as immature tubers contain more reducing sugars than completely developed tubers (Wiberley-Bradford & Bethke, 2018).

The use of chemical and organic fertilizers is still inefficient for smallholder farmers in terms of rates and timing, according to scholars. Due to the progressive increase in reducing sugars, customers are becoming less interested in processed irish potatoes (Ducreux et al., 2021). Additionally, reducing sugars cause poor ships quality (changes in color, flavor, and nutritional content),

and customers experience neurotoxicity as a result of acrylamide (Passos et al., 2018). This type of potato are rejected by hotels and potato processors has an impact on irish potato export and the tourism sector through tourists' reluctance to consume local potatoes, which would also result in a decrease in visitors and revenue. Farmers can also grow potatoes for domestic consumption rather than exporting them abroad (Merhi et al., 2020).

According to research, potatoes with less than 0.2 grams of fructose and glucose per kilogram of fresh weight are unsuitable for roasting due to insufficient flavor and browning, while roast products with a minimum crispiness made from potatoes with more than 1 grams of reducing sugar per kilogram contain more than 500 grams of acrylamide. It is suggested that potatoes that can be roasted and fried should have a reducing sugar content of less than 1g/kg of fresh weight. Additionally, empirical research has shown that Irish require proper fertilization to have superior nutritional value metrics. According to (ARVALIS Institut du végétal, 2004), potatoes with less than 0.2 grams of fructose and glucose per kilogram of fresh weight are unsuitable for roasting due to insufficient flavor and browning, while roast products with a minimum crispiness made from potatoes with more than 1 grams of reducing sugar per kilogram contain more than 500 grams of acrylamide. It is suggested that potatoes that can be roasted and fried should have a reducing sugar content of less than 1g/kg of fresh weight. Additionally, empirical research has shown that Irish require proper fertilization to have superior nutritional value (Kumar et al., 2004). Furthermore, nothing is known about the nutritional value of the several potato cultivars growing in Rwanda in terms of dry matter, specific gravity, and starch content. This contributes to a disconnect between the needs of consumers and processors in terms of diversity and utilization, and the interests of farmers (Komen et al., 2017). In order to provide the crop with all the nutrients it needs, fertilizer quality and amount are crucial (Hütsch et al., 2018). However, other studies show that fertilization methods (both organic and inorganic) have never been studied to determine their impact on reducing sugar, dry matter, specific gravity and starch composition of Irish potato cultivars. Therefore, the purpose of this study is to assess how organic and industrial fertilizers affect reducing sugars, specific gravity, dry matter, and starch composition of irish potato

Materials and Methods

Potatoes were planted in Busogo sector on the model farm campus of the University of Rwanda in Musanze District, Rwanda's Northern Province. It is located at 1°33'26" south latitude and It may be found at 29°32'39" east latitude and 1°33'26" south latitude. The area is well-known for its Andosol because of the volcanic soil. A Randomized Complete Block Design (RCBD) was employed to set up the experiment, with three replications and twenty treatments reflecting the cultivars that were used as factors. Five cultivars from the Musanze RAB Station were used in the study: Kinigi, Kirundo, Gisubizo, Gikungu, and Twihaze. Blocks were divided by 1 m, and guard rows of 0.5 m, with a spacing of 80 cm between rows and 30 cm within rows, separated adjacent plots. They were raised during the 2021–2022 growing season under traditional cultural conditions (Table 1). Farmyard manure is applied at a rate of 10T/ha, and mineral fertilizer NPK $_{17.17.17}$ is applied at a rate of 300kg/ha, either in combination, alone, or not at all, over a period of two seasons.

Based on the table, the highest temperature of 22.45ºC was recorded in January, while the average season's temperature ranged from 11.13ºC to 22.45ºC in 2022 and 2021 respectively. In 2022 and 2021, respectively, there were 21.86 and 21.73 mm of seasonally average rainfall (Rwanda Meteo, 2021).

Soil Analysis Methods

The soil samples were first air dried, lightly powdered, and screened through a 2mm and 0.5mm sieve after being taken from the field. Then, traditional analytical techniques were used. In a 1:2.5 ratio of soil to water or KCl, pH water and pH KCl were measured using a pH meter. Soil organic carbon was determined using the Walkey-Black oxidation method, total N was determined using the Kjeldahl digestion, distillation, and titration method, available P was determined using the Olsen extraction method, exchangeable bases were determined using the ammonium acetate extraction method, and from extract concentrations, Ca and Mg were measured After that, ECEC was calculated by adding exchangeable bases and acidity as described by Okalebo et al., (2002).

Table 1. Climatic characterization of the trial areas

Season A (2022)					
Period in Month	RH (%)	Precipitation (mm)	Solar radiation (watt/m^2)	Temperature (ºC)	
				Tmax	Tmin
October	81.57	8.52	157.15	20.48	11.13
November	79.99	3.29	175.85	14.52	7.07
December	80.79	4.35	182.49	22.11	12.58
January	76.71	5.7	169.96	22.45	11.87
Season B (2021)					
Period in Month	RH (%)	Precipitation (mm)	Solar radiation (watt/m^2)	Temperature (ºC)	
				Tmax	Tmin
April	-39.68	10.97	4.22	21.63	12.44
May	-99	6.90	-99	21.94	12.24
June	-99	2.57	-99	20.78	12.09
July	-99	1.30	-99	20.26	11.39

Table 2. Characterization of study site

Parameter	Units	Season I	Season II	Parameter	Unit	Season I	Season II
PH(H_20)	-	5.8	5.4	Ca^{2+}	$cmol_c$/kg	5.27	4.71
Available P	ppm	135	180	Mg^{2+}	$Cmol_c$/kg	3.03	2.76
Total N	%	0.32	0.45	sand	%	48.4	46.4
OM	%	7.84	9.46	Clay	%	21.6	21.6
OC	%	4.55	5.49	Silt	%	30	32
CEC	$Cmol_c$/kg	20.67	20.00	Textural class		Loam	Loam
K^+	$Cmol_c$/kg	0.66	0.60	TEA	$Cmol_c$/kg	0.19	0.13

Key: TEA: Total exchangeable acidity, N: Nitrogen, OM: Organic matter, OC: Organic carbon, CEC: Cation exchange capacity

Sampling

Reducing sugars

Healthy potatoes of processing size were chosen for the biochemical investigation. Each plot's center rows were randomly selected for twenty fresh potato tubers, and three blocks were used for each cultivar (three replications). They underwent laboratory food analysis using Martin Lishman's flow procedure after being rinsed in portable water, shredded into small pieces, and subjected to flow. The sample of 20 potato tubers from the test plot to serve as a representative sample was taken. These were washed and dried separately. Each tuber was cut in lengthwise into eight parts. Cut each wedge into 1-cm pieces. All pieces were inserting in the press's basin. Over the bowl, place the press. by tightening the screws potato bits were compressed, the top reservoir is completely filled with juice. With the micro-pipette, removal of 1ml of juice from the reservoir were made and avoiding any impurities. Caution for each fresh sample, fresh tip were used. Juice sample were added to one of the tubes containing the dilution solution (distilled water). Homogenization of the fluid is made by turning the tube upside down. A tiny bit of the solution were filled to the yellow cap. Insert a single paper strip into the monitor.

Caution

Avoid putting your fingers near the reactive (yellow) tip of the strip. Verification code on the strip. Dip the front edge of the yellow tip into the solution in the cap in case the symbol of flashing displayed in screen. The reading is already in progress. The glucose readings in mg/dl were appearing in 5 seconds. Take a note of the quantity (G). For each sample, the exercise were repeated, Repeat 3 times (G1, G2, G3). Result of average measurement (mg/dl) = (G1, G2, G3)/3. These 3 means count of stripes. Utilize the correction table to look up the juice's glucose content in g/l. Percentage Juice glucose content (JCG) was calculated following the formula:

$$\text{JCG (\%)} = \frac{\frac{g}{l}Glucose}{10}$$

$$\text{\% FWG= juice's glucose (\%)} \times \frac{(100-DM*)}{100}$$

FWG: fresh weight glucose

DM*: Dry matter percentage in the tubers

Specific gravity

Around 5 kg of potatoes were cleaned, dried, and weighed in the air and in tap water.

It was determined using the following equation

$$\text{SG} = \frac{a}{1-b}$$

Where a is weight in air and b is weight in water (Turamyenyirijuru, 2020)

Dry matter

Nine processing-sized potatoes were cut and thoroughly combined with dry materials. Following that, 10 g of material were weighed in a crucible with three replications and cooked in a forced-air oven at 80 ^oC for 72 hours, or until a constant weight was achieved dry matter was calculated following this formula:$\frac{\text{Dry weight}}{\text{Fresh weight}} X100$.

Samples weighing around 3 g were placed in a 250 ml volumetric flask. Following the addition of 20 ml of concentrated HCl and 3 glass beads, 200 ml of purified water was added. Until a clear solution was achieved, the solution was refluxed. After adding 50% NaOH and 3 drops of phenolphthalein as an indicator, the solution was neutralized. Whatman no 541 filter paper with 20–25 mm pore size was then used to filter the mixture into a 250 volumetric flask, where it was diluted to the proper strength with distilled water.

Starch, g per 100g = % total sugar X 0.9

Statistical Analysis

The 15th version of Genstat statistical software were used to perform an ANOVA on the acquired data, and the Least Significant Difference test between treatments was used to examine means separation. Additionally, linear relationships between the variables were computed using Pearson correlation analysis.

Results and Discussion

The investigation of variation in the reducing sugar content of various Irish potato varieties revealed impacts of variation where season and treatment affect fresh Irish potato's highly substantial glucose content. The greater glucose in season 2022 A than in season 2021 B is an indication of the effects of seasons on lowering sugar (glucose), which is explained by weather conditions by the higher soil moisture content in season A than B. During the growth of Irish potatoes, moisture content permits both translocation and the flow of plant nutrients. The findings are consistent with those of (Kumar et al., 2004) who found that potato tubers grown during a drought are less water stressed and had lower decreasing sugar levels. Additionally, water challenged tubers showed a substantial correlation between invertase activity and hexose formation, according to (Kumar et al., 2004). Low precipitation during the growth stage led to low reducing sugar content. The findings are consistent with (Belachew, 2016), who found a significant correlation between the

tuber's access to water before harvest and the levels of sucrose found after harvest. Twihaze's high glucose content can be attributed to genetic characteristics, and these characteristics have a significant impact on a mature tuber's early decreasing sugar levels. A heritable characteristic is the propensity to have a high or low concentration of total sugar or a specific sugar.

Effects of Farmyard Manure on Reducing Sugar of Irish Potato Varieties

The results showed that Twihaze and Kirundo varieties treated with 10 tons of farmyard manure recorded high glucose (0.09%) in season B (2021), while Gisubizo variety under control recorded low glucose (0.01%). However, the prior farming methods are to blame for the high glucose levels for the Kirundo and Twihaze cultivars grown in control plots. Twihaze treated with farmyard manure had a high glucose value of 0.65% in season A 2022, while Kinigi planted as a control had a low glucose value of 0.10%. Gikungu, Gisubizo, and Kinigi's recorded glucose values are all categorized as low by (ARVALIS-Institut du végétal's, 2004) standards of interpretation since they are all less than 0.4%, whereas Kirundo and Twihaze's values are categorized as moderate because they range from 4.5 % to 6%. The high glucose content of Twihaze variety is attributes to the fact that the plot was located at the bottom and due to water erosion, some plant nutrients like N, P and organic matter deposited in the plot thereafter affect the level of glucose (Guenet et al., 2014). Additionally, the analysis of variance showed that farmyard manure had a highly significant (p 0.001) impact on Irish potato cultivars with low to moderate glucose content (Table 3).

Effect of Chemical Fertilizers on Reducing Sugar Content of Irish Potato Varieties

Chemical fertilizers, in particular NPK, help reducing sugar by making mineral nitrogen, potassium, and phosphorus readily available. A significant amount of nitrogen also retards crop maturation, resulting in a tuber with a relatively high nitrate content and low dry matter concentration. In order to estimate the amounts of nitrogen, phosphate, and potassium fertilizer to be applied to the potato crop, mineral testing of the soil was done to determine the actual soil fertility prior to planting. However, the prior farming methods are to blame for the high glucose levels for the Kirundo and Twihaze cultivars grown in control plots.

Similar findings were made by (Ababulgu, 2018), who noted a notable impact of the application of blended NPS fertilizer and animal dung.

Results showed that Twihaze variety (0.11%) treated with 300 kg of NPK had the highest glucose content in season B 2021, while Gisubizo variety had the lowest glucose content (0.01%). (Table3). Additionally, Twihaze types that got 300 kg of NPK had a high glucose content of 0.78% in season A, but Kinigi varieties had a low glucose content of 0.10%. The recorded glucose values for Gikungu, Gisubizo, and Kinigi are all categorized as low by (ARVALIS-Institut du végétal, 2004) because they are all less than 0.45%, while Kirundo's glucose content is categorized as moderate and Twihaze's glucose value is categorized as high because it is greater than 0.7%. Additionally, the analysis of variance showed that chemical fertilizers (NPK) had a highly significant (p 0.001) impact on the glucose content of various Irish potato cultivars (Table 4).

Effect of Mixture of FYM Manure and Chemical Fertilizers on Reducing Sugar Content of Irish Potato's Varieties

The combination of farmyard manure and NPK 17 17 17 has an impact on the glucose content of Irish potato types in the Musanze District, as shown in Table 6. Results showed that in season B 2021, Twihaze variety had a high glucose content of 0.15 percent and Gisubizo variety had a low glucose content of 0.01%. Additionally, season A 2022 results showed that Twihaze variety had high glucose content of 0.80% while Kinigi variety had low glucose content of 0.10%. All recorded glucose values for Gikungu, Gisubizo, and Kinigi are categorized as low because they are all less than 0.45%, in accordance with (ARVALIS-Institut du végétal's, 2004 standards of interpretation. Similar to how the glucose concentration found in Kirundo is categorized as moderate since it is between 0.45 and 0.6%, whereas Twihaze is categorized as high because it is greater than 0.7%. Additionally, the analysis of variance showed that farmyard manure and chemical fertilizers (NPK) had a highly significant (p 0.001) impact on the glucose content of several Irish potato cultivars (Table 5).

Table 3. Effect of farmyard manure on glucose content of Irish potato varieties

Treatment description	Glucose in fresh potato (%)	
	Season B 2021	Season A 2022
Gikungu (Control)	0.04^{b}	0.14^{ac}
Gikungu +FYM	0.03^{ab}	0.22^{ab}
Gisubizo (Control)	0.01^{c}	0.15^{ac}
Gisubizo+FYM	0.02^{c}	0.23^{ab}
Kinigi (Control)	0.03^{ab}	0.10^{d}
Kinigi+FYM	0.03^{ab}	0.11^{d}
Kirundo (Control)	0.09^{a}	0.43^{c}
Kirundo+ FYM	0.09^{a}	0.51^{b}
Twihaze (Control)	0.08^{a}	0.58^{b}
Twihaze+FYM	0.09^{a}	0.65^{a}
Lsd	0.05	0.05
Cv	18.4	3.0
P value	<0.001	<0.001

Means with same letter are not significantly different

Table 4. Effect of chemical fertilizers on reducing sugar content of irish potato varieties

Treatment description	Glucose in irish potato (%)	
	Season B 2021	Season A 2022
Gikungu (Control)	0.04[b]	0.14[ab]
Gikungu+ NPK	0.03[ab]	0.23[d]
Gisubizo (Control)	0.01[c]	0.15[ab]
Gisubizo+ NPK	0.05[b]	0.25[d]
Kinigi (Control)	0.03[ab]	0.10[ab]
Kinigi+NPK	0.03[ab]	0.12[ab]
Kirundo (Control)	0.09[a]	0.43[c]
Kirundo +NPK	0.09[a]	0.52[b]
Twihaze (Control)	0.08[a]	0.58[b]
Twihaze +NPK	0.11[a]	0.78[a]
LSD	0.05	0.05
CV	18.4	3.0
P value	<0.001	<0.001

Means with same letter are not significantly different

Table 5. Effect of mixture of FYM manure and chemical fertilizers on reducing sugar content of irish potato's varieties

Treatment description	Glucose's irish potato (%)	
	Season B 2021	Season A 2022
Gikungu (Control)	0.04[c]	0.14[ac]
Gikungu+NPK+FYM	0.02[ab]	0.24[ab]
Gisubizo (Control)	0.01[ab]	0.15ac
Gisubizo+NPK+FYM	0.08[b]	0.29[ab]
Kinigi (Control)	0.0[3c]	0.10[d]
Kinigi+FYM +NPK	0.05[c]	0.15[ac]
Kirundo (Control)	0.09[b]	0.43[c]
Kirundo+FYM+NPK	0.07[b]	0.55[b]
Twihaze (Control)	0.08[b]	0.58[b]
Twihaze+FYM+NPK	0.15[a]	0.80[a]
Lsd	0.05	0.05
Cv	18.4	3.0
P value	<0.001	<0.001

Means with same letter are not significantly different

By supplying additional amino acids and so increasing the starch and sugar levels in the tubers, the application of both chemical and organic substances has a detrimental influence on the quality of the tubers. In addition to the use of mineral fertilizers on potatoes, the value of bovine manure is now understood due to the periodic gradual release of plant nutrients and their long-term impacts on the chemical characteristics of soil. The results support (Sun et al., 2018)'s findings that fertilizations increase reducing sugar content, which has an impact on the quality and nutritional value of derived products (chips) by causing Acrylamide to develop. The increased levels of free amino acids brought on by higher nitrogen fertilization have been connected to this departure from the predicted level of reducing sugar (glucose), although not all free amino acids are affected to the same extent. Studies on the effect of nitrogen on sugar accumulation during storage demonstrated that high nitrogen fertilizer rates decreased the amount of glucose and fructose in the crop at harvest, but that sugar accumulation increased and sucrose accumulation decreased throughout storage when compared to no or low fertilization (Kolbe et al., 1995). According to (Mohammed et al., 2018), varying rates of inorganic fertilizer (N and P) combined with different amounts of farmyard manure (FYM) resulted in noticeably distinct reductions in sugar and tuber dry matter yield.

Effect of Farmyard Manure and NPK 17 17 17 on Specific Gravity, Dry Matter and Starch Of Irish Potato

Results showed that dry matter, specific gravity, and starch content are affected by maturity and season, with the highest values reported in season 2022 B, where harvesting was carried out 90 days after planting. Environmental factors like weather and genetic producer of types are responsible for the differences.

The use of inorganic and organic fertilizers had a significant impact (p 0.05) on dry matter in seasons A and B, according to the analysis of variance. Additionally, data indicated that specific gravity and starch in both seasons were extremely significant (p 0.001), and that the Kinigi variety had higher values of dry matter, specific gravity, and starch in both seasons (A and B) of 24.58%, 1.10, and 18.59%, respectively. Overall findings showed that Twihaze cultivar had low dry matter, specific gravity, and starch contents of 17.63%, 1.06, and 12.12%, respectively. Because it impacts chip crispiness and oil uptake during processing, Kinigi's high specific gravity justifies its suitability for chips as well as the fact that tubers with a high specific gravity are chosen for dehydrated and fried items. This changes product production (Kumar et al., 2004). A product's flavor is enhanced by having a high specific gravity while using less energy in production. Potatoes with a low specific gravity, however, have been shown to be better for canning since they are less likely to disintegrate throughout the process (Ndungutse et al., 2019).

Table 6. Effect of farmyard manure and NPK $_{17\ 17\ 17}$ on Specific gravity, Dry matter and Starch of irish potato

Treatment description	Season B 2021 for 120 DAP			Season A 2022 for 90 DAP		
	DM (%)	SP_Gravity	Starch (%)	DM (%)	SP_Gravity	Starch %)
T0 +Gikungu	20.43^{c}	1.08^{c}	16.04^{b}	20.96^{ab}	1.08c	15.80^{b}
T0 +Gisubizo	21.70^{b}	1.08^{c}	15.79^{c}	19.93^{ab}	1.07^{ab}	14.04^{c}
T0 +Kinigi	18.63^{ac}	1.07^{ab}	12.77^{d}	19.22^{ac}	1.07^{ab}	13.34^{d}
T0 +Kirundo	23.80^{b}	1.08^{c}	16.31^{b}	22.08^{b}	1.08^{c}	15.39^{b}
T0 +Twihaze	18.78^{ac}	1.07^{ab}	12.94^{d}	20.09^{ab}	1.07^{ab}	14.21^{c}
FYM +Gikungu	18.57^{ac}	1.07^{ab}	12.59^{d}	20.26^{ab}	1.08^{c}	14.35^{c}
FYM +Gisubizo	20.50^{c}	1.08^{c}	14.67^{ab}	19.62^{ac}	1.07^{ab}	13.75^{c}
FYM +Kinigi	21.58^{b}	1.08^{c}	15.49^{c}	21.60^{c}	1.08^{c}	15.58^{b}
FYM+Kirundo	18.55^{ac}	1.07^{ab}	11.07^{e}	21.43^{c}	1.08^{c}	15.49^{b}
FYM +Twihaze	20.95^{c}	1.08^{c}	15.04^{c}	21.57^{c}	1.08^{c}	15.04^{b}
NPK +Gikungu	19.30^{ab}	1.07^{ab}	13.26^{d}	20.23^{ab}	1.08^{c}	14.24^{c}
NPK +Gisubizo	20.78^{c}	1.08^{c}	14.90^{ab}	19.50^{ab}	1.07^{ab}	13.63^{c}
NPK +Kinigi	24.58^{a}	1.10^{a}	18.59^{a}	24.58^{a}	1.10^{a}	18.59^{a}
NPK +Kirundo	20.43^{c}	1.08^{c}	14.58^{ab}	20.43^{ab}	1.08^{c}	14.58^{c}
NPK +Twihaze	18.13^{ac}	1.07^{ab}	12.29^{ac}	19.48^{ac}	1.07^{ab}	13.60^{c}
NPK+FYM +Gikungu	21.10^{b}	1.08^{c}	14.82^{ab}	21.10^{c}	1.08^{c}	14.82^{c}
NPK+FYM +Gisubizo	24.17^{a}	1.09^{b}	18.16^{a}	24.17^{a}	1.09^{b}	12.72^{ab}
NPK+FYM +Kinigi	21.55^{b}	1.08^{c}	15.63^{c}	21.26^{c}	1.08^{c}	15.34^{b}
NPK+FYM +Kirundo	18.80^{ac}	1.07^{ab}	14.06^{ab}	19.37^{ac}	1.07^{ab}	14.55^{c}
NPK+FYM +Twihaze	17.63^{d}	1.06^{ac}	10.18^{f}	18.82^{d}	1.07^{ab}	12.12^{e}
Lsd	4	0.014	2.72	3.5	0.014	3
CV	1.1	0.1	1.6	1.0	0.1	1.4
P value	0.014	<0.001	<0.001	0.024	0.002	<0.001

Means with the same letter are not significantly different

These findings are in line with those from (Kumar et al., 2004) and (Abebe et al., 2013), which found that 25 varieties were produced, with results ranging from 1.050 to 1.119 for 17 types and two cropping seasons. According to (Soboka et al., 2018) , six types of potatoes cultivated in two distinct locales have specific gravities ranging from 1.086 to 1.107.

The outcomes, however, outperformed those of (Ekin, 2011), who recorded specific gravities ranging from 1.065 to 1.077 on eight kinds.

According to one study, both genetic and environmental variables can affect specific gravity (Abebe et al., 2013). According to (Fitzpatrick et al., 1964), potatoes fall into one of three categories: high if the specific gravity is above 1.086, intermediate if it is between 1.077 and 1.086, and low if it is less than 1.07

Conclusion

The change in reducing sugar is variable from season to season due to weather conditions such as moisture content as potato tubers grown during a drought are less water stressed and had lower reducing sugar levels. Tuber maturity, variety of potato are also the cause of variation in reducing sugar as immature potato has high reducing sugar and Kinigi cultivar has lower reducing sugar. The differences in dry matter, specific gravity, and starch content are also affected by maturity, season and genetic mert of the potato cultivars.

Acknowledgement

Authors would like to express the gratitude to the international Anatolian Agriculture, Food, Environment and Biology congress (TARGID 2022) and the Turkish Science and Technology Publishing (TURSTEP) in general for not only allowing to present this research but also for their annual organization of congress, free of charges paper publication.

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