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Effect of Different Rates of Potassium and Nitrogen on the Growth and Yield of Potato (*Solanum tuberosum* L.) in Sulaimani Governorate

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Abstract: Field experiment A trial was established at the Directorate of Agricultural Research/Sulaimani-Kurdistan region, Iraq during 2014 and 2015 winter seasons. The research was carried out based on the different concentrations of potassium (100, 200 and 400 kg ha⁻¹ K₂O) and nitrogen (40, 80 and 120 kg ha⁻¹ N) with fixed dose of phosphorus 80 kg ha⁻¹ P₂O₅ as to evaluate growth characteristics and yield attributes of potato plant (*Solanum tuberosum* L.). The experiment was arranged in a factorial randomized complete block design (RCBD) with three replicates and included six potassium and nitrogen combination treatments. No significant effect of potassium was observed between two years on plant height, starch and protein content, tuber weight, marketable yield and unmarketable yield. Potassium application had a significant effect on no. branches/plant, tuber number plant⁻¹ and % dry matter in both years. In general, the results suggested that a subset of treatment mixes was associated with improved outcomes over time.

Keywords: Levels, Growth, Potassium and Nitrogen, Yield, Potatoes

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1. Introduction

Potato (*Solanum tuberosum* L.) was chosen for this study because of its significant economic role in the Kurdistan region. On a world scale, it is one of the most important food crops worldwide; cultivation is increasing (particularly in developing countries and the tropics) because of its versatility and nutrition quality [1]. It is the third most consumed crop, human-wise [2]. Potatoes are the most important agricultural crop in Iraq and a staple food for its people. The country's average potato yield is about 15.84 ton/ha [3]. Potatoes are known for their energy content and nutritional value. They are composed of approximately 77% water, 16.3% starch, 0.9% sugar, 4.4% protein, 0.9% minerals, 0.59% dietary fiber, and 0.14% crude fat. In addition to their macronutrient profile, potatoes provide a substantial amount of vitamins A, B, and C, as well as key minerals such as potassium (K), magnesium (Mg), and iron (Fe) [4], [5]. Fertilization plays a crucial role in potato cultivation, serving as a key component in achieving optimal yields, enhancing crop performance, and quality of tubers. The potato is a plant with high nutrient demands because of forming abundant vegetative mass and a high quantity of tubers at the unit area. It is a great consumer of nitrogen, phosphorus, potassium, magnesium and calcium,

as well as micro elements [6]. Also, reported showed that potato being a high nutrient mining crop it needs higher amount of N, P and K for its economic tuber production. Fertilization, especially of potassium, is well known to be a critical factor for potato growth and yield [7]. Many research works have found more tubers can be produced by elevating potassium (K) [8], either due to producing big size of tuber or increasing the amount of tubers per plant, or both [9]. In addition to increasing the yield, potassium also improves the quality of crop [10]. The latter is well recognized to play a critical role in several vital processes including photosynthesis, enzyme activation and protein, carbohydrate and fat syntheses. It also involves in translocation of photosynthetic and increases the plant tolerance against pests and diseases [11], [12].

Potassium is a primary nutrient for the potato plant, and it is necessary for proper enzyme activities and osmotic regulation (Fageria et al., 1998) required to maintain cell structure and turgor [13]. Potash is an essential nutrient for all plants and plays a significant role in potato yield and quality of both the tuber crop as well as plant health vigor [14]. It plays a key role in water regulation within the plant; without adequate potassium, water use efficiency declines [15]. Sufficient potassium levels also help plants cope with drought stress by maintaining cell turgidity [16]. Additionally, potassium is essential for transporting sugars produced during photosynthesis from the leaves to the tubers, where they are converted into starch [17]. Furthermore, K increases absorption of water and root permeation but also functions like a cell membrane control system, in addition to stimulating in rising water efficiency [18]. N is tried to apply more commonly and also in greater quantities than any fertilizers through potato production [19]. This shows that nitrogen is an important component for crop production, as well as the potatoes production has a rising requirement for it [20]. Nitrogen deficiency is the greatest common mineral nutrient deficiency in agricultural soils. As a result, farms in developed countries tend to apply relatively high amounts of nitrogen fertilizer. However, inefficiencies within the soil–plant system often limit nitrogen uptake, leaving excess nitrogen in the soil. This not only represents a waste of valuable resources but also raises environmental concerns [21]. Freshly developed potato varieties need evaluation to improve N management and enhance tuber yield and its components [22]. Hence, the objective was to discriminate the effects of different level rates of potassium sulfate (K_2SO_4) and nitrogen on vegetative growth, tuber quality, and total potato yield as affected by growing potatoes in sandy clay soil [under dry environment].

2. Materials and Methods

A 2-year field experiment (2014-2015) was carried out at the Directorate of Agricultural Research, Kanipanka Station in Sulaimani governorate, Kurdistan Region of Iraq. The site is located at the following geographic coordinates: 30° 32' 35" N and 45° 21' 00" E. Trials were conducted in the winter cropping season of 2014 and 2015 to assess various potassium and nitrogen levels on growth and yield components of potato (cv Provento). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Three forms of nitrogen, potassium, and phosphorus were applied in three different rates, like 500:0:0, 450:25:30, and 400:50:60, separately in all treatments. One-half of the nitrogen rate and full rates of potassium (K_2O) and phosphorus (P_2O_5) were applied at sowing. The residual nitrogen was applied after germination. The experimental design included 36 plots with dimensions of 3 × 2.4 m (7.2 m²). The spacing between plots and blocks was maintained at 1 meter and 2 meters, respectively. The treatments are designated as:

- T₁= 0 kg ha⁻¹K₂O, 40 kg ha⁻¹N
- T₂= 100 kg ha⁻¹K₂O, 40 kg ha⁻¹N
- T₃= 200 kg ha⁻¹K₂O, 40 kg ha⁻¹N
- T₄= 400 kg ha⁻¹K₂O, 40 kg ha⁻¹N
- T₅= 0 kg ha⁻¹K₂O, 80 kg ha⁻¹N

T₆= 100 kg ha⁻¹K₂O, 80 kg ha⁻¹N

T₇= 200 kg ha⁻¹K₂O, 80 kg ha⁻¹ N

T₈= 400 kg ha⁻¹K₂O, 80 kg ha⁻¹ N

T₉= 0 kg ha⁻¹K₂O, 120 kg ha⁻¹N

T₁₀=100 kg ha⁻¹K₂O, 120 kg ha⁻¹N

T₁₁= 200 kg ha⁻¹K₂O, 120 kg ha⁻¹N

T₁₂= 400 kg ha⁻¹K₂O, 120 kg ha⁻¹N

80 kg ha⁻¹ P₂O₅ (pure) applied to all treatments.

Some physical and chemical properties of soil in Kanipanka

Prior to sowing and fertilizer application, soil samples were taken from a depth of 0–30 cm to assess key chemical and physical properties. The soil samples were air-dried, crushed, and sieved to pass through a 2 mm sieve and stored in plastic bottles before soil analysis. Its particle sizes were determined using the hydrometer method [22]. Soil pH and electrical conductivity (EC) were measured electrometrically using a digital pH meter (WTW) and the EC model developed by Herman Paulsen, following the methodology outlined [23], respectively. Soil organic carbon was determined using a modified (Walkley and Black) method based on organic matter oxidation by potassium [24]. The Total Calcium Carbonate Equivalent as determined by the titration method [25]. interchangeable. The base cations were extracted and used in a neutral PH = 7 solution 1N NH₄OAc, to extract K⁺, Ca²⁺, NaCl, HCO₃⁻, CO₃²⁻, and Mg²⁺, and Na⁺ and K⁺ have been calculated using a flame photometer [26]. The available phosphorus was determined utilizing Olsen's method with a Spectrophotometer [27]. Total nitrogen was determined using the Kjeldahl method, and the nitrogen in the soil was estimated [28].

Table 1. Some physical and chemical properties of the soil of Kanipanka used in the field Experimental location.

Property	Value
Location	Kanipanka
Physical properties	
Sand (%)	4.55
Silt (%)	54.01
Clay (%)	41.19
Texture class	Silty clay
Chemical properties	
CaCO ₃ (%)	7.14
P ₂ O ₅ (ppm)	0.18
OM (g kg ⁻¹)	0.26
pH	7.45
N (Mg kg ⁻¹)	22
ECe (ds m ⁻¹)	19.688
Soluble ions (meq L⁻¹)	
CO ₃ ²⁻	0.088
Na ⁺	0.142
Ca ²⁺	1.40
Mg ²⁺	2.98
Cl ⁻	0.40
HCO ₃ ⁻	0.00
K ⁺	2.90

A. Measurement Parameter

The measurement parameters comprise most of the yield components of potato's five plants were selected at random from each plot for recording data plant height (cm),

number of tiller per plant-1, dry matter, Starch, Protein, yield per plant/kg, Yield per plant kg/d, yield marketable, Yield unmarketable ,number tuber per plant, Weight tuber kg .

B. Statistical Analysis

After that collected data, the statistical analyses of variance of (Anova) were carried out using is Software (SAS) version 9.2 and treatment effects were significant, mean compared of were made Using the least significant the difference (Duncan's multiple range test) at the 5% level of probability during the study of the experiment observations were recorded as mean values of the data [29].

C. Weed Management

Weed control was carried out before potato emergence to minimize early competition between weeds and crop plants. The pre-emergence herbicide Metribuzin (Sencor 70 WP) was applied uniformly at a rate of 0.75 kg active ingredient ha⁻¹ immediately after planting, followed by light irrigation to activate the herbicide in the upper soil layer. After crop emergence, weeds were manually removed twice during the growing season, the first at three weeks after emergence and the second before the flowering stage. This procedure followed a similar approach to that reported by Sharif et al. (2024) in their study on sorghum (*Sorghum bicolor* L.), where 2,4-D herbicide was applied pre-emergence at sowing to control weed infestation [30].

3. Results and Discussion

The analysis of variance revealed significant differences among years and treatments for some of the studied traits, as shown in Table (2). The effect of years was significant at the 0.01 probability level for tuber dry matter percentage, indicating a strong influence of environmental conditions prevailing in each growing season. A significant effect at the 0.05 level was also observed for the number of branches per plant, whereas no significant differences were detected for the remaining traits, suggesting relative stability across seasons. The effect of treatments was significant at the 0.01 level for tuber dry matter percentage and average tuber weight, and at the 0.05 level for plant height and number of tubers per plant, while no significant differences were found for the other traits, reflecting a varied response of the studied traits to fertilizer levels. The interaction between years and treatments was not significant for any of the traits, indicating that the response of treatments was consistent across both growing seasons.

Table 2. Analysis of variance (ANOVA) for the traits evaluated in this study.

Source	df	Plant height (cm)	Number of branches	Number of tuber	Dry matter tuber %	Mean weight tuber	Protein %
Rep	2	17.04 ^{NS}	2.44 ^{NS}	5.17 ^{NS}	3.20517 ^{NS}	975.96 ^{NS}	1.42 ^{NS}
Years	1	20.84 ^{NS}	7.35*	10.10*	17.32**	250.71 ^{NS}	0.09 ^{NS}
treatment	11	157.67*	2.38 ^{NS}	23.43 ^{NS}	46.84 ^{NS}	2707.62*	6.10 ^{NS}
years*treatment	11	142.30 ^{NS}	6.82 ^{NS}	13.81 ^{NS}	61.49 ^{NS}	2192.26 ^{NS}	0.75 ^{NS}
Error	46	286.87	14.89	119.59	164.46	5304.25	22.19
Source	df	Starch %	Yield per plant/g	Total yield marketable ton/ha ⁻¹	yield marketable ton-ha ⁻¹	Unmarketable ton-ha ⁻¹	
Rep	2	3.62 ^{NS}	0.12 ^{NS}	15.38 ^{NS}	0.09 ^{NS}	750.53 ^{NS}	
years	1	4.50 ^{NS}	0.006 ^{NS}	0.66 ^{NS}	0.001 ^{NS}	560.18 ^{NS}	
Treatment	11	35.92 ^{NS}	0.43 ^{NS}	53.19 ^{NS}	0.47 ^{NS}	409.08 ^{NS}	
Years*treatment	11	50.92 ^{NS}	0.13 ^{NS}	15.62 ^{NS}	0.11 ^{NS}	1046.02 ^{NS}	
Error	46	139.12	1.16	140.48	0.10	9274.16	

DF: degree of freedom, NS: non-significant difference, *: Significant difference at $p < 0.05$, **: Significant difference at $p < 0.01$

A. Plant height (cm).

According to the mean comparison data across years (Tables 2 and 3), varying potassium and nitrogen application rates had no statistically significant effect on plant height. The highest recorded plant height (52.85 cm) was observed in the first year in plots treated with 0 kg ha⁻¹ K₂O and 120 kg ha⁻¹ nitrogen. Whereas, the lowest plant height of (47.63 cm) was recorded at the level of 0 k₂O with 80 N kg ha⁻¹ fertilizer applications during the first years. The tallest plants (53.66 cm) were achieved with the 2nd year application of 400 k₂O with 120 N kg ha⁻¹. In the second year, crop plots that were treated with 0 K₂O + 80 N kg ha⁻¹ fertilizers showed a significant effect to decrease plant height (47.33cm), [31], [32].

B. Number of Branches Plant-.1

The variance analysis showed that the application rate of N and K did not have a significant effect on the number of branches per plant during each year (Tables 2 and 3). During the first year, the maximum number of branches per plant (4.50) was noted in plants fertilized with 200 kg ha⁻¹ K₂O and 40 kg ha⁻¹ nitrogen while minimum branches per plant (3.33) were found in plots received 0kg/ha K₂O and +contrast _norms_29KgHa-1 N consumed by strawberry. In the second year, the highest number of branches (4.00) were observed in plots applied with 100 kg ha⁻¹ K₂O and 120 kg ha⁻¹ N while the least number of branches (2.60) was obtained in treatments with 0 kg ha⁻¹ K₂O and 40 kg ha⁻¹ nitrogen [33].

Table 3. Effect of different levels of potassium and nitrogen on plant height and number of branches per plant in potato (*Solanum tuberosum* L.) at Kanipanka.

Treatment	Plant height (cm)		Number of tillers	
	2014	2015	2014	2015
T1	50.9 ^{abc}	49.20 ^{d-h}	3.33 ^{cde}	3.66 ^{bcd}
T2	50.3 ^{abc}	49.66 ^{b-h}	3.66 ^{bcd}	3.33 ^{cde}
T3	49.65 ^{abc}	48.33 ^{efgh}	4.50 ^a	3d ^e
T4	50.35 ^{abcd}	53.66 ^{ab}	3.66 ^{bcd}	2.66 ^e
T5	47.63 ^d	47.33 ^{gh}	4 ^{abc}	3.33 ^{cde}
T6	48.58 ^{cd}	49.43 ^{c-h}	4 ^{abc}	3.3 ^{cde}
T7	52.13 ^{ab}	52.16 ^{a-e}	4.33 ^{ab}	3d ^e
T8	51.88 ^{ab}	51.4 ^{a-h}	3.66 ^{bcd}	3d ^e
T9	52.85 ^a	51.21 ^{a-h}	3.66 ^{bcd}	4 ^{abc}
T10	51.76 ^{ab}	50 ^{b-h}	4 ^{abc}	3d ^e
T11	51.87 ^{ab}	50.87 ^{a-h}	3.33 ^{cde}	3.3 ^{cde}
T12	51.35 ^{abc}	53.16 ^{abcd}	4 ^{abc}	3.3 ^{cde}

Different letters within a column indicate statistically significant differences at $p < 0.05$.

C. Number of tubers per Plant.

Mean comparisons presented in Tables 2 and 3 indicated that varying potassium and nitrogen levels had no statistically significant effect on the number of tubers per plant across both years. In the first year, the highest number of tubers per plant (10.058) was recorded in plots treated with 400 kg ha⁻¹ K₂O and 80 kg ha⁻¹ nitrogen, while the lowest (7.58) was observed in plots receiving 400 kg ha⁻¹ K₂O and 40 kg ha⁻¹ nitrogen. In the second year, the maximum tuber count (11.416) was found in plots with 0 kg ha⁻¹ K₂O and 120 kg ha⁻¹ nitrogen, whereas the minimum (8.833) occurred under the 0 kg ha⁻¹ K₂O and 40 kg ha⁻¹ nitrogen treatment.

The higher average number of tubers per plant is likely attributed to increased potassium and nitrogen fertilization, as potassium enhances root development, which in turn promotes tuber formation. These results align with previous studies involving nitrogen and potassium application, including findings by Yadav et al. (2014), who

reported a significant increase in tuber number with elevated levels of potassium and nitrogen [34].

D. Tuber dry matter content (%)

Tuber dry matter content increased dramatically when different levels potassium and nitrogen application increased. Table 2 and 3, the highest dry matter content (23.98%) was achieved of 400 K₂O and 80 N kg ha⁻¹, while the lowest dry matter content (21.13%) was achieved combined of zero K₂O and 80 N kg ha⁻¹ treatments in the first year. However, the highest dry matter content (26.3%) was observed in plots that received for the combination of 400 K₂O and 80 N kg ha⁻¹, in the second year. While the lowest dry matter content (20.13%) was achieved with zero K₂O and 40 kg ha⁻¹ during in the second year. Potassium plays an important role in water and dissolved intake, which can alter growth type as well as tuber dry matter. When given in large quantities, potassium tends to reduce dry matter content, with the effect being more pronounced in light soils than in soils having. [35].

Table 4. The Effect of varying Potassium and Nitrogen levels on the number of tubers per plant and tuber dry matter of potato (*Solanum tuberosum* L.) at Kanipanka location.

Treatment	Number of tubers per plant		Dry matter tuber	
	2014	2015	2014	2015
T1	9.250 ^{abc}	9.990 ^{abc}	21.13 ^b	20.85 ^{bc}
T2	9.416 ^{abc}	9.333 ^{abc}	21.67 ^b	22.5 ^b
T3	9.750 ^{abc}	9.083 ^{abc}	21.78 ^{ab}	21.67 ^{bc}
T4	7.583 ^c	9.583 ^{abc}	22.45 ^{ab}	22.73 ^b
T5	9.416 ^{abc}	9.083 ^{abc}	21.55 ^b	22.5 ^b
T6	9.250 ^{abc}	10 ^{abc}	22.28 ^{ab}	23.17 ^{ab}
T7	8.750 ^{abc}	8.833 ^{abc}	22.79 ^b	22.6 ^b
T8	10.083 ^{abc}	11.166 ^{ab}	23.98 ^a	26.23 ^a
T9	9.083 ^{abc}	11.416 ^a	22.88 ^{ab}	23.20 ^{ab}
T10	8.583 ^{bc}	9.416 ^{abc}	22.53 ^{ab}	22.16 ^{bc}
T11	9.225 ^{abc}	10.75 ^{ab}	21.22 ^b	23.3 ^{ab}
T12	9.583 ^{abc}	10.25 ^{abc}	23.30 ^{ab}	23.3 ^{ab}

E. Mean weight Tuber.

Variance analysis showed that potassium and nitrogen application rates had no significant effect on tuber weight per plant across both years (Tables 2 and 3). In the first year, the highest tuber weight per plant (87.26 kg) was recorded in plots treated with 100 kg ha⁻¹ K₂O and 120 kg ha⁻¹ nitrogen, while the lowest (65.59 kg) was observed in the control plots. In the second year, the maximum tuber weight (87.51 kg) was obtained from plots receiving 400 kg ha⁻¹ K₂O and 40 kg ha⁻¹ nitrogen, whereas the minimum (68.17 kg) was recorded in plots treated with 200 kg ha⁻¹ K₂O and 120 kg ha⁻¹ nitrogen [36].

F. Protein Content. (%)

The application of various potassium and nitrogen levels had no significant effect on the protein content in the potatoes compared to the control during each of the years. Based on the analysis of variance (Tables 2 and 3), the highest crude protein content (8.90%) was recorded in the first year from plots treated with 100 kg ha⁻¹ K₂O and 120 kg ha⁻¹ nitrogen. While, the least protein content (8.01%) was recorded at the 400 K₂O and 80 N kg ha⁻¹ plots from the first year. The highest recorded protein content, reaching 8.98%, was observed during the second year in plots treated with 100 kg ha⁻¹ of potassium oxide (K₂O) and 40 kg ha⁻¹ of nitrogen (N). Notwithstanding this, the least protein content (7.91%) were observed from level of 200 K₂O and 40 N kg ha⁻¹, in the Protein Content (8.93%) based on two years of data at 100 K₂O and 40 N kg ha⁻¹, who demonstrated that the influence of different doses of Potassium fertilizers used on protein content (%) was non-significant,

backed up this result. Sindhu, 1974 also seems varieties to agree that the interaction of Potassium fertilizer [37].

Table 5. The Effect of varying Potassium and Nitrogen levels on mean weight of one tuber and tuber protein percentage of potato (*Solanum tuberosum* L.) at Kanipanka location.

Treatment	Mean weight one of tuber		Protein%	
	2014	2015	2014	2015
T1	65.59 g	69.60 ^{efg}	8.18 ^{abc}	8.10 ^a
T2	66.24 g	76.58 ^{b-g}	8.89 ^{ab}	8.98 ^a
T3	75.71 ^{c-g}	86.23 ^{a-e}	8.07 ^{bc}	7.91 ^{ab}
T4	80.97 ^{abc}	87.51 ^{a-f}	8.28 ^{abc}	8.19 ^a
T5	72.52 ^{bcd}	70.92 ^{defg}	8.28 ^{abc}	8.32 ^a
T6	71.89 ^{cd}	71.20 ^{defg}	8.53 ^{abc}	8.30 ^a
T7	78.81 ^{abcd}	75.80 ^{c-g}	8.77 ^{abc}	8.96 ^a
T8	74.77 ^{abcd}	74.60 ^{c-g}	8.01 ^c	7.95 ^a
T9	85.07 ^{ab}	76.18 ^{b-g}	8.42 ^{abc}	8.40 ^a
T10	84.78 ^{ab}	81.56 ^{a-g}	8.90 ^a	8.89 ^a
T11	79.51 ^{abcd}	68.17 ^{fg}	8.25 ^{abc}	8.24 ^a
T12	87.26 ^a	77.216 ^{b-g}	8.50 ^{abc}	8.44 ^a

G. Starch Percentage. (%)

Over the two-year study period, variance analysis revealed that potassium and nitrogen application rates had no significant impact on the number of tubers per plant (Tables 2 and 3). The highest starch content in potatoes (16.588%) was recorded in the first year from plots receiving 120 kg ha⁻¹ of nitrogen without any potassium supplementation. In contrast, the lowest starch level (13.90%) was observed in the control plots during the same year. Interestingly, the peak starch concentration (16.825%) was measured in the second year in plots treated with 200 kg ha⁻¹ of K₂O and 120 kg ha⁻¹ of N. Meanwhile, the lowest starch content in the second year (14.107%) was found in plots with 40 kg ha⁻¹ of nitrogen and no potassium application [38].

H. Weight Tuber per plant (kg)

Statistical comparison over two years revealed that the different potassium and nitrogen doses did not significantly affect tuber yield per plant (Tables 2 and 6). The maximum tuber weight (0.903 kg per plant) was obtained in first year from plots receiving 120kg N ha⁻¹ with zero K application. The lowest tuber weight (0.6361 kg) was, however, recorded during the same year from T4 treatment level comprising 400 kg ha⁻¹ of K₂O and 40 kg ha⁻¹ of N. In two years pooled data maximum tuber weight (0.834 kg) were obtained by application of 400 kg ha⁻¹ of K₂O with 120 kg ha⁻¹ of N while its minimum value (0.669 kg) was recoded from application plots receiving 80 kg ha⁻¹ of N without potassium [31], [32].

Table 6. The Effect of varying Potassium and Nitrogen levels on tuber starch percentage and tuber weight per plant (kg) of potato (*Solanum tuberosum* L.) at Kanipanka location.

Treatment	Starch%		Weight Tuber per plant(kg)	
	2014	2015	2014	2015
T1	15.092 ^{ab}	14.107 ^{abc}	0.647 ^{bc}	0.669 ^{bc}
T2	15.468 ^{ab}	16.053 ^{ab}	0.661 ^{bc}	0.740 ^{abc}
T3	15.543 ^{ab}	15.316 ^{ab}	0.801 ^{abc}	0.760 ^{abc}
T4	16.107 ^a	16.261 ^{ab}	0.636 ^c	0.700 ^{bc}
T5	15.369 ^{ab}	16.0531 ^{ab}	0.723 ^{abc}	0.727 ^{abc}
T6	13.90 ^b	15.818 ^{ab}	0.679 ^{bc}	0.704 ^{bc}
T7	16.245 ^a	15.904 ^{ab}	0.710 ^{bc}	0.656 ^{bc}

T8	16.102 ^a	16.617 ^a	0.825 ^{abc}	0.876 ^{abc}
T9	16.588 ^a	16.609 ^a	0.891 ^{ab}	0.877 ^{abc}
T10	16.181 ^a	15.750 ^{ab}	0.794 ^{abc}	0.802 ^{abc}
T11	15.167 ^{ab}	16.825 ^a	0.760 ^{abc}	0.666 ^{bc}
T12	16.227 ^a	15.607 ^{ab}	0.903 ^a	0.834 ^{abc}

I. Total marketable yield. Ton ha-1

Results in Table 2 and 3 revealed that potato tuber yield increased with increasing potassium and nitrogen levels had significant ($p < 0.05$) differences to all varieties. The highest tuber yield, reaching 42.725 tons ha⁻¹, was obtained in the first year from plots treated with 400 kg ha⁻¹ of K₂O and 120 kg ha⁻¹ of nitrogen. In contrast, the lowest yield during that year (27.96 tons ha⁻¹) was recorded in untreated plots. In the second year, the maximum yield (38.895 tons ha⁻¹) was achieved in plots receiving 120 kg ha⁻¹ of nitrogen without potassium application. In spite of this, the least of tuber yield (28.916-ton ha-1) were observed from level of 200 K₂O with 80 N kg ha-1, in the second year. Rahmawati et al. (2021) reported a consistent and significant rise in total tuber yield associated with increasing potassium application levels [39].

J. marketable tuber yield (tonha-1).

The application of various potassium and nitrogen levels had no significant marketable tuber yield effect on the potatoes compared to the control during each of the years. As indicated by the analysis of variance presented in Tables 2 and 3, the highest marketable tuber yields (40.788-ton ha-1) while the 400 kg ha-1 K₂O and 120 kg N ha-1 plot obtained a minimum yield marketable tuber (26.504-ton ha-1) application during the first year. In the second year, the highest marketable tuber yield (37.728 tons ha⁻¹) was achieved in plots treated with 400 kg ha⁻¹ of K₂O and 80 kg ha⁻¹ of nitrogen. In contrast, the lowest yield (25.927 tons ha⁻¹) was recorded from plots receiving no potassium and only 40 kg ha⁻¹ of nitrogen [40].

Table 7. The Effect of varying Potassium and Nitrogen levels on total yield and marketable yield (ton ha⁻¹) of potato (*Solanum tuberosum* L.) at Kanipanka location.

Treatment	Total potato yield (ton -ha ⁻¹)		Yield marketable (ton- ha ⁻¹)	
	2014	2015	2014	2015
T1	28.496 ^{bc}	29.344 ^{bc}	26.664 ^a	25.972 ^c
T2	29.096 ^{bc}	32.6 ^{abc}	27.107 ^{bc}	32.6 ^{abc}
T3	35.256 ^{abc}	33.584 ^{abc}	32.34 ^{abc}	32.908 ^{abc}
T4	27.96 ^c	30.84 ^{bc}	26.504 ^c	29.8 ^{bc}
T5	31.824 ^{abc}	31.984 ^{abc}	30.908 ^{abc}	30.948 ^{abc}
T6	30.696 ^{bc}	30.996 ^{abc}	29.524 ^{bc}	29.988 ^{abc}
T7	33.616 ^{abc}	28.916 ^{abc}	31.928 ^{abc}	27.772 ^{bc}
T8	34.068 ^{abc}	38.568 ^{abc}	32.72 ^{abc}	37.728 ^{ab}
T9	39.876 ^{ab}	38.592 ^{abc}	37.868 ^{ab}	37.692 ^{ab}
T10	34.64 ^{abc}	35.3 ^{abc}	32.236 ^{abc}	34.892 ^{abc}
T11	37.588 ^{abc}	29.312 ^{bc}	35.998 ^{abc}	29.078 ^{abc}
T12	42.752 ^a	36.716 ^{abc}	40.788 ^a	36.028 ^{abc}

K. Un-marketable tuber yield (ton-ha-1).

During the first year, the highest unmarketable tuber yield (2.916 tons ha⁻¹) was recorded in plots treated with 200 kg ha⁻¹ of K₂O and 40 kg ha⁻¹ of nitrogen. In contrast, the lowest unmarketable yield (0.586 tons ha⁻¹) was observed in untreated plots during the same year. However, the maximum value of Un-marketable tuber yield (3.372 ton -ha-1) was measured in the second year at plots of 0 K₂O with 40 N kg ha-1 application. Despite this, the minimum of Un-marketable tuber yield (0.45ton ha-1) were observed from level of 100 K₂O with 80 N kg ha-1, in the second year. The average of Un-marketable tuber

yield (2.602-ton ha⁻¹) was recorded from the plots that received 0K₂O and 40 N kg ha⁻¹, allowing the tubers to also, the main and interaction impact of nitrogen and potassium on unmarketable tuber production were both insignificant (Table 2 and 3). This finding shows that unmarketable tubers could be 0 K₂O and 40 N Kg ha⁻¹ more effectively by adjusting other parameters like unmarketable tubers [41].

L. Weight potato per plant (kg)

In the first year, the highest potato weight per plant (0.927 kg) was recorded in plots treated with 200 kg ha⁻¹ of K₂O and 40 kg ha⁻¹ of nitrogen. The lowest value during that year (0.606 kg) was observed in untreated plots. In the second year, the maximum weight per plant (0.819 kg) was achieved with 40 kg ha⁻¹ of nitrogen and no potassium application, while the lowest weight (0.590 kg) was recorded in plots receiving 100 kg ha⁻¹ of K₂O and 80 kg ha⁻¹ of nitrogen. The highest of weight potato per plant of (0.819kg) was recorded from the plots that received 0K₂O and 40 N kg ha⁻¹ Resulting in greater weight potato per plant, allowing the tubers to also, the main and interaction impact of nitrogen and potassium on weight potato per plant production were both insignificant (Table 2 and 3). This finding shows that weight potato per plant could be 0 K₂O and 40 N Kg ha⁻¹ more effectively by adjusting other parameters like weight potato per plant tubers.

Table 8. The Effect of varying Potassium and Nitrogen levels on unmarketable yield (ton ha⁻¹) and tuber weight per plant (kg) of potato (*Solanum tuberosum* L.) at Kanipanka location.

Treatment	Yield un-marketable(ton-ha ⁻¹)		Weight potato per plant(kg)	
	2014	2015	2014	2015
T1	1.832 ^a	3.372 ^a	0.606 ^c	0.590 ^a
T2	1.989 ^a	0.68 ^a	0.616 ^{bc}	0.753 ^a
T3	2.916 ^a	0.684 ^a	0.735 ^{abc}	0.747 ^a
T4	1.46 ^a	1.345 ^a	0.602 ^c	0.677 ^a
T5	0.916 ^a	0.518 ^a	0.703 ^{abc}	0.703 ^a
T6	0.586 ^a	0.503 ^a	0.671 ^{bc}	0.681 ^a
T7	0.844 ^a	1.144 ^a	0.716 ^{abc}	0.631 ^a
T8	0.674 ^a	0.84 ^a	0.744 ^{abc}	0.856 ^a
T9	2.008 ^a	0.45 ^a	0.861 ^{abc}	0.856 ^a
T10	2.404 ^a	0.204 ^a	0.733 ^{abc}	0.792 ^a
T11	0.795 ^a	2.234 ^a	0.818 ^{abc}	0.705 ^a
T12	1.964 ^a	0.982 ^a	0.927 ^{ab}	0.819 ^a

4. Conclusion

Results were inconclusive for a potassium and nitrogen effect on total potato growth and crop yield, but tended to be positive. There were marked yield disparities between the trailed potato genotypes, 'Prenvito' being the most productive one. This genotype produced consistently higher plant height, tuber count, tuber weight, dry matter content, crude protein and starch concentration as well the marketable and unmarketable yields than any other variety. During the 2-year study, maximum total yield (39.38 tons ha⁻¹) was obtained with 'Prenvito' from a treatment of 300 kg K₂O ha⁻¹ and 120 kg N ha⁻¹. Economic analysis also indicated favorable return for potassium application to chili growers. Thus, it is advisable to include potassium fertilizers while practicing standard fertilization for growing of potato in kanipanka and similar soils.

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